



NOAA
CORAL REEF
CONSERVATION PROGRAM



CORAL REEF CONSERVATION PROGRAM

GOALS & OBJECTIVES

2010 - 2015



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NOAA Coral Reef Conservation Program. 2009. NOAA Coral Reef Conservation Program Goals & Objectives 2010-2015. Silver Spring, MD: NOAA.

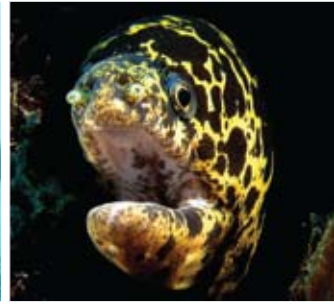
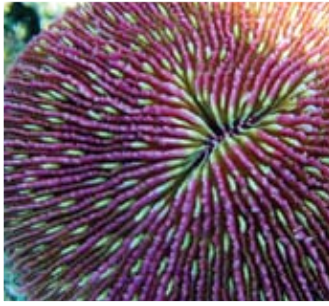
The NOAA Coral Reef Conservation Program would like to thank the CRCP threat-based and international working groups, as well as those who provided input during the public comment period, for their contributions. The commitment, time, and effort brought to this process is greatly appreciated. These goals and objectives will play an integral part in helping chart the future course of the CRCP.

Special thanks to Zhe Liu for graphic design and Lauren Chhay for photo support.

An underwater panorama of coral (*Acropora spp.*) in Chuuk Lagoon, Federated States of Micronesia.

Photo Credit: Dave Burdick





GOALS OUTLINE

CLIMATE CHANGE IMPACTS

- Increase coral reef resilience to climate change and ocean acidification through effective management strategies.
- Identify, understand, and communicate risks and vulnerability of U.S. coral reef ecosystems, ecosystem services, and dependent human communities to climate change and ocean acidification.
- Enhance strategic management of coral reef ecosystems through improved and applied understanding, forecasts, and projections of climate change and ocean acidification 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.

FISHING IMPACTS

- Increase the abundance and average size of key coral reef fishery species to protect trophic structure and biodiversity and improve coral reef ecosystem condition.
- Support effective implementation and management of marine protected areas (MPAs) and ecological networks of MPAs that protect key coral reef ecosystem components and functions.
- Increase stakeholder engagement and capacity to improve local compliance with and enforcement of fisheries management regulations that further coral reef ecosystem conservation.
- Utilize locally relevant education and communication strategies to increase public and policy maker understanding of fishing impacts in coral reef ecosystems and support for effective management options.

IMPACTS FROM LAND-BASED SOURCES OF POLLUTION

- Reduce pollutant loading from watersheds to priority coral reef ecosystems.
- Promote in-water management activities to restore priority coral reef ecosystems that have been adversely impacted by accumulated sediments, nutrients, and algae.
- Build and sustain management capacity at the local level through local, state, regional, and federal coordination of financial, institutional, and human resources to reduce and prevent the impacts of land-based sources of pollution on coral reef ecosystems.

This colony of a star coral species provides the main structure of this portion of reef in the Florida Keys.
Photo credit: George Cathcart © 2007





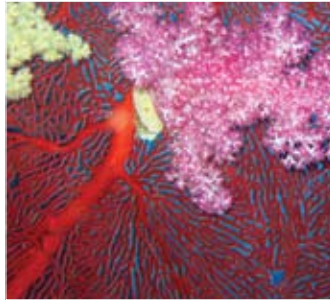
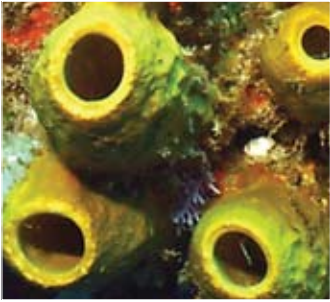
INTRODUCTION

Coral Reef Ecosystems, Valuable Yet Threatened

Healthy coral reefs are among the most biologically diverse and economically valuable ecosystems on earth, providing hundreds of billions of dollars in food, jobs, recreational opportunities, coastal protection, and other important services. For example, Hawai'i's coral reefs, when combining recreational, amenity, fishery, and biodiversity values, were estimated to have direct economic benefits of \$360 million/year (Cesar et al, 2002). Yet they are threatened by an increasing array of impacts – primarily from global climate change, unsustainable fishing, and pollution. According to the *Status of Coral Reefs of the World: 2008* (Wilkinson, 2008), 19 percent of the world's reefs are effectively lost, 15 percent are seriously threatened with loss in the next 10-20 years, and 20 percent are under threat of loss in the next 20-40 years. The decline and loss of coral reef ecosystems have significant social, cultural, economic, and ecological impacts on people and communities in the United States and around the world. However, with effective leadership and management, healthy, resilient reef ecosystems can continue to provide these valuable services to current and future generations.

NOAA Coral Reef Conservation Program

NOAA's Coral Reef Conservation Program (CRCP) was established in 2000 to help fulfill NOAA's responsibilities under the Coral Reef Conservation Act (CRCA) and Presidential Executive Order 13089 on Coral Reef Protection. The mission of the CRCP is to protect, conserve, and restore coral reef resources by maintaining healthy ecosystem function. The primary objective of the CRCP is to address strategic coral reef management needs in a targeted, cost-effective and efficient manner. To make the most of limited resources and to have the largest impact to reverse general declines in coral reef health, the CRCP is narrowing the focus of its U.S. domestic program and shifting allocation of CRCP resources to taking on-the-ground and in-the-water action. The CRCP is also expanding its international presence by becoming more actively involved in coral conservation efforts primarily in the Pacific, the Coral Triangle region, and the Caribbean (summarized in a separate document titled *NOAA Coral Reef Conservation Program International Strategy 2010-2015*). To narrow its range of activities, the CRCP will emphasize efforts to understand and address the top three recognized global threats to coral reef ecosystems: climate change impacts, fishing impacts, and impacts from land-based sources of pollution.



