



**NOAA**  
**CORAL REEF**  
CONSERVATION PROGRAM

**Climate Change Strategy and Implementation  
Plan**

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2014 - 2016

## Executive Summary

The Climate Change Strategy and Implementation Plan refines and builds upon the Coral Reef Conservation Program Goals and Objectives 2010-2015 to direct Program investments in reducing the impacts of climate change and ocean acidification to coral reef ecosystems. The Coral Program's approach, partnerships, and past accomplishments lay the foundation for this pathway forward. The focus of the Coral Program is to support effective ecosystem-based management and adaptation with a foundation of sound science to understand the impacts of climate change and ocean acidification to coral reef ecosystems. Based on this information, the Program provides targeted tools, products, and services to inform on-the-ground management of coral reef ecosystems.

Coral Program climate funds over the next 3-5 years will focus on activities that contribute to the following priorities (numbering does not indicate an order of important). The practice of climate-smart conservation should underpin all activities undertaken by the Program and its partners to achieve these priorities.

1. Support reef managers in evaluating and understanding the vulnerability and resilience of their reefs and dependent communities and in using this information to inform management decisions.
2. Develop, refine and disseminate climate products and services to our management partners, meeting their unique timing, format and content requirements and use this information for decision-making.
3. Build the capacity of managers to integrate science and local knowledge into management and raise awareness about climate change impacts and the benefits and potential for sound ecosystem-based management.

Climate change and ocean acidification will continue to present greater and greater challenges for coral reef managers, stakeholders, and our partners. This will require a certain agility and responsiveness to emerging issues and the opportunities they present, whether those be related to policy or extreme events.

This document will be used by the Program to craft our internal requests for proposals, external federal funding opportunities, and in the evaluation of the proposals that we receive. We hope that our partners will use it to better understand our priorities as we work together to tackle the challenge climate change and ocean acidification present to coral reef conservation and management.

## Purpose

Climate change and ocean acidification have been identified as the most important global threat to coral reefs<sup>1,2</sup>. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability* coral reefs, along with the Arctic Sea, are identified as systems that are uniquely threatened even if additional temperature rise is held to 2°C rise.<sup>3</sup> The Climate Change Strategy and Implementation Plan refines and builds upon the [Coral Reef Conservation Program Goals and Objectives 2010-2015](#) to direct Program investments in reducing the impacts of climate change and ocean acidification to coral reef ecosystems.

## Context

### *Geography*

The NOAA Coral Reef Conservation Program, authorized by the [Coral Reef Conservation Act](#) (CRCA) in 2000, supports effective management and sound science to preserve, sustain and restore valuable coral reef ecosystems for future generations. Domestically, the Coral Program funds and engages in activities with NOAA and partners in seven US states and jurisdictions with coral reef resources including American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), Guam, Hawai'i, Florida, Puerto Rico, and the US Virgin Islands (USVI) as well as uninhabited islands including the Northwestern Hawaiian Islands, the Pacific Remote Island Areas, and the Flower Garden Banks. The Coral Program is also engaged in international coral reef conservation work focused in the Pacific Freely Associated States (the Federated States of Micronesia (FSM), the Republic of the Marshall Islands, and the Republic of Palau), the Caribbean, and the regions of Samoa/Southwest Pacific and the Coral Triangle (Solomon Islands, Papua New Guinea, Timor-Leste, the Philippines, Malaysia and Indonesia). The Climate Change Strategy and Implementation Plan will guide Coral Program investments in these locations to assist coral reef managers and dependent communities to understand the impacts of climate change and ocean acidification and proactively plan for and respond to these impacts.

### *Administration Priorities*

The [National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes \(National Ocean Policy\)](#), the [United States Department of Commerce Strategic Sustainability Performance Plan](#), the [National Fish Wildlife and Plants Climate Adaptation Strategy](#), and most recently the [President's Climate Action Plan](#) and [Executive Order 13653 Preparing the US for the Impacts of Climate Change](#) provide the context in which NOAA Programs move forward to address the impacts of climate change and ocean acidification.

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<sup>1</sup> Hoegh-Guldberg, O., P. J. Mumby, A. J. Hooten, R. S. Steneck, P. Greenfield, E. Gomez, C. D. Harvell, P. F. Sale, A. J. Edwards, K. Caldeira, N. Knowlton, C. M. Eakin, R. Iglesias-Prieto, N. Muthiga, R. H. Bradbury, A. Dubi, and M. E. Hatziolos. 2007. Coral Reefs under Rapid Climate Change and Ocean Acidification. *Science* 318: 1737-1742.

<sup>2</sup> Dodge, R.E., et al. (2008) A Call to Action for Coral Reefs. *Science* 322:189-190.

<sup>3</sup> IPCC, Summary for Policymakers, in *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge Univ. Press, Cambridge and New York, 2014).

## Coral Program contributions to climate-related Administration priorities

### **The President's Climate Action Plan (PCAP)**

The PCAP directs federal agencies to take a series of steps to make it easier for American communities to strengthen their resilience to extreme weather and prepare for other impacts of climate change. *The Coral Program contributes to these efforts under the second pillar of the PCAP, Prepare the United States for the Impacts of Climate Change under the executive actions of Protecting our Economy and Natural Resources and Using Sound Science to Manage Climate Impacts.*

### **Executive Order 13653 Preparing the United States for the Impacts of Climate Change**

E.O. 13653 establishes the Task Force on Climate Preparedness and Resilience to advise the Administration on how the Federal Government can respond to the needs of communities nationwide that are dealing with the impacts of climate change. *The Coral Program, through the US Coral Reef Task Force, is providing support to our jurisdictional partners who are members of this Task Force.*

### **National Fish Wildlife and Plant Climate Adaptation Strategy (NFWPCAS)**

The NFWPCAS was developed by an intergovernmental working group of federal, state, and tribal agency representatives to inspire and enable natural resource administrators, elected officials and other decision makers to take action to adapt to a changing climate. *The Coral Program and partners contribute to the NOAA implementation with activities under all seven strategies aimed to address climate change impacts and help conserve ecosystems and make them more resilient.*

### **Department of Commerce (DOC) Climate Adaptation Strategy**

EO 13514, *Federal Leadership in Environmental, Energy, and Economic Performance* and EO 13653, *Preparing the United States for the Impacts of Climate Change*, require that each Federal agency develop, implement, and update comprehensive plans that integrate consideration of climate change into agency operations and overall mission objectives. *Coral Program activities have been highlighted as examples of adaptation actions DOC is supporting. These have included our climate change adaptation work as part of the U.S. Coral Triangle Initiative Support Program, our leadership in the US Coral Reef Task Force Coral Adaptation Planning project, and our portfolio of work to support the incorporation of resilience into coral reef management.*

### **Executive Order 13547 Stewardship of the Ocean, Our Coasts, and the Great Lakes and the National Ocean Policy (NOP) Implementation Plan**

EO 13547 and its associated implementation plan describes specific actions Federal agencies will take to address key ocean challenges, give states and communities greater input in Federal decisions, streamline Federal operations, save taxpayer dollars, and promote economic growth. *Climate-related activities of the Coral Program are reported under action/milestone 4d "Complete State/territory-specific coral bleaching response plans and/or resilience/adaptation strategies to better coordinate action to address the impacts of climate change and ocean acidification on coral reef ecosystems".*

The Coral Program is also guided by the [NOAA Next Generation Strategic Plan](#) and contributes to meeting multiple climate related objectives under the *Climate Adaptation and Mitigation Goal*, the *Resilient Coastal Communities and Economies Goal*, the *Healthy Oceans Goal* and the *Science and Technology Enterprise*. The Coral Program is instrumental in realizing the

commitments of the US Coral Reef Task Force (USCRTF) and its resolutions including [Resolution 28.2: Coral Reefs and Climate Change Renewed Call to Action](#) as well as earlier resolutions related to climate change and ocean acidification ([18:1](#), [16:8](#), [10:5](#), [8:5](#), and [2:3](#)). The Program also contributes to the requirements of the Magnuson-Stevens Act, the Endangered Species Act, the Coastal Zone Management Act, the National Marine Sanctuaries Act, and the Federal Ocean Acidification Research and Monitoring Act in considering the impacts of climate change and ocean acidification to coral reef ecosystems. Program outcomes contribute to and support regional and international efforts such as the Southeast Conservation Adaptation Strategy, Specific Work Plan on Coral Bleaching in the Convention on Biological Diversity; the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security; the International Coral Reef Initiative; and assessment activities such as those of the Global Coral Reef Monitoring Network, the Global Socioeconomic Monitoring Initiative for Coastal Management, the US Global Climate Change Research Program and the Intergovernmental Panel on Climate Change.