Climate change impacts threaten coral reef ecosystems through increased mass coral bleaching and disease, sea level rise, and storm activity. Additionally, increasing atmospheric carbon dioxide has already begun to reduce calcification rates in reef-building and reef-associated organisms by altering sea water chemistry through decreases in pH (ocean acidification). In the long term, failure to address the impacts of rising temperatures and ocean acidification could make many other management efforts futile.

Fishing impacts in coral reef areas, when ecologically unsustainable, can lead to the depletion of key functional groups of reef species in many locations, with cascading impacts on coral reef habitats and associated species and ecosystems.

Impacts from land-based sources of pollution (e.g. agriculture, coastal development, road construction, and oil and chemical spills) on coral reef ecosystems include increased sedimentation, eutrophication, toxins, and pathogen introduction. These pollutants and related synergistic effects can cause disease and mortality in sensitive species, disrupt critical ecological functions, cause trophic structure and dynamics changes, and impede growth, reproduction, and larval settlement.

These threats are compounded by the increase in global population and demographic shifts toward coastal regions. This contributes to increased local pressure on coastal ecosystems with greater demands for food, recreation, tourism, and other resource needs, and increased global pressure on energy consumption and greenhouse gas emissions. The CRCP recognizes that a balance must be struck between resource conservation and consideration of human welfare.

Addressing the Three Priority Threats

The CRCP, in partnership with the coral reef management community, will address strategic

management needs and place increased emphasis on place-based management. The CRCP has engaged a community of experts to help identify the twenty-year strategic goals and five-year objectives the CRCP will work towards to effectively address each of the top three threats to coral reef ecosystems, both domestic and international. The CRCP is committed to continually refining its performance and efficiency measures to improve program effectiveness and better evaluate overall CRCP performance.

This document provides the NOAA CRCP strategic guidance on the program priorities for FY 2010-2015 and commits the CRCP



to work with other agencies and partners to facilitate implementation of these Goals and Objectives. These Goals and Objectives are not intended to commit other agencies or partners to implementing the identified actions; however, the CRCP cannot hope to accomplish its goals without partners.

Ecosystem-based Management: Integrating Across Threats in Specific Geographies

While the Goals and Objectives are organized into three distinct threats, the management of these and other threats cannot be separated when working in actual geographies. The implementation of the Goals and Objectives will be integrated into an ecosystem-based management approach in the jurisdictions. Within each threat, the Goals and Objectives identify a common need to select and work in priority coral reef areas to ensure a holistic and integrated

management approach to support healthy, resilient coral reef ecosystems. The priority areas, selected by each jurisdiction, might differ slightly due to the ultimate conservation strategy and goal. However the prioritization process will consider jurisdiction needs and priorities, will take other geographic-specific threats into account, and will allow for the integration of local and indigenous ecological knowledge, while also building upon the current foundation of science and management in each location. Many coral reef jurisdictions have already identified priority areas in need of increased management action and these locally identified areas will be integrated into the full scheme of priority areas the CRCP considers. The CRCP recognizes that effective management should not take a one-size-fits-all approach, but be based on the needs of the varying ecosystems and communities. The CRCP, therefore, is working in partnership with the coral reef managers in each jurisdiction to develop specific management priorities. These management priority documents will be a critical part of CRCP decision-making.



For example: the placement of a marine managed area can effectively address the impacts of fishing and/or conserve an area potentially resilient to climate change, coupled with efforts to address land-based sources of pollution from adjacent and associated watersheds.

For example: actions to abate impacts of fishing and land-based sources of pollution can make coral reefs more resilient to climate change; more resilient coral reefs support intact fish resources that maintain ecosystem function and provide food resources for humans; and resilient coral reefs are more able to snap back to health after land-based pollutants are reduced.

A Multidisciplinary Integrated Approach

Implementation of the Goals and Objectives calls for a multidisciplinary approach to coral reef conservation. The CRCP will continue to monitor and research coral reef ecosystems because increased understanding is necessary for improved management. Understanding the biological and physical aspects of these complex ecosystems is critical for successful management; however, it is not the complete picture. People and communities rely on these resources so it is often the social, economic, or political aspects of coral reef management that drive decisions. Thus the CRCP will seek to engage and actively involve communities in coral reef management.



The CRCP will increase its activities related to social science, education and outreach, and community engagement. To ensure

the biophysical science and socioeconomic information are being adequately considered, governance structures and processes must be well-functioning. Governments must work across agencies, public processes must be open and transparent, and sufficient capacity, both human and technical, must exist to achieve strong management. This multidisciplinary approach to conservation means the CRCP's work will include on-the-ground management actions, biophysical monitoring, applied research, modeling, socioeconomic research, community engagement, enforcement, education, outreach, and capacity building.

Building Local Capacity & Partnerships

Lack of capacity currently constrains local coral reef conservation success and must be addressed to enable management strategies to increase coral reef resilience. This lack of capacity includes staffing, facilities, funding, and technical expertise as well as legislative authority and enforcement. While new management actions are identified in

the following Goals and Objectives, existing tools such as watershed and coastal planning, water quality protection and marine zoning must be strengthened and applied more effectively. The CRCP recognizes that federal-local partnerships must be strengthened, particularly in the areas of communication, collaboration, and implementation of joint management actions. Federal support is needed to help finance local efforts, but also to ensure that sound scientific research and monitoring are maintained, and that results are understood and used by managers and decision-makers to inform policies and decisions for conservation of coral reef ecosystems.

Promoting an Effective Governance Framework

Coral reef ecosystems frequently span broad ranges of geographical and organizational jurisdictions thus, coordination across federal, state, and local governments and with non-governmental organizations is essential for designing and implementing effective management and conservation solutions. However, the existing legislative, regulatory, and institutional frameworks are often insufficient or fragmented and lack the coordination needed to effectively or coherently address the myriad issues facing coral reef ecosystems. For example, authority for coral reef ecosystem components (e.g. fish) and physical parameters (e.g. water quality) lie with a range of local, state, and federal entities, and these issues/ecosystem components are often considered independently of one another. In some cases, current frameworks discourage agencies from acting to include key threats such as climate change. The CRCP aims to work with our many partners to design, support, and implement effective regional and jurisdictional management schemes that consider coral reef ecosystems holistically and provide a foundation for better governance of our coral reef resources (ecological, social, and economic).



Enhancing Community Engagement and Understanding: Communication, Education, and Outreach

The CRCP recognizes the value of an informed and engaged public, empowered to act in partnership for coral reef conservation. The CRCP will expand our efforts to reach key target audiences and utilize new and innovative tools to increase awareness and stewardship of coral reef resources. The CRCP work in communication, outreach and education will expand upon current CRCP activities and will be an integral part of achieving the Goals and Objectives.

Supporting Baseline Observations and Monitoring

Each of the three threat-based strategies identify monitoring as a foundational need to ensure that the activities the CRCP conducts and funds are responsive to changes in both the ecosystems and in the needs of the communities dependent upon these ecosystems. For successful conservation of coral reef ecosystems, management must be responsive to changes in environmental, economic, and social conditions. The CRCP supports integrated, consistent, and comparable monitoring efforts across jurisdictions. This includes developing agreed upon metrics that enhance holistic assessment of coral reef ecosystem condition, coordinated across threats. The CRCP supports monitoring efforts to:

- Document the status of reef species of ecological and economic importance;
- Track and assess changes in reef communities in response to environmental stressors or human activities; and
- Evaluate the effectiveness of specific management strategies and identify actions for future adaptive responses.

The CRCP is engaged in a variety of data-rich efforts and will ensure that data acquisition, transmission, metadata, preservation, and dissemination are consistent throughout the CRCP, and that data collected will be integrated and interpreted to meet coral reef managers' information needs.

NOAA CRCP Process and Implementation

The development of the CRCP Goals and Objectives is one step in a multi-step process. This document does not constitute a stand-alone implementation plan. Using the Goals and Objectives as the keystone, the CRCP is engaged in concurrent efforts to assess jurisdictional governance and capacity gaps, improve performance measures, and develop an education, outreach, and communication strategy. This information will further inform what specific work needs to be done to accomplish the Goals and Objectives.



Implementation of the Goals and Objectives is an iterative process. While the Goals and Objectives are presented in a logical order, they must be addressed simultaneously given the immediacy of the need for action to prevent further degradation to coral reef ecosystems. Improving the knowledge base through science and monitoring current management actions are necessary, but the need for more information should not delay current actions. New information will feed back into the process to refine the actions that are taken and the objectives will be revisited by the CRCP over time to ensure the CRCP is continuing in the right direction.

Conclusion

The news about coral reef ecosystems is alarming. Rapid warming, accelerating pollution, and destructive fishing are decimating coral reefs faster than they can adapt for survival. Damaged and degraded coral reefs fail to provide the sustenance and coastal protection upon which humans depend. The situation calls for renewed urgency and priorities based on lessons learned with successful coral reef conservation efforts supporting and maintaining the overall economic benefits from coral reef ecosystems. NOAA's CRCP hopes that these Goals and Objectives will provide a rallying point and lay out a path to outcomes that conserve coral reef ecosystems for the future.



Mass bleaching events, like the 2006 event depicted here in the Keppel Islands, Great Barrier Reef, Australia, are a major threat to the health of coral reef ecosystems in the U.S. and around the world.

Photo credit: © Commonwealth of Australia





CLIMATE CHANGE IMPACTS STRATEGIC GOALS AND OBJECTIVES

Climate change and ocean acidification have been identified by many groups as the most important threat to coral reefs on a global basis. In 2007, the Intergovernmental Panel on Climate Change (IPCC) noted that the evidence is now “unequivocal” that the earth’s atmosphere and oceans are warming and concluded that these changes are primarily due to anthropogenic greenhouse gases, especially the accelerating increase in emissions of carbon dioxide (CO₂). While reducing CO₂ and other greenhouse gas emissions is vital to stabilize the climate in the long term, excess CO₂ already in the atmosphere has changed and will continue to change global climate throughout the next century. Global ocean temperature has risen by 0.74°C/1.3°F since the late 19th century causing more frequent and severe bleaching of corals around the world. At the current increasing rate of greenhouse gas emissions, a temperature rise of up to 4.0°C/7.2°F this century is a distinct possibility. These changes have already had deleterious impacts on coral reef ecosystems and will continue to affect coral reef

ecosystems globally over the coming century. At the same time, the ocean absorbs approximately one-third of the additional CO₂ generated every year by human activities, making the ocean more acidic (Caldeira and Wickett 2003, Sabine et al. 2004). The resulting change to ocean chemistry has important consequences for corals and other marine life, especially other important reef calcifiers. Warming seas and ocean acidification are already affecting reefs by causing mass coral bleaching events and slowing the growth of coral skeletons (Hoegh-Guldberg et al. 2007; De’ath et al. 2009). Bleaching and infectious disease outbreaks are likely to be more frequent and severe as temperatures rise, increasing coral mortality. Climate changes will have other impacts on marine systems such as sea level rise; altered frequency, intensity, and distribution of tropical storms; altered ocean circulation with its effects on larval connectivity and productivity; and others. All of these impacts will combine, often synergistically, to eliminate important ecosystem function and reduce global biodiversity.

We can improve the future of coral reefs, but doing so requires action now to reduce the lethal combination of climate change, ocean acidification, ecologically unsustainable fishing, and the damaging impacts from land-based sources of pollution (Marshall and Schuttenberg 2006). Immediate policy and management actions are required if tropical ecosystems are to withstand the impacts of climate change and ocean acidification. Three sets of actions are needed to protect coral reef ecosystems from the effects of climate change and ocean acidification.