#### *Threats and Coral Program Priorities*

The Coral Program identified the impacts of climate change, land-based sources of pollution and fishing as the three primary threats to coral reef ecosystems and in 2010 released [goals and objectives](#) as well an [International Strategy](#) to address these threats. Progress towards meeting these goals is tracked through a series of [performance measures](#) and the [Coral Program MPA Management Assessment Checklist](#). Since the release of the Goals and Objectives, the Program has also undertaken a series of activities to guide and focus its investments further with the release of the [Social Science Strategy: 2010-2015](#), the [National Communications, Education and Outreach Strategy: 2010-2015](#), the [Land-based Sources of Pollution Implementation Plan: 2011-2015](#), the [Fishing Impacts Implementation Plan: 2013-2017](#), and the [National Coral Reef Monitoring Plan](#). The [Ocean Acidification Science Plan 2012-2016](#) provides more specific guidance on the Program's investment in research and monitoring to understand the potential consequences of ocean acidification on coral reef ecosystems and its management implications. The success of the Coral Program depends on its close partnership with managers on the ground in the seven US coral jurisdictions and to that end, investments are also guided by the [management priorities](#) identified in those places. Given the synergistic and at times cumulative effects of climate change and ocean acidification with local stressors to reefs, addressing local management priorities also increases the resilience of reefs. The Program is also committed to provide the best available data and information on the status of US coral reef ecosystems to understand their vulnerabilities and inform management through the Coral Reef Ecosystem Integrated Observing System and the National Coral Reef Monitoring Plan (NCRMP).

#### *Jurisdictional Climate Priorities*

The jurisdictions have engaged in additional activities that establish climate priorities including local action strategy development, vulnerability assessments, and coastal community adaptation training and planning. All seven coral reef jurisdictions have bleaching and crisis response plans, in draft or finalized form, and are using them to guide conservation and response activities during these events. The US Virgin Islands recently held the "USVI Climate

Change Ecosystem-based Adaptation Workshop: Allowing for Resilient Communities” to identify next steps and has formed the Virgin Islands Reef Resilience Program. The Puerto Rico Climate Change Council recently released [Puerto Rico’s State of the Climate 2010-2013: Assessing Vulnerabilities in a Changing Climate](#) and there is a [Climate Change Action Plan for the Florida Reef System 2010-2015](#). In the Pacific Islands region, through the Pacific Islands Managed and Protected Area Community, American Samoa, CNMI, and Guam have both completed [Adapting to Climate Change Workshops](#) and have identified next steps for their jurisdictions. These workshops have also been completed in FSM and Palau. American Samoa has many ongoing efforts to prepare the territory for the impacts of climate change including the establishment of a Climate Change Adaptation Advisory Board, the development of a Territorial Climate Change Adaptation Framework, the [Amouli Village Resilience Plan](#) and the recent Two Samoa Reef Resilience Workshop for Marine Managed Area Practitioners. Hawai’i has undertaken many efforts to move forward on adaptation, including the development of [A Framework for Climate Change Adaptation in Hawai’i](#) and passage of the Climate Change Adaptation Policy. The draft [Saipan Climate Change Vulnerability Assessment](#) has been released by the [CNMI Climate Change Working Group](#). The Coral Program will work with the jurisdictions where possible to support activities relevant to coral reefs and climate change in their plans and strategies as well as climate-related recommendations in the [Jurisdictional Capacity Assessments](#).

## Approach

### *Climate-Smart Conservation*

Climate change is a global threat and as such, all coral reef conservation efforts undertaken by the Coral Program should be climate-smart. Climate-smart conservation is the intentional and deliberate consideration of climate change in natural resource management, realized through forward-looking goals and linking actions to they reduction of key climate impacts and vulnerabilities<sup>4</sup>. Climate-smart conservation recognizes the need to manage for change, not just persistence – focusing on ecological functions, rather than historical assemblages of plants and animals. Key attributes of climate-smart conservation include:

- Link actions to climate impacts – Conservation strategies and actions are designed specifically to address the impact of climate change in concert with existing threats; actions are supported by an explicit scientific rationale.
- Embrace forward-looking goals – Conservation goals focus on future rather than past, climatic and ecological conditions; strategies take a long view (decades to centuries) but account for near-term conservation challenges and needed transition strategies.
- Consider a broader landscape context – On-the-ground actions are designed in the context of broader geographic scales to account for likely shifts in species distribution, to sustain ecological processes, and to promote cross-institutional collaboration.

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<sup>4</sup> Stein, B.A., P. Glick, N. Edelson, and A. Staudt (eds.). 2014. Climate-Smart Conservation: Putting Adaptation Principles into Practice. National Wildlife Federation, Washington, D.C. [http://www.nwf.org/pdf/Climate-Smart-Conservation/NWF-Climate-Smart-Conservation\\_5-08-14.pdf](http://www.nwf.org/pdf/Climate-Smart-Conservation/NWF-Climate-Smart-Conservation_5-08-14.pdf)

- Adopt strategies robust in an uncertain future – Strategies and actions ideally provide benefit across a range of possible future conditions (including extreme events) to account for uncertainty in climate and ecological and human responses to climate shifts.
- Employ agile and informed management (adaptive management) – Planning and resource management is capable of continuous learning and dynamic adjustment to accommodate uncertainty, respond to new knowledge, and to cope with rapid shifts in climatic, ecological, and socio-economic conditions.
- Minimize carbon footprints – Strategies and projects minimize energy use and greenhouse gas emissions and sustain the natural ability of ecosystems to cycle and sequester carbon.
- Account for climate influence on project success – Managers should consider how climate impacts may compromise project success, and avoid investing in efforts likely to be undermined by climate-related changes unless part of an intentional strategy.
- Safeguard people and wildlife – Strategies and actions enhance the capacity of ecosystems to protect human communities from climate change impacts in ways that also sustain and benefit fish, wildlife and plants.
- Avoid maladaptation<sup>5</sup> - Actions to address impacts on human communities or natural systems do not exacerbate other climate-related vulnerabilities or undermine conservation goals and broader ecosystem sustainability.

Climate change and ocean acidification and their implications for project implementation and success should be a consideration in all of the internal projects and external grants and cooperative agreements the Coral Program funds and we should strive to make our conservation efforts climate-smart.

### *Ecosystem-based Management & Adaptation*

The decline and loss of most coral reefs during recent decades is due to a combination of the global pressures of climate change and ocean acidification coupled with regional and local stressors – including but not limited to cumulative impacts from land-based sources of pollution, ecologically unsustainable fishing, and habitat destruction associated with coastal development and vessel groundings. These local stressors act synergistically to reduce the resilience of coral reef ecosystems<sup>6</sup>. Reducing emissions and the rate of climate change is largely dependent on national and international policies; given the uncertainty in agreement on these policies, actions by local management are essential for enhancing coral reef resilience to climate change. This approach to resilience underpins effective ecosystem-based management, an integrated, holistic approach to management that considers the connectedness of the entire ecosystem, including humans, rather than a single issue, species, or ecosystem service in

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<sup>5</sup> Maladaptation - action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups (Barnett, J. and O'Neill, S. (2010) Maladaptation. *Global Environmental Change* 20 (2010) 211–213.)

<sup>6</sup> Hoegh-Guldberg, O., P. J. Mumby, A. J. Hooten, R. S. Steneck, P. Greenfield, E. Gomez, C. D. Harvell, P. F. Sale, A. J. Edwards, K. Caldeira, N. Knowlton, C. M. Eakin, R. Iglesias-Prieto, N. Muthiga, R. H. Bradbury, A. Dubi, and M. E. Hatzioios. 2007. Coral Reefs Under Rapid Climate Change and Ocean Acidification. *Science* 318: 1737-1742

isolation<sup>7,8</sup>. In many of the coral reef jurisdictions this “ridge to reef approach” is not new, and in some areas has been in place for generations as a traditional approach to managing marine and coastal resources<sup>9</sup>. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive, and resilient condition so that it can provide the services humans want and need<sup>10</sup>. Building on effective ecosystem-based management, ecosystem-based adaptation integrates biodiversity and ecosystem services into an overall strategy to help people adapt to the adverse impacts of climate change and focuses on the provision of multiple economic, social, environmental, and cultural benefits. It includes the sustainable management, conservation, and restoration of ecosystems to provide services that help people adapt to both current climate variability and climate change<sup>11</sup>. Key partners including the Australia Great Barrier Reef Marine Park Authority (GBRMPA) and the Nature Conservancy (TNC) are adopting the principles of effective ecosystem-based adaptation and their efforts provide learning opportunities to improve climate adaptation strategies for our reef management partners. These principles include:

- Reduce non-climate stressors that have degraded the condition of critical ecosystems thereby reducing their resilience to climate change.
- Involve local communities in both the planning and implementation of ecosystem-based adaptation measures.
- Develop multi-partner strategies taking advantage of the tangible opportunity to solve problems by aligning conservation, development, and poverty alleviation interests from the perspective of both funding and cooperation.
- Enhance existing good practices in natural resource management - integrated management of resources is particularly critical to the implementation of ecosystem-based adaptation.
- Adopt adaptive management approaches that facilitate and accelerate learning about appropriate options for the future by carefully monitoring climate impacts and adaptation measure effectiveness so that adjustments can be made in response to changing conditions.
- Integrate ecosystem-based adaptation with wider adaptation strategies including risk management components such as early warning systems and awareness raising, and in some cases physical infrastructural interventions. It is important to encourage and enable

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<sup>7</sup> Marshall, P., H. Schuttenberg. 2006. A reef manager’s guide to coral bleaching. Great Barrier Reef Marine Park Authority, Townsville.

<sup>8</sup> Levin, S.A., and J. Lubchenco. 2008. Resilience, Robustness, and Marine Ecosystem-based Management. *BioScience* 58(1):27-32.

<sup>9</sup> Berkes, F., Colding, J., and Folke, C. 2000. Rediscovery of Traditional Ecological Knowledge as Adaptive Management. *Ecological Applications*. 10(5):1251-1262.