- Reduce greenhouse gases. This requires reducing emissions and reducing accumulated greenhouse gases to avoid dangerous, irreversible climate change effects. While regulating emissions falls outside of NOAA's mandate, NOAA has a clear role to monitor climate change and ocean acidification, project their impacts on ecological and human systems, and develop ways to address these impacts that support local, national, and international policy. Unfortunately, we can expect at least another 1°C/1.8°F temperature rise within this century from the greenhouse gases already released. Therefore it is essential that we not only reduce emissions, but take urgent actions to reduce the impact of elevated greenhouse gases on coral reef ecosystems.
- Increase the resilience of coral reef ecosystems to climate change by reducing local stressors including land-based sources of pollution and ecologically unsustainable fishing. We need to identify and address those local stressors that will particularly reduce the ability of reefs to withstand future climate change and ocean acidification.
- Reduce the local impacts of climate change and ocean acidification on coral reefs to help corals and coral reefs increase their ability to survive as these global stressors increase.

These latter two sets of actions fall within NOAA's responsibilities and will help keep coral reef ecosystems intact until greenhouse gas levels are stabilized and reduced to sustainable levels. NOAA and its partners must redouble efforts to reduce local stressors, while monitoring and

evaluating their effectiveness at ameliorating the impact of global-scale stressors. In many cases, however, it will not be enough to reduce non-climate stressors, so we will need to take direct action to reduce the stress that climate change and ocean acidification have on reefs at local levels.

To address the problems of anthropogenic climate change and ocean acidification four goals have been identified to help coral reefs cope with climate change. These are:

- Increase coral reef resilience to climate change and ocean acidification through effective management strategies;
- Identify, understand, and communicate risks and vulnerability of U.S. coral reef ecosystems, ecosystem services, and dependent human communities to climate change and ocean acidification;
- Enhance strategic management of coral reef ecosystems through improved and applied understanding, forecasts, and projections of climate change and ocean acidification impacts; and
- 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.

These goals are presented in a logical sequence but must be addressed simultaneously. Various parts of NOAA and its many partners have made important strides toward monitoring, understanding, and predicting climate change, ocean acidification, and impacts of both on coral reef ecosystems. The CRCP will capitalize on existing efforts and build strong partnerships to reduce the impacts of climate change and ocean acidification on all coral reefs, including those in remote locations.



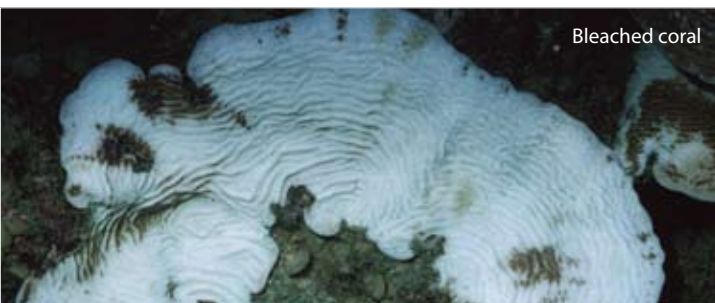
1 Climate Change Impacts Goal

Increase coral reef resilience to climate change and ocean acidification through effective management strategies.

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 cumulative impacts from ecologically unsustainable fishing, land-based sources of pollution, and habitat destruction associated with coastal development. These local stressors act in concert to reduce the resilience of coral reef ecosystems. While mitigating the rate of climate change will largely depend on redirecting national and international policies on greenhouse gas emissions, the ability for coral reefs to survive climate change requires enhancing resilience through local management actions. This approach to resilience underpins effective ecosystem-based management (Levin and Lubchenco 2008). We need to enhance local management to enable the

protection, marine zoning) must be improved and applied more effectively to enhance resilience to climate change. However, a lack of local capacity constrains local coral reef management success and this must be addressed to enable timely implementation of management strategies to increase coral reef resilience. Therefore, effectively communicating the clear link between coral reef conservation and human welfare is required to secure stakeholder and legislative support for strengthened and innovative management actions needed to save coral reefs.

This goal is organized around a comprehensive approach towards maximizing the resilience of coral reefs in U.S. jurisdictions. The objectives under this goal will support coral reef management success to build management capacity and strengthen governance and public support for immediate action to effectively reduce stressors known to weaken reef resilience; implement and evaluate existing and emerging tools to forecast climate change impacts and protect reefs by conferring resilience to impacts; develop place-based crisis response plans; eliminate or overcome regulatory barriers that currently inhibit action; and enable continual integration of scientific advances into applied management strategies. While ecosystem resilience reaches far beyond the issue of climate change, managing non-climate stressors is an important ‘no regrets’ approach to increase the resilience of coral reef ecosystems to the threats of



Bleached coral



Recovered coral

survival of coral reef ecosystems. Managers need greater support and new tools to protect coral reefs against climate change impacts while they continue to reduce non-climate stressors. New management actions to increase coral reef resilience to climate change must be identified and tested, while existing tools (e.g., watershed/coastal planning, water quality

climate change and ocean acidification. Such activities often involve the most direct action local managers and politicians can take and, as such, stand the best chance of success. Finally, it is important for resource managers to have the information they need to support local, national, and global efforts to reduce greenhouse gases.

Objective C1.1: Provide training opportunities to coral reef managers to increase their understanding of the impacts of climate change, the predicted range and uncertainty of changes that will occur, and management strategies that address the impacts of climate change.

Objective C1.2: Develop and implement effective local communication plans that provide relevant and up-to-date information on climate change and ocean acidification to stakeholders.

Objective C1.3: Develop and implement climate related crisis response plans in all U.S. 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.



Objective C1.4: Working with jurisdictions, assess how to improve regulatory and management frameworks to facilitate adaptation to climate change and ocean acidification.

Objective C1.5: In collaboration with reef managers, develop, test, and apply the best available science to provide new and innovative tools to help managers prepare and respond to climate change and ocean acidification related impacts.

Monitoring the stressors and responses of reefs to global climate change and ocean acidification are essential to assess and document the vulnerability of coral reef ecosystems. This requires characterization of changes in the physical and chemical state of the environment and the responses of coral reefs to these changes from organismal to ecosystem scales. Knowledge of ecosystem vulnerability can then be used to understand the vulnerability of dependent human systems and to assess the risks inherent in various potential emissions targets. While other parts of NOAA and the Federal Government will monitor climate change at large spatial scales, monitoring impacts to coral reef ecosystems likely will fall on the CRCP to implement.

Objectives within this goal focus on clearly understanding and describing the changes occurring in the physical and chemical environment, responses of coral reef ecosystems in the face of these changes, and the effects on and responses of human communities dependent on reef resources. These activities provide the baseline knowledge and monitoring to validate predictive assessments of climate change impacts and evaluate management strategies in support of the other climate change goals. They also generate the documentation necessary to support management action to reduce impacts of climate change and ocean acidification and develop new management frameworks to apply in areas that are particularly resilient or vulnerable to these changes. Finally, they provide clear assessments of changes and impacts and identify thresholds needed to predict future impacts.

Objective C2.1: Characterize physical and chemical changes in coral 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.

Objective C2.2: 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.

2 Climate Change Impacts Goal

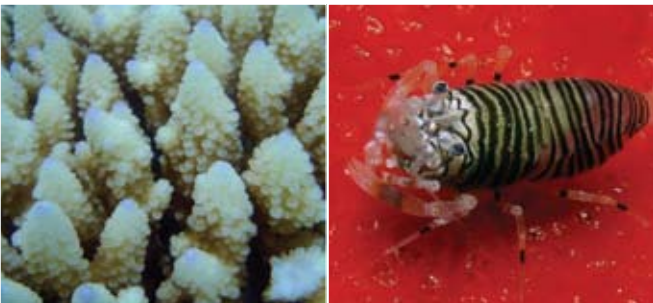
Identify, understand, and communicate risks and vulnerability of U.S. coral reef ecosystems, ecosystem services, and dependent human communities to climate change and ocean acidification.

Objective C2.3: 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.

Objective C2.4: 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 the risk due to climate change and ocean acidification.

Objective C2.5: 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.

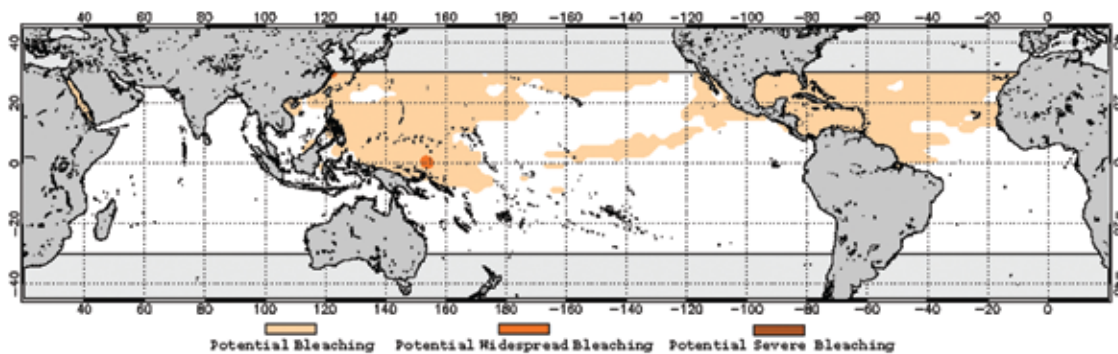


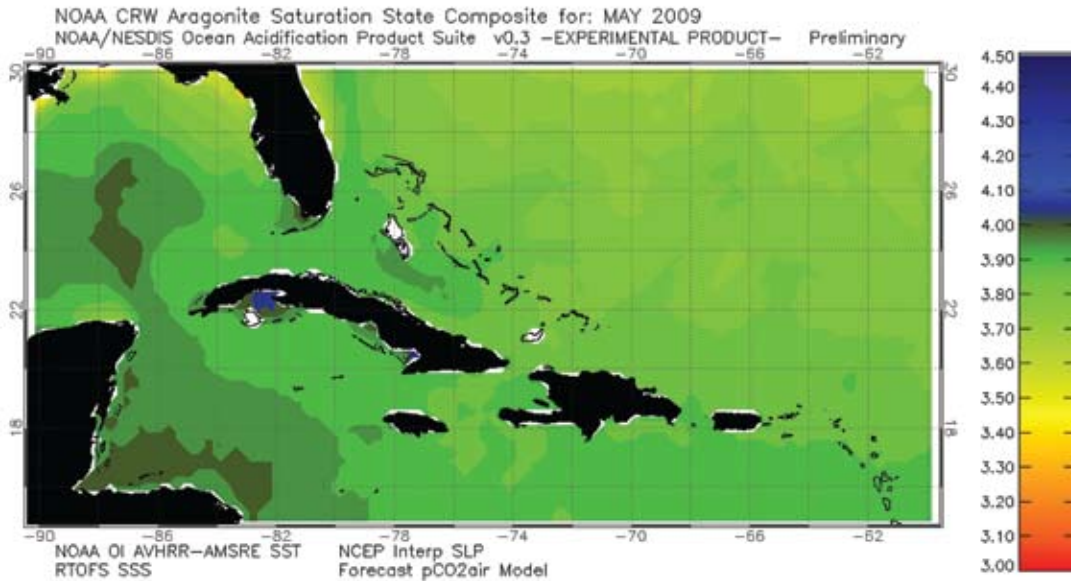
3 Climate Change Impacts Goal

Enhance strategic management of coral reef ecosystems through improved and applied understanding, forecasts, and projections of climate change and ocean acidification impacts.