<sup>10</sup> McLeod, K. L., J. Lubchenco, S. R. Palumbi, and A. A. Rosenberg. 2005. Scientific Consensus Statement on Marine Ecosystem-Based Management. Signed by 221 academic scientists and policy experts with relevant expertise and published by the Communication Partnership for Science and the Sea at <http://compassonline.org/?q=EBM>

<sup>11</sup> Cols, A., N. Ash, and N. Ikkala. Ecosystem-based Adaptation: a natural response to climate change. Gland, Switzerland: IUCN. 16 pp.

technology transfer and dialog between planners and practitioners with expertise in hard engineering and in ecosystem management.

- Create mechanisms to communicate, educate, transfer knowledge, build capacity, integrate science and local knowledge and raise awareness about climate change impacts and the benefits and potential for sound ecosystem management.

### **Conservation through Strong Partnerships**

The Coral Program has no direct management authority over coral reef resources. The Program depends on its strong partnerships with international, federal, state/territorial, and local managers and key stakeholders; and the provision of sound science, tools, and information to support management decisions to be climate-smart. Building and strengthening partnerships, both internal and external to NOAA, underpins the climate related work of the Program. Important existing and new partnerships, successes and opportunities are described here though this list is not exhaustive. Every effort should be made to strengthen these partnerships and build new ones.

#### *Management Partners*

The science, monitoring, and information products developed by the Program in its climate portfolio should be driven by management questions and should be accomplished through dialogue with managers to determine the right format, timing, and content of the products. In the 2013 Coastal Resource Management Survey, respondents identified coastal planning and development and conservation as their top two priorities with climate change, sea level rise, and resilience as their top three issues. Climate change and impacts data was listed as the most popular and the top requested category for improved data<sup>12</sup>. Thus part of the climate portfolio will be to work with managers to raise awareness of potential impacts, of available climate information and tools, and help identify gaps and new product needs.

#### *Internal NOAA Partnerships*

The Coral Program, as a matrix program, has always drawn on the knowledge and expertise of many NOAA offices. Recently efforts have been made to strengthen the ties with the Climate Program Office (CPO), the new Ocean Acidification Program (OAP), the National Marine Fisheries Service (NMFS) Office of Science and Technology, the National Weather Service Climate Prediction Center (CPC), and the NESDIS Regional Climate Services (RCS) Program, specifically via the Pacific (Pacific Islands) and Southern (Caribbean) Regional Climate Services Directors (RCSDs). This has resulted in shared funding of projects, leveraging of efforts and resources, and the ability to tap into additional technical expertise to achieve more efficient project results. There are more opportunities on which to capitalize including the potential to co-fund grants with CPO, OAP, and the National Centers for Coastal Ocean Science Center for Sponsored Coastal Ocean Research, to apply vulnerability assessment methodologies being

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<sup>12</sup> Insights into Coastal Management Needs: Results from the NOAA Coastal Services Center and Office of Ocean and Coastal Resource Management Customer Survey. April 2014. Eastern Research Group, Inc. Lexington, Massachusetts. Prepared for NOAA Coastal Services Center under contract EA133C-09-CQ-0034, task order 32.

developed by NMFS Office of Science and Technology to coral reef fisheries, and to support the National Marine Sanctuaries engaged in the Climate-Smart Sanctuaries process. The formation of the NOAA Office for Coastal Management will provide an opportunity to build upon existing collaborations to provide more tools, training, and services to our state and territorial management partners.

NOAA is working to strengthen its regional teams and coordinate work through efforts like the [NOAA in the Caribbean](#) (NOAA Carib) partnership initiative, and in response to strategic guidance such as the [NOAA Caribbean Strategy](#). The Coral Program has been, and should continue to be engaged, in efforts where coral reefs and climate change are a focus. Continued engagement with the Pacific Islands Climate Information System (PaCIS), CPO, and the RCSDs provides an opportunity to inform larger discussions of how to provide climate products and services through the Global Framework for Climate Services and the Climate Services Partnership. Traditionally these efforts have focused on issues of freshwater resources, agriculture and food security, and sea level rise. Efforts are now being broadened to consider the needs of coastal and marine resource managers. We also partner with PaCIS and the Pacific Islands RCSD on a USAID-funded project to Enhance Global Climate Change Adaptation Capacity in Pacific Islands Developing States (USAID-NOAA PSIDS), which will result in a coral reef manager dashboard of climate variability and change information and other products relevant to our partners.

#### *External Federal Partnerships*

Partnerships with other federal agencies to address the impacts of climate change and ocean acidification to coral reef ecosystems have been some of our most productive. Work with the US Environmental Protection Agency (US EPA) and the US Coral Reef Task Force (USCRTF) Climate Change Working Group to develop a framework and guidance on climate adaptation for coral reef managers based on the Climate-smart Conservation: Putting Adaptation Principles into Practice is currently underway. The USGS Pacific Coastal and Marine Science Center is doing relevant coral reef research in the Pacific Islands that could be used by our management partners. Engagement in PaCIS has led to contributions to the Pacific Islands Regional Climate Assessment and greater consideration of the information needs of coral reef managers as plans are put into place to deliver climate services to the Pacific Islands. Advantage should be taken of opportunities to work with the Department of Interior (DOI) led Landscape Conservation Cooperatives, especially the Caribbean Landscape Conservation Cooperative (CLCC) and the Pacific Islands Climate Change Cooperative (PICCC) to raise the profile of coral reef ecosystems and contribute to the scientific and technical expertise made available for the conservation community in these regions. DOI has established eight regional climate science centers, which have coral- and climate-specific projects. USDA has announced the creation of seven regional climate risk management and adaptation hubs, along with three "sub-hubs" including one focused on the Caribbean. Through engagement with LCCs, DOI climate science centers, and USDA climate hubs and sub-hubs, the efforts of the Coral Program can be placed in a broader context and contribute to the full spectrum of conservation activities in these regions. Furthermore, these entities continue to invest in regional climate science to support priority

conservation management needs. The Coral Program, working in collaboration with RCSDs and other partners, can inform and influence those priorities and funding decisions to ensure our coral reef management partners are getting the climate science and services they need to make informed decisions. NOAA also has a long-term partnership with the US Agency for International Development (USAID), which is discussed below in the context of our international work.

#### *International, NGO, and Academic Partnerships*

Engagement in international initiatives and partnerships provides a unique opportunity for the Coral Program as a preeminent coral reef conservation body in the US to share knowledge with the international community and perhaps more importantly to bring back materials, ideas and lessons learned to apply domestically. The field of adaptation is moving very quickly as climate change impacts are felt with more frequency and intensity and the sharing of knowledge, techniques, and lessons-learned saves time and resources and contributes to adaptive management. A very productive partnership with GBRMPA, the International Union for the Conservation of Nature, TNC, and World Wildlife Fund resulted in the publication of [The Reef Managers Guide to Coral Bleaching](#) and associated training series for coral reef managers. Working with the GBRMPA also resulted in improved products to provide early warning for bleaching events and collaboration on projects to further the thinking on proactive planning for and adapting to climate change and ocean acidification impacts to coral reef ecosystems. The GBRMPA has recently engaged in the [Australia Caribbean Coral Reef Collaboration](#) through the Australia Agency for International Development and the Caribbean Community Climate Change Centre with the goal of developing and implementing a regional plan of action for reducing coral reef vulnerability in a changing climate and to develop and test practical measures that managers and policymakers can deploy for real-world outcomes. NOAA has a memorandum of understanding with the Caribbean Community Climate Change Centre, which could be a vehicle to support ecosystem-based management and adaptation in the Caribbean basin. The Coral Program has successfully supported climate-related initiatives through regional platforms such as the Micronesia Challenge, the Two Samoas Initiative and the Coral Triangle Initiative. These efforts have provided new opportunities to collaborate and transfer experiences and lessons learned back to our management partners.

NOAA was one of the implementing partners in the USAID-funded US Coral Triangle Initiative Support Program (USCTI), which resulted in training curriculum and products for marine and coastal resource management. These included creating guidance on community-based vulnerability assessments and adaptation planning, incorporating climate change and ocean acidification into ecosystem-based approaches to fisheries management, and designing MPA and locally marine managed area networks with climate, fisheries, and biodiversity goals. These resources benefited from work being done within NOAA and in other regions by partners. Working with the jurisdictions to apply this guidance domestically is a logical next step. The recent finalization of a new 5-year agreement with USAID in the Asia-Pacific region provides yet more opportunities for these types in engagement by Coral Program scientists and staff.

Our partnerships with NGOs such as TNC through their Global Marine Initiative, Micronesia, and Caribbean Programs have contributed significantly to our Program successes. Work to strengthen collaborations with World Wildlife Fund (WWF) and Conservation International (CI) are also important, especially building on the work in the Coral Triangle region as the USCTI Support Program comes to an end. Our partnerships with the academic community including the University of Hawai'i, University of the Virgin Islands, University of Puerto Rico, University of the West Indies Centre for Resource Management and Environmental Studies, University of Miami/RSMAS, Columbia University, and University of Rhode Island, University of Florida, University of Guam, University of Queensland, and James Cook University have resulted in high quality research projects and products focused on climate change and ocean acidification impacts on coral reef ecosystems and we should continue to cultivate these partnerships and disseminate our research priorities for considerations. New opportunities to work collaboratively with the Ocean Tipping Point project through the University of California Santa Barbara National Center for Ecological Analysis and Synthesis and Stanford University's Center for Ocean Solutions, and the Stockholm Resilience Centre at Stockholm University are key to our progress in supporting management to increase reef resilience.