Information from the climate modeling community continues to improve and is increasingly applicable to questions at finer scales. For this information to be helpful to managers and decision-makers concerned with coral reef ecosystems, these forecasts must be provided in ways that are applicable and at levels of local relevance. Despite the current knowledge of climate change impacts to coral reef ecosystems, the coral reef management community has not effectively integrated or applied these forecasts or used them to provide information needed for decision-making. This will require a concerted effort to couple climate scenarios issued at fine spatial scales with ecosystem responses, and preferably with coral reef ecosystem models. Activities within this goal will improve the way

2009 Jun 09 NOAA Coral Reef Watch Coral Bleaching Thermal Stress Outlook for Jun-Sep 2009





that state-of-the-art climate modeling forecasts and projections are prepared and delivered so that they provide information needed for coral reef ecosystem management decisions and assessments of future risk. This will require enhanced collaboration between coral reef managers and scientists and the climate modeling community to model future stresses and the response of coral reef ecosystems and dependent human communities. Such integration will also require a greater understanding and modeling of the response of coral reef organisms, ecosystems, and dependent communities than currently exists. Once available, enhanced, high-resolution climate information will be translated into useable products from which coral reef managers and policymakers can plan and make strategic decisions. By anticipating stresses on coral reef ecosystems, managers can make proactive and sound management decisions to minimize negative impacts on both reefs and human communities. Finally, this will provide clear

guidance for policy makers to determine risks and costs involved in various future emissions targets and will hopefully



encourage reduction of atmospheric greenhouse gases.

Objective C3.1: 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.

Objective C3.2: 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.

Objective C3.3: 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.

Objective C3.4: Translate climate forecasts and projections into products that are relevant and useable for improved coral reef ecosystem management and decision-making.



4 Climate Change Impacts Goal

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.

Currently, reef managers have little direct control over global-scale stressors (primarily rising temperatures and CO₂ levels) threatening coral reef ecosystems. Additionally, we will have to face the global climate change that will result from the elevated greenhouse gas levels already in the atmosphere. As a consequence, coral reef ecosystems will suffer significant climate change and ocean acidification impacts even if reefs are well managed in all other respects and the international community acts quickly to reduce greenhouse gas emissions. As climate change and ocean acidification impacts continue, there will be an increase in the value of remaining reef populations and species, and an increasing need to maximize resilience at key locations. Although necessarily limited in their scope, intervention actions are merited in certain cases, such as on reefs that contain particularly valuable or threatened species or populations, or that have a high relative abundance of large reproductive colonies.

This goal supports direct efforts (including geoengineering and assisted adaptation or migration) to maximize survivorship and resilience on reefs affected by climate change and ocean acidification. This goal begins by testing and evaluating proposed intervention approaches – moving ideas from the lab to the

field – and helps establish potential thresholds at which intervention may be merited. Through an interactive process, tools will be developed that allow resource managers to identify intervention measures that may be practical for their sites. Approaches that make sense in one locale may be inappropriate in another, and different reefs will vary in their vulnerability to global change stressors. Finally, it supports implementation, monitoring, and evaluation of these intervention measures at sites selected as particularly resilient or with potential to become more resilient through intervention.

Objective C4.1: Facilitate the identification, development, and testing of intervention measures to reduce stress from climate change and ocean acidification on coral reef ecosystems in field settings.

Objective C4.2: 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).

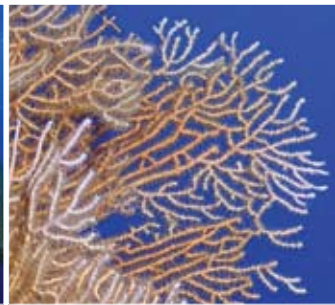
Objective C4.3: Support implementation and monitoring of promising intervention measures to reduce the impact of climate change and ocean acidification on coral reef ecosystems and evaluate the success of intervention measures (e.g. shading, pumping in cool water, local reduction of acidification, etc.).





A school of yellowspot emperors (*Gnathodentex aurolineatus*) at Gun Beach in the Tumon Bay Marine Preserve, Guam.

Photo credit: Dave Burdick



FISHING IMPACTS STRATEGIC GOALS AND OBJECTIVES

Coral reefs and associated habitats provide important commercial, recreational and subsistence fishery resources in the United States. Fishing plays a central social and cultural role in many island communities and can represent a critical source of protein. But coral reef fisheries, though often relatively small in scale, may have disproportionately large impacts on the ecosystem if conducted unsustainably. Rapid human population growth, demand for fishery resources, use of more efficient fishery technologies, and inadequate management and enforcement have led to the depletion of key reef species and habitat damage in many locations. Specific impacts of fishing on reefs generally include one or more of the following: 1) direct overexploitation of fish, invertebrates, and algae for food and the aquarium trade; 2) removal of a species or group of species impacting multiple trophic levels; 3) by-catch and mortality of non-target species; and 4) physical impacts to reef environments associated with fishing techniques, fishing gear, and anchoring of fishing vessels (Waddell 2005). Such threats are exacerbated when coupled with other coral reef stressors such as climate change and land-based sources of pollution.

Assessments such as the region-wide efforts in the U.S. Pacific have demonstrated declines in reef fish abundance and correlations between reduced fish biomass and proximity to human population centers (Schroeder et al., in press). In addition, socioeconomic studies have documented fishers' perceptions that fish are less abundant and coral reef health has declined (e.g. Griffith et al., 2007). Work in U.S. coral reef jurisdictions has shown; however, that appropriate management actions can reverse these trends. For instance, 'no-take' areas in the Florida Keys (Bartholomew et al., 2007) and marine preserves in Guam (Taylor, in press) have resulted in increased numbers and size of economically and ecologically important reef fish. Management actions focused on key coral reef species, such as the Fish Replenishment Areas in West Hawai'i, have also demonstrated success in protecting reproductive stock and maintaining the fishery for important aquarium trade species (Williams et al., 2009).