#### *Engagement in Communities of Practice*

The Coral Program supports and engages in many formal networks and communities of practice such as the Florida and Virgin Islands Reef Resilience Programs, the Reef Resilience Network, the Climate Adaptation Knowledge Exchange, the Pacific Islands Marine and Protected Areas Community (PIMPAC), and the Caribbean Marine Protected Areas Management network. Informally, the Coral Program reef resilience list is used to distribute the latest science and communications on reef resilience and coastal related climate adaptation, funding opportunities, etc. to over 490 members globally. The ability to communicate the latest climate science, share management and adaptation strategies, and lessons-learned through these networks are invaluable.

#### **Progress to date on the Climate Change and Ocean Acidification Goals & Objectives**

In 2010, a community of experts helped identify long-term goals and strategic objectives to address the top three threats to coral reef ecosystems. Specifically the Coral Program has identified four goals to address the impacts of climate change:

1. Manage for resilience – Increase coral reef resilience to climate change and ocean acidification through effective management strategies.
2. Address risks and vulnerabilities - Identify, understand and communicate risks and vulnerability of US coral reef ecosystems, ecosystem service, and dependent human communities to climate change and ocean acidification.
3. Provide forecasts and projections – Enhance strategic management of coral reef ecosystems through improved and applied understanding, forecasts, and projections of climate change and ocean acidification impacts.
4. Intervene to reduce climate stress and impacts – Support management efforts to increase survivorship of coral reef species and enhance reef resilience by evaluating and

implementing promising intervention strategies that directly reduce climate change and ocean acidification impacts.

There has been significant progress towards these goals since 2010 and the Program has focused primarily on monitoring to characterize physical and chemical changes in coral reef environments and responses of the ecosystem to these changes, modeling of climate change and ocean acidification in the reef environment, and translation of these models to inform management. Focus shifted in the last year to support the identification of resilient and vulnerable reefs and use this information to inform management. In Appendix 3 a summary of representative activities from FY10-FY13 are presented. This summary is not meant to be exhaustive in detail, but to give a sense of the work the Program and its partners have been accomplished since 2010.

The Coral Program has had a long history of engagement in foundational science and monitoring pertaining to climate processes and ecosystem response. Products and decision-support tools have been provided to managers based on this work. This has included the development of the Coral Reef Watch bleaching product suite, updates to those products, and the Seasonal Bleaching Outlooks; the first Ocean Acidification Product Suite and Ocean Acidification Test Bed; the work of the Atlantic Oceanographic and Meteorological Laboratory (AOML), the National Centers for Coastal Ocean Science (NCCOS), the Pacific Islands Fisheries Science Center (PIFSC), and the Southeast Fisheries Science Center (SEFSC) to better understand current reef condition and monitor the changing reef environment; and increasing our understanding of coral diseases processes and their connections to a changing climate. The program has also put into place a long-term status and trends monitoring program. NCRMP climate indicators include thermal stress (sea surface temperature and subsurface water temperature) and carbonate chemistry (dissolved inorganic carbon, total alkalinity, carbon dioxide aqueous and atmospheric partial pressures, and pH). NCRMP also monitors the ecological impacts of climate change, including coral growth and extension rates, net community calcification rates, and net reef bioerosion rates. Given fiscal constraints, any Coral Program climate related monitoring should fall under NCRMP and further research to understand the impacts of ocean acidification should be responsive to the Ocean Acidification Science Plan. Shorter-term monitoring and research that is climate related, question-driven and called for by a management need or is related to management effectiveness monitoring should be considered on a case-by-case basis.

### **Focus for Future Implementation of the Climate Goals & Objectives**

The focus of the Coral Program is to support effective ecosystem-based management and adaptation with a foundation of sound science to understand the impacts of climate change and ocean acidification to coral reef ecosystems. Based on this information, the Program provides targeted tools, products, and services to inform on-the-ground management of coral reef ecosystems.

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1. Support reef managers in evaluating and understanding the vulnerability and resilience of their reefs and dependent communities and in using this information to inform management decisions.
2. Develop, refine and disseminate climate products and services to our management partners, meeting their unique timing, format and content requirements and use this information for decision-making.
3. Build the capacity to of managers to integrate science and local knowledge into management and raise awareness about climate change impacts and the benefits and potential for sound ecosystem-based management.

Priorities for funding over the next 3-5 years fall mostly under *Goal 1 Manage for Resilience* and partially under *Goal 2 Address Risks and Vulnerability*. Objectives and activities under these goals empower managers to address the impacts of climate change and ocean acidification through effective and informed management practices and potential future activities in which the Program would like to engage are presented in Appendix 3. Future activities should capitalize on the conservation partnerships described in the previous sections of this document and build on the foundational work that has already been accomplished.

Support reef managers in evaluating and understanding the vulnerability and resilience of their reefs and dependent communities and in using this information to inform management decisions. - One of the key tenets of the Program's approach is managing for resilience. Guidance to understand the vulnerability of and take action to increase the resilience of key ecosystems is being issued through the President's Climate Action Plan and the NOAA Next Generation Strategic Plans. In all seven jurisdictional coral reef management priority documents, the need to understand coral reef vulnerability and/or resilience and manage appropriately is articulated. The concept of resilience and its theoretical applicability in managing reefs is not new, but recently the momentum in the global discussion and learning on how to assess and manage for resilience has escalated. NOAA and the Coral Program have a unique opportunity to do the science to understand the vulnerabilities of coral reefs to climate change and ocean acidification, to work with partners to co-generate and provide data and information products in digestible formats for use in assessments, to support actual assessments in different geographies and at different scales, and to build capacity to use the results in the management process. These are vital contributions to the global body of work in this research and management area at a critical time. There is an opportunity for the outcomes of vulnerability and resilience assessment to contribute to larger place-based efforts to realize the goal of ecosystem-based management whether in Coral Program priority areas, US Coral Reef Task Force Priority Watersheds or similar focus areas as defined by the NOAA Habitat Blueprint and other initiatives.

Develop, refine and disseminate climate products and services to our management partners, meeting their unique timing, format and content requirements and use this information for

decision-making. - The transformation of climate-related data and information into actionable knowledge for coral reef managers and stakeholders is essential to planning and decision making. There is a considerable amount of information that already exists but it must reach end-users in a form that is meaningful and empowers them to take the actions necessary to adapt to climate change. NOAA and the Coral Program are well positioned to understand the needs of our partners and work together to meet those needs especially through our partnerships with the Regional Climate Services Program and many of the climate-related initiatives of our federal partners, NGOs, and support of communities of practitioners like the Reef Resilience Network and the PIMPAC.

Build the capacity to of managers to integrate science and local knowledge into management and raise awareness about climate change impacts and the benefits and potential for sound ecosystem-based management. – The need to better understand the impacts of climate change and ocean acidification, the knowledge and capacity to plan and respond to these impacts and to communicate this information effectively to stakeholders is voiced repeatedly. The Coral Program should build on past successes and continue to work to improve our dissemination of science and information products, tools, and frameworks for resilience assessment and adaptation planning. Useful knowledge and tools should be transferred and built upon across regions, both domestically and internationally. Our ongoing and growing partnerships with TNC and USAID, as well as other federal agencies will be critical to this priority. Additionally outreach should be done to ensure that our partners are aware of and have access to trainings through other parts of NOAA and our partners.

### *Emergent Issues and Opportunities*

Climate change and ocean acidification will continue to present greater and greater challenges for coral reef managers, stakeholders, and partners in the coral reef jurisdictions and around the world. This will require a certain agility and responsiveness to emerging issues and the opportunities they present, whether those be policy-related or related to crisis or extreme events. Some examples follow but certainly others may arise.

- Subsequent to the adoption of the Coral Program Goals and Objectives, [20 new species of reef building coral were listed as threatened under the Endangered Species Act \(ESA\)](#). The original petition from the Center for Biological Diversity to list 83 coral species and subsequent review by NOAA cited anthropogenic climate change and ocean acidification as the leading factors among the various stressors responsible for the potential extinction of these species. Much of the climate related work in which the Coral Program is engaged would contribute to our understanding of how climate change and ocean acidification would further impact coral reef ecosystems and could be used to inform critical habitat designation and to develop recovery plans under the ESA, but there may also be species-specific knowledge gaps that would need to be addressed. The Coral Program is currently engaged in discussions with the National Marine Fisheries Service Office of Protected Resources to understand how the offices can work together more closely to address conservation of threatened and endangered species, including climate-related impacts.

- Natural cycles such as the El Niño/ Southern Oscillation can also create conditions that are more conducive for coral bleaching, especially when combined with the underlying warming of climate change. Outbreaks of coral disease and crown-of-thorns, invasive species, coral bleaching, hurricanes, and cyclones are just a few examples of unplanned for events that require response. The Coral Program should continue to engage in and support preparation for these types of events and encourage collaboration, coordination, and integration with coastal preparedness, disaster response, and other related initiatives to plan and respond to these impacts.
- Large-scale shifts in community structure due to the combination of global and local stresses to reefs ecosystems have already been observed. Declining reef health and structure result in loss of biodiversity and changes to associated fauna. Efforts to better understand these impacts and the science behind these inflection points, or tipping points, in ecosystems are advancing, for example through the Oceans Tipping Points project. The Coral Program should contribute to these advancements and be poised to disseminate tools and information to our management partners to help anticipate these potentially irreversible shifts and respond.
- The impacts of climate change and ocean acidification present many challenges to the science and management of coral reefs. The Program will look for opportunities to strategically invest and leverage our partnerships to support the research necessary to answer some of the pressing questions. Such as: what preventative and responsive actions can managers take to mitigate the impacts of climate change; what are the interactive effects of warming and acidification along with local stresses on coral reefs; and the development of climate-driven ecosystem models and coupling of physical, chemical, ecosystem and socioeconomic models that could help provide a framework for adaptation management.

The challenges that coral reef managers face are unprecedented given the combination of the global threats of climate change and ocean acidification and local stressors. The stakes for those that depend on coral reefs for food, coastal protection, cultural benefits, tourism, recreation, and other important services are high. However, with effective leadership, science, management, and partnerships to address these challenges, healthy, resilient reef ecosystems can continue to provide these valuable services to current and future generations.

## **Appendix 1: List of Acronyms**

AOML – Atlantic Oceanographic and Meteorological Laboratory (NOAA Office of Oceanic and Atmospheric Research)

AusAID – Australia Agency for International Development

CCA-LEAP – Climate Change Adaptation for Communities: A Guide for Vulnerability Assessment and Local Early Action Planning

CI – Conservation International

CLCC – Caribbean Landscape Conservation Cooperative

CNMI – Commonwealth of the Northern Mariana Islands

CoRTAD – Coral Reef Temperature Anomaly Database

CPO – Climate Program Office (NOAA Office of Oceanic and Atmospheric Research)

CRCA – Coral Reef Conservation Act

CRCP – Coral Reef Conservation Program (NOAA National Ocean Service)

CRED – Coral Reef Ecosystem Division

CRW – NOAA Coral Reef Watch

CSP – Climate Services Partnership

CTI – Coral Triangle Initiative

EAFM – Ecosystem-based Approach to Fisheries Management

EBM – Ecosystem-based Management

EBA – Ecosystem-based Adaptation

FSM – Federated States of Micronesia

GBRMPA – Great Barrier Reef Marine Park Authority

GFCS – Global Framework for Climate Services

GFDL – Geophysical Fluid Dynamics Laboratory (NOAA Office of Oceanic and Atmospheric Research)

GHG – Greenhouse Gas

G&O – Goals and Objectives (Coral Reef Conservation Program)

LCC – Landscape Conservation Cooperative (Department of Interior)

IPCC AR5 – Intergovernmental Panel on Climate Change 5<sup>th</sup> Assessment Report

MCT – Micronesia Conservation Trust

MPA – Marine Protected Area

NCRMP – National Coral Reef Monitoring Program (Coral Reef Conservation Program)

NCCOS – National Centers for Coastal Ocean Science (NOAA National Ocean Service)

NGO – Non-governmental Organization

NOAA – National Oceanic and Atmospheric Administration

NOAA-USAID PSIDS project - Enhance Global Climate Change Adaptation Capacity in Pacific Islands Developing States

OA – Ocean Acidification

OAP – Ocean Acidification Program (NOAA Office of Oceanic and Atmospheric Research)

OMB – Office of Management and Budget

ONMS – Office of National Marine Sanctuaries (NOAA National Ocean Service)

PaCIS – Pacific Islands Climate Information System

PIs – Principal Investigators

PSIDS – Pacific Small Island Developing States

PICCC – Pacific Islands Climate Change Cooperative

PIFSC – Pacific Islands Fisheries Science Center (NOAA National Marine Fisheries Service)

PIMPAC - Pacific Islands Marine and Protected Areas Community

PIRO – Pacific Islands Regional Office (NOAA National Marine Fisheries Service)

PMNM – Papahānaumokuākea Marine National Monument (NOAA Office of National Marine Sanctuaries)

RCP – Representative Concentration Pathways (GHG concentration trajectories)

RCSD – Regional Climate Service Director (NOAA)

SST – Sea surface temperature

TNC – The Nature Conservancy

USAID – United States Agency for International Development

USCRTF – United States Coral Reef Task Force

USCRTF CCWG – United States Coral Reef Task Force Climate Change Working Group

USCTI – United States Coral Triangle Initiative Support Program

US EPA – United States Environmental Protection Agency

USVI – United States Virgin Islands

UQ – University of Queensland

WCS – Wildlife Conservation Society

WWF – World Wildlife Fund

## Appendix 2: Links to Documents

Adapting to Climate Change Workshop Reports

<http://www.pimpac.org/activities.php?pg2=2&pg3=8>

A Framework for Climate Change Adaptation in Hawai'i

[http://files.hawaii.gov/dbedt/op/czm/ormp/reports/climate\\_change\\_adaptation\\_framework\\_final.pdf](http://files.hawaii.gov/dbedt/op/czm/ormp/reports/climate_change_adaptation_framework_final.pdf)

Amouli Village Resilience Plan

[http://data.nodc.noaa.gov/coris/library/NOAA/CRCP/project/20499/Amouli\\_Resiliency\\_Actions\\_and\\_Responses.pdf](http://data.nodc.noaa.gov/coris/library/NOAA/CRCP/project/20499/Amouli_Resiliency_Actions_and_Responses.pdf)

Climate Change Action Plan for the Florida Reef System 2010-2015

<http://frrp.org/SLR%20documents/FL%20Reef%20Action%20Plan-WEB.pdf>

Climate Change Vulnerability Assessment for the Island of Saipan, CNMI

[https://dl.dropboxusercontent.com/u/95270594/Saipan\\_VA\\_FULL.pdf](https://dl.dropboxusercontent.com/u/95270594/Saipan_VA_FULL.pdf)

Climate-smart Conservation: Putting Adaptation Principles into Practice

[http://www.nwf.org/pdf/Climate-Smart-Conservation/NWF-Climate-Smart-Conservation\\_5-08-14.pdf](http://www.nwf.org/pdf/Climate-Smart-Conservation/NWF-Climate-Smart-Conservation_5-08-14.pdf)

Coral Reef Conservation Act

<http://coralreef.noaa.gov/aboutcrpc/strategy/reauthorization/>

Coral Reef Conservation Program International Strategy 2010-2015

[http://coralreef.noaa.gov/aboutcrpc/strategy/currentgoals/resources/intl\\_strategy.pdf](http://coralreef.noaa.gov/aboutcrpc/strategy/currentgoals/resources/intl_strategy.pdf)

Coral Reef Conservation Program Goals and Objectives 2010-2015

[http://coralreef.noaa.gov/aboutcrpc/strategy/currentgoals/resources/3threats\\_go.pdf](http://coralreef.noaa.gov/aboutcrpc/strategy/currentgoals/resources/3threats_go.pdf)

Coral Program Fishing Impacts Implementation Plan: 2013-2017

<http://data.nodc.noaa.gov/coris/library/NOAA/CRCP/project/196/Final-CRCP-Fishing-Impacts-Implementation-Plan.pdf>

Coral Program Land-based Sources of Pollution Implementation Plan: 2011-2015

[http://coralreef.noaa.gov/aboutcrpc/resources/pdfs/crpc\\_implementation\\_plan.pdf](http://coralreef.noaa.gov/aboutcrpc/resources/pdfs/crpc_implementation_plan.pdf)

Coral Program MPA Management Assessment Checklist

[http://data.nodc.noaa.gov/coris/library/NOAA/CRCP/other/other\\_crpc\\_publications/mpa\\_checklist/crpc\\_mpa\\_management\\_assessment\\_checklist.pdf](http://data.nodc.noaa.gov/coris/library/NOAA/CRCP/other/other_crpc_publications/mpa_checklist/crpc_mpa_management_assessment_checklist.pdf)

Coral Program National Communications, Education and Outreach Strategy: 2010-2015

<http://coralreef.noaa.gov/aboutcrctp/resources/pdfs/crcpcomsedustrategy.pdf>

Coral Program National Coral Reef Monitoring Plan

[http://data.nodc.noaa.gov/coris/library/NOAA/CRCP/monitoring/noaa\\_crctp\\_national\\_coral\\_reef\\_monitoring\\_plan\\_2014.pdf](http://data.nodc.noaa.gov/coris/library/NOAA/CRCP/monitoring/noaa_crctp_national_coral_reef_monitoring_plan_2014.pdf)

Coral Program Ocean Acidification Science Plan 2012-2016

<http://www.oceanacidification.noaa.gov/sites/OceansAcidification/Documents/CoralProgram%20Ocean%20Acidification%20Science%20Plan%202012-2016%20FINAL.pdf>

Coral Program Performance Measures Manual

[http://coralreef.noaa.gov/aboutcrctp/howwework/resources/crcp\\_perf-measures.pdf](http://coralreef.noaa.gov/aboutcrctp/howwework/resources/crcp_perf-measures.pdf)

Coral Program Social Science Strategy: 2010-2015

[ftp://ftp.nodc.noaa.gov/pub/data.nodc/coris/library/NOAA/CRCP/project/20448/CRCP\\_Social\\_Science\\_Strategy.pdf](ftp://ftp.nodc.noaa.gov/pub/data.nodc/coris/library/NOAA/CRCP/project/20448/CRCP_Social_Science_Strategy.pdf)