Minimizing negative fishing impacts throughout coral reef ecosystems is critical to revitalizing and protecting coral reef resources for current and future generations. Given the many entities with jurisdiction or expertise over U.S. coral reef

resources, cooperation among partners is essential. The CRCP aims to support collaboration among federal, state, territory, commonwealth, and local governments; academic institutions; and non-government organizations to achieve the goals and objectives outlined below. These goals and objectives include:

- Increase the abundance and average size of key coral reef fishery species to protect trophic structure and biodiversity and improve coral reef ecosystem condition;
- Support effective implementation and management of marine protected areas (MPAs) and ecological networks of MPAs that protect key coral reef ecosystem components and functions;
- Increase stakeholder engagement and capacity to improve local compliance with and enforcement of fisheries management regulations that further coral reef ecosystem conservation; and
- Utilize locally relevant education and communication strategies to increase public and policy maker understanding of fishing impacts in coral reef ecosystems and support for effective management options.



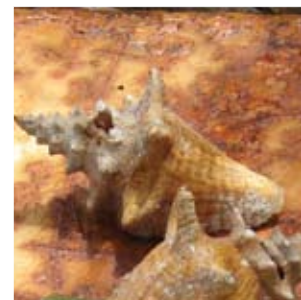
Fishing Impacts Goal 1

Increase the abundance and average size of key¹ coral reef fishery species to protect trophic structure and biodiversity and improve coral reef ecosystem condition.

Excessive fishing may reduce fish size and abundance and change species composition throughout coral reef ecosystems. This can be severe enough to compromise the natural ecological balance of the system (Bellwood et al. 2004). Studies suggest that when key functional reef species, such as herbivorous fishes, are overfished, associated phase-shifts from high-diversity coral-dominated systems to low-productivity algal-dominated communities can occur (Hughes 1994). Shifts in community structure may cause reefs to be less resilient to other hazardous events including coral bleaching and disease (Westmacott et al. 2000). Management, research and monitoring of fishing impacts is challenging due to the diversity of coral reef ecosystem species, the variety of methods used to extract them, and the paucity of basic information on fishing effort and ecology. Thus the intent of Goal 1 is to focus sound science and ecosystem-based management on key species or functional groups.

In addition, Goal 1 seeks to balance the desire for short-term fishery yield with the need for long-term fishery sustainability and coral reef persistence. Reducing impacts from fishing can enhance coral reef integrity, stability and aesthetics by increasing the abundance and average size of targeted species, restoring biodiversity, and maintaining coral reef ecosystem function. When fishing impacts are sufficiently reduced, coral reef ecosystems have the capacity to deliver ecological services while ensuring long-term reef productivity and persistence.

NOAA traditionally undertakes fisheries management under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). The following goals and objectives are consistent with MSFCMA and are not meant to supersede it nor any state and territorial fisheries management requirements. The intent of these goals and objectives are to improve and conserve coral reefs as intact, fully functioning ecosystems.



¹ Key coral reef species (or functional groups) should be identified by each jurisdiction or managed area, and are defined as the composite of species essential to effective ecosystem-based function. Key species/groups may be those most affected by extractive activities, those that serve as indicator or keystone species, or other criteria.



Objective F1.1: Support the creation or improvement of coral reef fisheries management plans that address ecological, social, and economic considerations.

Objective F1.2: Prioritize key coral reef associated species or functional groups (e.g. herbivores, apex predators, etc.) on which to focus management, research and monitoring activities for each jurisdiction or managed area.

Objective F1.3: Obtain essential life history and ecological information on key species or functional groups to support management actions.

Objective F1.4: Obtain necessary information on fishing effort in U.S. coral reef ecosystems by measuring fishing intensity, fishing mortality, frequency, area coverage, community dependence, etc. to inform management activities.

Objective F1.5: Predict appropriate levels of extraction for key species or groups by developing and utilizing valid, precise, place-based and realistic ecosystem dynamics models.

Objective F1.6: Conduct applied biological, social, and economic research and monitoring to evaluate effectiveness of coral reef ecosystem management actions on key species or groups.

Fishing Impacts Goal 2

Support effective implementation and management of marine protected areas (MPAs) and ecological networks of MPAs that protect key coral reef ecosystem components and functions.

Marine protected areas (MPAs) are valuable marine management tools for protecting and

fostering the recovery of populations, habitats and ecosystems that have been depleted or degraded by excessive exploitation. A large body of scientific research supports the role of marine reserves ('fully-protected' or 'no-take' MPAs) in increasing the abundance, size and productivity of exploited marine fish, and increasing the biodiversity of fish communities within the protected areas - the so-called 'reserve effect' (Halpern 2003). Because of the importance of dispersal in the marine environment, well designed ecological networks of MPAs are needed to effectively protect biodiversity, habitats and ecosystem functions.

Concerns over economic and social impacts have sometimes led to selective, rather than complete, closure to extractive activities. Although ecosystem benefits from partial closures may accrue, theory and practice suggest that 'no-take' marine reserves are more effective for the protection and recovery of coral reef



ecosystems affected by fishing. In order to maximize effectiveness it is also critical to utilize appropriate land and watershed-use provisions (see Land-Based Sources of Pollution section) and implement MPAs within the context of other coral reef fisheries management tools.

As with any management action, societal support and compliance are key elements to ensuring MPA effectiveness. In implementing MPAs and MPA networks, ecological and societal outcomes must be weighed, and the local management context must be considered. The CRCP remains committed to strengthening the effectiveness of existing MPAs, as well as supporting the establishment of new MPAs, reserves, and networks where determined to be locally appropriate.

Objective F2.1: Identify, characterize and rank priority areas for protection within each jurisdiction, including (but not limited to):

- spawning sites, nursery habitats, or other areas critical to particular life-history stages
- biodiversity hotspots
- areas with greatest resilience or potential for restoring resilience
- areas facing the greatest threats

Objective F2.2: Synthesize research on the performance of MPAs that protect key coral reef ecosystem components and functions.