Executive Order – Preparing the United States for the Impacts of Climate Change

<http://www.whitehouse.gov/the-press-office/2013/11/01/executive-order-preparing-united-states-impacts-climate-change>

Management Priority Setting Documents for US jurisdictions

<http://coralreef.noaa.gov/aboutcrctp/strategy/reprioritization/managementpriorities/welcome.html#background><http://coralreef.noaa.gov/aboutcrctp/strategy/reprioritization/managementpriorities/welcome.html>

National Fish Wildlife and Plants Climate Adaptation Strategy

<http://www.wildlifeadaptationstrategy.gov/pdf/NFWPCAS-Final.pdf>

NOAA Caribbean Strategy

<http://www.regions.noaa.gov/secar/highlights/draft-noaa-caribbean-strategy-available-for-reveiw-and-comment/>

NOAA in the Caribbean

<http://www.regions.noaa.gov/secar/index.php/noaa-in-the-caribbean/>

NOAA Next Generation Strategic Plan [http://www.ppi.noaa.gov/wp-content/uploads/NOAA\\_NGSP.pdf](http://www.ppi.noaa.gov/wp-content/uploads/NOAA_NGSP.pdf)

Proposal to List 66 Reef-building Coral Species under the Endangered Species Act (NOAA Information Page)

<http://www.nmfs.noaa.gov/stories/2012/11/82corals.html>

President's Climate Action Plan

[http://thehill.com/images/stories/news/2013/06\\_june/25/obama-climate-plan.pdf](http://thehill.com/images/stories/news/2013/06_june/25/obama-climate-plan.pdf)

Puerto Rico's State of the Climate 2010-2013: Assessing Vulnerabilities in a Changing Climate

<http://www.drna.gobierno.pr/oficinas/arn/recursosvivos/costasreservasrefugios/pmzc/prccc/prccc>

Southeast Conservation Adaptation Strategy

<https://griffingroups.com/groups/profile/1500/secas>

The Reef Managers Guide to Coral Bleaching

[http://www.coris.noaa.gov/activities/reef\\_managers\\_guide/](http://www.coris.noaa.gov/activities/reef_managers_guide/)

United States Department of Commerce Strategic Sustainability Performance Plan

<http://www.osec.doc.gov/oas/Documents/OSEEP/Annual%20Rpts%20&%20Scrcards/DOC%20012%20SSPP%20Public%20Release%20FINAL%202-4-2013.pdf>

US Coral Reef Task Force Resolution 28.2: Coral Reefs and Climate Change Renewed Call to Action <http://www.coralreef.gov/meeting28/pdf/climatechange282.pdf>

US National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes (National Ocean Policy) <http://www.whitehouse.gov/the-press-office/executive-order-stewardship-ocean-our-coasts-and-great-lakes>

and Draft National Ocean Policy Implementation Plan <http://www.whitehouse.gov/administration/eop/oceans/implementationplan>

## Appendix 3: Coral Program Climate Goal Prioritization and Analysis

CRCP Goals and Objectives	Contribution to Funding Priorities			Progress (CRCP and Partners Representative Activities)	Next Steps (CRCP and Partners) (numbering does <u>not</u> indicate an order of importance)
	1	2	3		
<b>GOAL 1: Increase resilience to climate change and ocean acidification through effective management.</b>					
<p><b>Objective 1.1</b> Provide training opportunities to coral reef managers to increase their understanding of the impacts of climate change, the predicted range of changes that will occur, including the uncertainty associated with those predictions, and management strategies that address the impacts of climate change. <i>Managers and policy makers need the knowledge and capacity to respond to changing conditions and to take effective actions to increase resilience.</i></p>				<p>1. Reef Resilience and Climate Change trainings were completed with each jurisdiction before the G&amp;Os were released. Reef Resilience Training of Trainer Workshops (ToT) were held in the Caribbean, Pacific, SE Asia and the Western Indian Ocean (TNC). TNC has developed an online training course, which has been widely used and is now going through updates.</p> <p>2. Guidance and training has been developed and delivered for Micronesia and the Coral Triangle regions on community-based vulnerability assessments and local early action planning (CCA-LEAP). Adapting to Climate Change Trainings have been held in CNMI, American Samoa and throughout Micronesia through PIMPAC/Micronesia Conservation Trust (MCT)/TNC. Guam training scheduled for FY14.</p> <p>3. NOAA ONMS International Program have done climate and MPA related trainings in American Samoa and many international locations.</p>	<p>1. Build training components to current US EPA/NOAA/USCRTF Coral Adaptation Project as it matures.</p> <p>2. Continue to work towards a successor to the Reef Manager's Guide to Coral Bleaching and training program focused on more proactive guidance for managers with key partners.</p> <p>3. Explore the use of scenario planning as a tool for managers to envision a range of possible futures and embrace uncertainty in management decisions and develop guidance to assist managers in this exercise.</p> <p>5. Complete an Adapting to Climate Change training in Hawai'i.</p> <p>6. Promote the transfer of lessons learned and tools that have been successfully applied cross-basin (Pacific – Atlantic/Caribbean).</p> <p>7. Investigate the need for application of curriculum from USCTI Support Program and modules being developed as part of the USAID-NOAA PSIDS project on coastal resource management domestically and implement if needed.</p> <p>8. Ensure our partners are aware of training opportunities across NOAA.</p> <p>9. Meet the continued need for training on climate change basics and communicating climate change to stakeholders, policy makers, etc.</p> <p>10. Support TNC and other partners in the updating, development and delivery of in-person and online trainings related to coral reef ecosystems and climate change. Work with TNC to determine the next phase of the Reef Resilience and Climate Change training workshop series.</p>
<p><b>Objective 1.2</b> Develop and implement effective local communication plans that provide relevant and up-to-date information on climate change and ocean acidification to stakeholders. <i>This includes mechanisms to provide needed information to local managers to help them develop strong stakeholder support for local actions, including more effective regulation to increase resilience, and support for local, national, and global efforts to reduce greenhouse gases.</i></p>				<p>1. Initial work on "coral reef manager's dashboard" for locations in the Pacific and in the Caribbean with the NOAA Regional Climate Service Directors.</p> <p>2. Resurrected the USCRTF Education &amp; Outreach working group with support of the Climate Change Working Group.</p> <p>3. PIMPAC/MCT Community-based Adapting to a Changing Climate Outreach Toolkit training being offered in Micronesia.</p> <p>4. BleachWatch, Eyes on the Reef, and other programs engage community members through communication and citizen monitoring effects.</p>	<p>1. Partner with PaCIS, the RCSDs, PICCC, CLCC and others to deliver climate products and services to CRCP management partners and stakeholders meeting unique timing, format and content requirements</p> <p>2. Encourage all climate-related projects to include communication components with management partners to support their outreach to stakeholders.</p> <p>3. Share existing climate communication resources that "make the case" for climate change, ecosystem-based management, adaptation and increasing resilience including case studies.</p> <p>4. Explore the need to for adapting the PIMPAC/MCT Community-based Adapting to a Changing Climate Outreach Toolkit for other locations.</p> <p>5. Explore the use of scenarios for climate change adaptation planning efforts to engage stakeholders and communicate the range of potential climate futures.</p>

<p><b>Objective 1.3</b> Develop and implement climate related crisis response plans in all US coral reef jurisdictions to provide a framework for early warning, communication, monitoring, research, and management response to protect coral reef ecosystems from acute events such as coral bleaching, infectious disease outbreaks, tropical storm impacts, and major rainfall events. <i>Monitoring change, communicating with stakeholders, and management actions are all needed and require advance planning and strong local support.</i></p>	○	●	◐	<ol style="list-style-type: none"> <li>1. Florida, Hawaii (Main and PMNM), USVI completed; Guam, CNMI, American Samoa and Puerto Rico drafted and being used. Jurisdictions have used plans and draft plans to guide response to recent bleaching and crown of thorn outbreak events.</li> <li>2. The Amouli Village Resilience Plan (American Samoa) is being implemented.</li> <li>3. The 2010-2015 Climate Change Action Plan for the Florida Reef System is being implemented.</li> <li>4. Papahānaumokuākea Marine National Monument Climate Action Plan is in draft.</li> </ol>	<ol style="list-style-type: none"> <li>1. Support jurisdictions in implementing their response plans, especially during bleaching, disease, grounding, and invasive species outbreak events.</li> <li>2. Support activities identified by jurisdictions and communities in climate action and adaptation plans to reduce the vulnerability of coral reef ecosystems and dependent communities.</li> </ol>
<p><b>Objective 1.4</b> Working with jurisdictions, assess how to improve regulatory and management frameworks to facilitate adaptation to climate change. <i>Many resource managers are limited in their ability to address climate change because of existing regulation and legislation. Changing this necessitates enhancing the legal framework and strengthening the political will to act. Actions will be taken to enable policy makers to identify and reduce impediments and enhance constructive approaches to increase resilience of coral reef ecosystems to climate change and ocean acidification.</i></p>	○	○	◐	<ol style="list-style-type: none"> <li>1. The Climate Adaptation Project is applying national adaptation frameworks/guidance to the coral reef manager situation (US EPA/NOAA/USCRTF).</li> <li>2. Jurisdictional capacity assessments may provide insight on current regulations and legislation as it pertains to coastal management issues and maybe a starting point in some places.</li> <li>3. Work by NCCOS to develop a comprehensive regional decision-support framework to prioritize coral reefs for conservation in USVI is geared towards supporting managers with permitting decisions.</li> <li>4. Work in USVI and in CNMI on resilience assessments will also result in materials for managers to use to prioritize, justify &amp; communicate the need for management actions.</li> </ol>	<ol style="list-style-type: none"> <li>1. Support jurisdictions interested in this analysis with placing interns or fellows to work on this issue for Coastal Management and Climate Change and consider partnering with other parts of the NOAA to do so.</li> <li>2. Engage the National Sea Grant Law Center, the University of Hawai'i Center for Island Climate Adaptation and Policy, and other partners to support jurisdictions in policy analysis.</li> <li>2. Use results of CRCP jurisdictional capacity assessments to target identified capacity gaps and associated recommendations that would address climate change resilience and adaptation needs.</li> </ol>
<p><b>Objective 1.5</b> In collaboration with reef managers, develop, test, and apply the best available science to provide new and innovative tools that to help managers prepare and respond to climate change and ocean acidification related impacts. <i>To take actions, managers need high quality warnings and field-tested responses. Through collaborations between managers and scientists, new products specifically geared to enhance management action will be developed and tested.</i></p>	●	●	○	<ol style="list-style-type: none"> <li>1. Reef resilience projects in CNMI, the Pacific Basin, and USVI through PIRO, PIFCS, NCCOS, CRW, etc. are all working with managers to develop an analytical framework to ensure resilience to climate change is included in coral reef management.</li> <li>2. Guidance and training has been developed and implemented for Micronesia and the Coral Triangle regions on community-based vulnerability assessments and local early action planning (CCA-LEAP).</li> <li>3. Guidance has been developed and trainings completed for the Coral Triangle Region on Ecosystem-based Approaches to Fisheries Management with a companion Incorporating Climate and Ocean Change in EAFM Guide.</li> <li>4. Integrated Marine Protected Area Climate Tools (IMPACT) has done a needs assessment in FL of managers climate information needs.</li> </ol>	<ol style="list-style-type: none"> <li>1. Hold in-person meeting of PIs and key partners working on resilience assessments, frameworks and data/products to inform assessments and ensure the results of this work is “translated” into products and information useful to managers.</li> <li>2. Monitor resilience funded project progress, application of information to management decisions, consider assessments in new geographies, and continue to look at ways for NOAA/CRCP data to be used to inform assessments.</li> <li>3. Collaborate with others doing resilience assessments (e.g. Ocean Tipping Points) to exchange lessons learned.</li> <li>4. Support the development of updated guidance for managers on reef resilience assessments based on field-testing results.</li> <li>5. Develop a successor to the Reef Manager’s Guide to Coral Bleaching focused on more proactive guidance for managers with key partners</li> <li>6. Contribute to efforts to operationalize resilience into management (GBRMPA, UQ, WCS, etc.)</li> <li>7. Work with partners to bring new and innovative tools developed in other areas back for domestic application such as the CTI tools and those developed by the GBRMPA through the Australian-Caribbean Collaboration on Coral Reefs.</li> <li>8. Work with our science centers and academic partners to apply science to develop and test interventions to prevent and respond to impacts.</li> </ol>
<p><b>GOAL 2: Identify, understand, and communicate climate risks and vulnerability of the US coral reef ecosystems, ecosystem services, and dependent human communities to climate change and ocean acidification.</b></p>					
<p><b>Objective 2.1</b> Characterize physical and chemical changes in coral</p>				<ol style="list-style-type: none"> <li>1. CRW, CRED, AOML, OAP, NCCOS and the Fisheries Science</li> </ol>	<ol style="list-style-type: none"> <li>1. Conduct baseline physical and chemical monitoring in accordance</li> </ol>

<p>reef environments by enhancing question-based monitoring to fill gaps in our current observations. This both establishes a baseline to assess climate change impacts on coral reef ecosystems and reveals changes through time.</p> <p><i>Managers will not be able to act without evidence of environmental changes that identify the extent of threats. While other parts of NOAA and the Federal government will monitor at large scales, monitoring changes within coral reef ecosystems likely will fall on the CRCP to implement.</i></p>				<p>Centers have done a great deal of work in the past.</p> <ol style="list-style-type: none"> <li>2. Many federal, state/territorial, and academic partners are also contributing to this objective.</li> <li>3. Priority geographies have been established in each jurisdiction and NCRMP now defines the programs national status and trends monitoring including climate.</li> <li>4. The Ocean Acidification Test-bed provides platform for OA monitoring and ecosystem response research.</li> <li>5. CoRTAD provides historical climatological record of satellite SST.</li> </ol>	<p>to NCRMP.</p> <ol style="list-style-type: none"> <li>2. Coordinate all of our ocean acidification monitoring with the NOAA Ocean Acidification Program and in accordance with the CRCP Ocean Acidification Science Plan.</li> <li>3. Support CoRTAD as the CRCPs climatological data record for satellite SST.</li> <li>4. Work with other internal and external partners (federal, territorial, and academic) to be informed of available monitoring data that partners may be able to access and use.</li> <li>5. Work with jurisdictional partners to support management-driven, question based monitoring needed to inform management decisions.</li> </ol>
<p><b>Objective 2.2</b> Characterize the responses of coral reef ecosystems and their related components to climate change and ocean acidification to separate impacts from climate change and ocean acidification from impacts of other environmental threats and to test the effectiveness of management actions.</p> <p><i>Detailed observations of organismal and ecosystem changes are necessary to separate impacts from climate change and ocean acidification from other environmental threats. Such field observations are essential to understanding ongoing threats and to test effectiveness of management actions.</i></p>				<ol style="list-style-type: none"> <li>1. CRW, CRED, AOML, OAP, NCCOS and the Fisheries Science Centers have done a great deal of work in the past.</li> <li>2. Many federal, state/territorial, and academic partners are also contributing to this objective.</li> <li>3. SEFSC, CRED, &amp; CRW work to understand coral disease occurrence and interactions with climate change.</li> <li>4. SEFSC work to evaluate the impacts of climate change and ocean acidification on early life stages of <i>Acropora</i> in the Caribbean.</li> <li>5. Ocean Acidification Test-bed provides platform for OA monitoring and ecosystem response research.</li> <li>6. AOML work in FL is modeling reef process response to ocean acidification stress and identifies resilient and susceptible reef habitats.</li> </ol>	<ol style="list-style-type: none"> <li>1. Work with OAP to encourage process related studies at the Ocean Acidification Test-bed Locations from internal and external partners</li> <li>2. Work with our science centers and academic partners, as well as new partners such and the LCCs and DOI climate science centers to fulfill knowledge gaps in ecosystem response to climate change.</li> <li>3. Work with other internal and external partners (federal, territorial, and academic) to be informed of available monitoring data that partners may be able to access and use.</li> <li>8. Work with our science centers and academic partners to apply science to better understand the causes of change in organisms and ecosystems.</li> </ol>
<p><b>Objective 2.3</b> Characterize socioeconomic effects of climate change impacts on coral reef ecosystems to identify vulnerable reef-dependent human communities and understand the impacts to these communities.</p> <p><i>We will both develop our ability to forecast impacts of climate change on human systems and to monitor impacts as they occur. By understanding how climate change impacts influence human systems, we will better understand the cost of action and inaction to mitigate greenhouse gases and adapt to impacts.</i></p>				<ol style="list-style-type: none"> <li>1. Economic valuation studies have been done in all 7 jurisdictions over the last 12 years. Questions pertaining to knowledge, perception and attitude and observed changes due to climate change are included in the bank of survey questions for OMB clearance and the socioeconomic monitoring portion of NCRMP also includes climate related indicators.</li> <li>2. The Coral Program is involved in an effort of the National Socio-Environmental Synthesis Center to look at the socioeconomic impacts of ocean acidification on shellfish and coral reefs.</li> </ol>	<ol style="list-style-type: none"> <li>1. Apply the appropriate SocMon protocols with the climate change indicators in communities within the jurisdictions and incorporate that information into management decision-making.</li> <li>2. Work with our science centers and academic partners, as well as new partners such as the LCCs and DOI climate science centers to fulfill knowledge gaps concerning the socioeconomic effects of climate change and ocean acidification impacts to coral reefs.</li> <li>3. Work with other internal and external partners (federal, territorial, and academic) to be informed of available monitoring data that partners may be able to access and provide guidance on how best to incorporate that information into management.</li> </ol>
<p><b>Objective 2.4</b> Promote conservation of coral reef ecosystems through identification of areas that are potentially resilient to climate change and vulnerable areas where actions are likely to increase resilience. Encourage and promote management actions necessary to avoid or minimize impacts and spread risk due to climate change and ocean acidification.</p> <p><i>It is not enough to observe the changes in coral reef ecosystems in response to climate change. The CRCP must provide options to local managers to respond and improve the ability of coral reef ecosystems to weather these changes. The CRCP will establish criteria through which managers can evaluate the potential vulnerability and resilience of coral reef ecosystems to climate change and ocean acidification, use the monitoring discussed above to identify resilient and vulnerable sites, and recommend the best course of action to maximize resilience in coral reefs under their jurisdiction. Sites will be given priority for action at reefs that are</i></p>				<ol style="list-style-type: none"> <li>1. Reef resilience projects in CNMI, the Pacific Basin, and USVI through PIRO, PIFSC, NCCOS, CRW, etc. are all working with managers to develop an analytical framework to ensure resilience to climate change is included in coral reef management.</li> <li>2. Reef Resilience Assessments have been completed in parts of CNMI, Palau and Indonesia through partner funding (TNC, USGS, etc).</li> <li>3. AOML published work showing that coral reefs downstream of seagrass beds may serve as refugia to ocean acidification, an important first step towards understanding natural CO<sub>2</sub> sequestration mechanisms that may create differing spatial and temporal risk of coral reefs to ocean acidification.</li> </ol>	<ol style="list-style-type: none"> <li>1. Develop guidance beyond the scientific paper based on the field-testing of the 11 indicators identified in McClanahan et al, for reef managers who want to do resilience assessments.</li> <li>2. Collaborate with others doing resilience assessments (e.g. Ocean Tipping Points) to exchange lessons learned.</li> <li>3. Complete assessments of reef resilience in each jurisdiction with local management entities if appropriate.</li> <li>4. Use the resilience assessments to inform ESA processes like critical habitat designation and developing recovery plans.</li> </ol>

<p><i>especially resilient or, if especially vulnerable, where threats to resilience are believed to be most manageable.</i></p>					
<p><b>Objective 2.5</b> Provide and communicate regular national comprehensive risk assessments regarding the threat of climate change and ocean acidification to coral reefs and dependent human communities through relevant, existing reports such as local, national, and global reef status reports and IPCC assessments. <i>Information on climate change and ocean acidification and their impacts will identify reef areas most at risk and communicate the need to mitigate climate change. Assessments of risk to coral reefs are needed in such reports (e.g., State of Coral Reef Ecosystems of the US, Status of Coral Reefs of the World, and IPCC Assessment Reports, etc.) to support local actions to enhance reef resilience and to engender support for local, national, and global efforts to reduce greenhouse gases.</i></p>	●	●	●	<ol style="list-style-type: none"> <li>1. Dunne and Lamkin projects may contribute to IPCC assessments beyond AR5.</li> <li>2. Contributed to Reefs at Risk Revisited and Reefs at Risk Revisited Coral Triangle.</li> <li>3. Contributed to the Pacific Islands Regional Climate Assessment and the National Climate Assessment.</li> <li>4. PICCC funded “Integrating detailed assessments of climate threats on Pacific coral reefs and responses of traditional Hawaiian communities into management planning” – results published in Nature Climate Change, based on IPCC AR5 and RCP experiments with interactive management tools and are served on CRW website.</li> </ol>	<ol style="list-style-type: none"> <li>1. The program has funded the science and modeling, but these results need to be translated into a format that is useful to coral reef managers – our next step should be to ensure that the coral related modeling &amp; projection results are in the correct format and part of a decision support tool.</li> </ol>
<p><b>GOAL 3: Enhance strategic management of coral reef ecosystems through the improved and applied understanding, forecasts and projections of climate change and ocean acidification impacts.</b></p>					
<p><b>Objective 3.1</b> Collaborate with climate modeling groups to assess and advise development of physical and chemical models at spatial and temporal scales appropriate to inform management decisions. <i>This is necessary to assure that the output of climate models provide the necessary input to assessments of the response of coral reef ecosystems and dependent human communities.</i></p>	◐	◐	○	<ol style="list-style-type: none"> <li>1. Projects through GFDL, SEFSC, and PICCC have used IPCC AR5 models and RCP trajectories to downscale global climate models and focus on reef specific parameters and metrics.</li> <li>2. There are downscaling efforts that may be relevant to coral reef managers in both the Caribbean and Pacific basins funded through the LCCs, academic institutions and other partners.</li> <li>3. CRW partners with the NWS Climate Prediction Center to deliver seasonal forecasts of coral bleaching conditions.</li> <li>4. AOML is developing a new ocean acidification product suite that provides monthly maps of aragonite saturation state for the Caribbean sea.</li> <li>5. AOML recently published updated global projections for bleaching and ocean acidification threats to coral reefs based on ensembles of IPCC AR5 climate models using the new Representative Concentration Pathway experiments.</li> </ol>	<ol style="list-style-type: none"> <li>1. Translate the science and modeling the program has funded into a format that is useful to coral reef managers.</li> <li>2. Ensure that the program and partners are aware of relevant downscaling exercises that could be used to inform management action.</li> <li>3. Ensure that the program and partners are aware of guidance and training on developing and using scenarios in natural resource management.</li> </ol>
<p><b>Objective 3.2</b> Through process studies and modeling, develop integrated impact models of changes in coral reef ecosystems in response to the physical and chemical processes associated with climate change and ocean acidification, and the interactions of these processes with local stressors. <i>Management and policy decisions on climate change and ocean acidification require accurate, meaningful assessments of the threats to coral reef ecosystems. This will require new efforts to develop integrated models and improvements in our understanding of fundamental responses of organisms and ecosystem processes to build these models. Further improvements of our understanding of organismal to ecosystem responses to these stressors are needed to assure that these impact projections are accurate and meaningful.</i></p>	◐	◐	○	<ol style="list-style-type: none"> <li>1. Projects funded through GFDL and SEFSC have used IPCC AR5 models and RCP trajectories to project coral bleaching frequency, coral cover, and impacts of potential changing ocean currents on connectivity and loss of reef habitat on fisheries.</li> <li>2. Current literature includes studies on synergistic effect of water quality and thermal stress, etc.</li> </ol>	<ol style="list-style-type: none"> <li>1. Ensure research community results on ecosystem response to climate change and ocean acidification are communicated to management partners.</li> <li>2. Build partnerships with the research community and academia to help inform coral reef ecosystem related work.</li> <li>3. W with the OAP to continue to fund ocean acidification related research.</li> </ol>
<p><b>Objective 3.3</b> Forecast and project climate change and ocean acidification related impacts on reef-dependent social and economic systems. Coupling of physical, chemical, ecosystem, and socioeconomic models will be required to project future impacts.</p>	◐	◐	○		<ol style="list-style-type: none"> <li>1. Focus effort in working with partners who are doing this work to ensure the outputs are useful and delivered to managers.</li> </ol>

<p><b>Objective 3.4</b> Translate climate forecasts and projections into relevant and useable products for improved coral reef ecosystem management and decision-making. <i>The management community must be involved to assure that model results address management needs and are communicated in ways that managers and decision-makers can use them.</i></p>	●	●	●	<p>1. CRW and the work funded through PICCC deliver deliver forecasts and projections through products and decision-support-tools for managers.</p>	<p>1. Translate the science and modeling the program has funded into a format that is useful to coral reef managers 2. Ensure that the program and partners are aware of relevant downscaling exercises that could be used to inform management action.</p>
<p><b>GOAL 4: Support management efforts to increase survivorship of coral reef species and enhance reef resilience by evaluating and implementing promising interventions strategies that directly reduce climate change and ocean acidification impacts.</b></p>					
<p><b>Objective 4.1</b> Facilitate the identification, development, and testing of intervention measures to reduce stress or impacts from climate change and ocean acidification on coral reef ecosystems in field settings. <i>Through careful testing, potential intervention measures can be evaluated for their applicability in real-world settings, moving ideas from the laboratory to field tests. Testing and evaluation will be required before many managers will consider implementing intervention measures. Conversely, managers are key to identifying appropriate field settings to evaluate new techniques.</i></p>	○	○	○	<p>1. AOML's work in the Florida Keys identified ocean acidification refugia created by seagrass carbon sequestration. The use of seagrasses as CO<sub>2</sub> scrubbers is now being evaluated for oyster hatcheries. This showed that careful management of ecosystems that are adjacent and linked to coral reefs may promote resilience from ocean acidification 2. Partner organizations such as PICCC have funded work in American Samoa through The Climate Foundation that investigates options to cool reefs during thermal stress events.</p>	<p>Given the levels of funds the CRCP has available for Climate Change and OA related projects, there is unlikely to be funds to dedicate to this work directly. Opportunities to work with through other mechanism (grants) or through partnerships with other agencies (NSF) and the academic community to encourage such work should be fostered. The Coral Program recognizes that there is a need develop and apply science to respond to impacts. For example when a thermal bleaching event happens, what can we do to mitigation coral and other ecosystem disturbance and death?), and should work with partners to develop and test such interventions, both preventative and responsive.</p>
<p><b>Objective 4.2</b> Work with managers to provide objective tools to evaluate the effectiveness, applicability, and feasibility as well as the potential negative impacts of intervention measures (i.e. develop an intervention toolkit). <i>Each coral reef ecosystem is as unique as is its management setting. Test of intervention measures will be evaluated and provided to managers for consideration at their sites. By equipping and training resource managers on potential intervention measures, managers can make wise decisions on the feasibility of implementation.</i></p>	○	○	○		
<p><b>Objective 4.3</b> Support implementation and monitoring of promising intervention measures to reduce the impact of climate change and ocean acidification on coral reef ecosystems and evaluate the success of intervention measures (e.g. shading, pumping in cool water, local reduction of acidification, etc.). <i>Most management agencies lack the financial and technical resources to implement intervention measures on their own. High priority sites will be matched with high-potential intervention methods to reduce the impact of climate change and ocean acidification locally. Intervention measures will be considered for inclusion in the suite of actions taken in areas potentially resilient to climate change.</i></p>	○	○	○		