Objective F2.3: Using outputs of Objective 2.1 and 2.2, appropriate models, and socioeconomic considerations, identify MPAs that require increased protections or improved management, and areas to be considered for siting of new MPAs that protect key coral reef ecosystem components and functions.



Objective F2.4: Work with relevant agencies, offices, and communities to create, implement, and improve the management of MPAs that protect key coral reef ecosystem components and functions.

Objective F2.5: Conduct biological and socioeconomic research and monitoring to assess the performance of MPAs with respect to protection and restoration of key coral reef ecosystem components and functions.

Fishing Impacts Goal 3

Increase stakeholder engagement and capacity to improve local compliance with and enforcement of fisheries management regulations that further coral reef ecosystem conservation.

The success of management actions targeted at reducing the impacts of fishing on coral reef ecosystems will be largely dependent on voluntary compliance with, or necessary enforcement of, regulations, managed areas, or best management practices. Increasing community involvement in planning, implementation, and enforcement activities will increase local capacity, collaboration,

and communication, all of which are essential to protect key species/functional groups and ensure that fisheries regulations and marine protected areas are effective. Improved stakeholder participation can also provide local

and traditional knowledge critical to tailoring management activities to specific geographic areas. Additionally, compliance may be improved by identifying locally appropriate economic alternatives to unsustainable fishing. Monitoring the outcomes of programs designed to increase community participation, compliance, and enforcement will provide important information for adaptive management of coral reef ecosystems.

Objective F3.1: Increase participation of stakeholder or citizen groups in fisheries management planning, decision-making, and monitoring activities that improve conservation of coral reef ecosystems.



Objective F3.2: Strengthen local agency and community capacity for effective and consistent enforcement of regulations or behaviors that reduce impacts of fishing on coral reef ecosystems.

Objective F3.3: Work with partners to identify economic alternatives that reduce effects of non-traditional extractive livelihoods on coral reef ecosystems and provide options for communities impacted by coral reef fisheries management actions.

Objective F3.4: Conduct biological and socioeconomic research and monitoring necessary to assess the effectiveness of compliance and enforcement activities, understand community concerns, flag roadblocks to implementation, and incorporate into management efforts.

on coral reef ecosystems requires improved communication of the goals, values, and benefits of management activities leading to broader public support and understanding of their impacts

and timelines. The scope of this goal is activities relevant for each jurisdiction or local manager.

Objective F4.1: Develop curricula incorporating locally relevant lessons plans about coral reef ecosystems and fisheries management that meet current state and national standards.

Objective F4.2: Develop and implement effective strategies and tools to improve communication between scientists, managers and policy makers on best management practices to protect key coral reef ecosystem species and functional groups.

Objective F4.3: Develop targeted, locally-relevant outreach and communication strategies to increase community understanding and support for regulations to protect key coral reef ecosystem species/functional groups and expanded use of marine protected areas.

Objective F4.4: Obtain socioeconomic and human dimension data to inform jurisdiction-specific education and communication strategies and initiatives and monitor program outcomes.

Fishing Impacts Goal 4

Utilize locally relevant education and communication strategies to increase public and policy maker understanding of fishing impacts in coral reef ecosystems and support for effective management options.

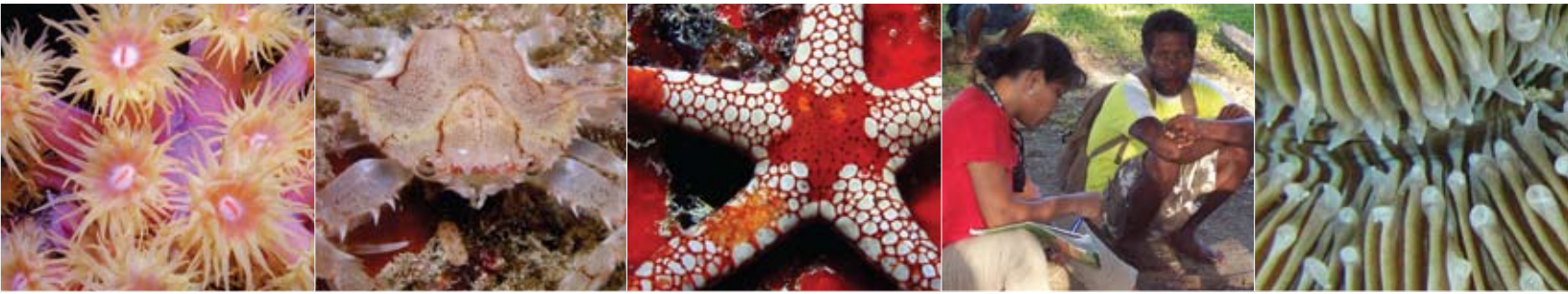
Effective education and outreach mechanisms are critical to communicating basic coral reef ecosystem information and the nuances inherent in research, monitoring and management of these complex ecosystems. Coral reef species are highly inter-dependent and face a variety of threats that may cause both individual and synergistic effects. Thus, management actions may not demonstrate an immediate cause/effect impact on the ecosystem. Effective implementation of long-term policies that will reduce the impacts of fishing





Sedimentation along the southwestern coast of Guam near Ana'e Island.

Photo Credit: Dave Burdick



IMPACTS FROM LAND-BASED SOURCES OF POLLUTION STRATEGIC GOALS AND OBJECTIVES

It is now well accepted that many major coral reef ecosystem stressors originate from land-based sources, most notably, toxicants, sediments, and nutrients. Within the United States and its jurisdictions, there are numerous locations where coral reef ecosystems are highly impacted by watershed alteration, run-off, and coastal development (Bellwood et al., 2004; Pandolfi et al., 2003; Richmond et al., 2007). The importance of identifying the extent of and reducing these effects has now become crucial, as land-based pollution and coastal development put 22% and 30%, respectively, of coral reefs on Earth at risk (Bryant et al., 1998). The April 2004 Report of the U.S. Commission on Ocean Policy highlighted the need for “an ecosystem and watershed-based management” approach to ocean pollution, and identified both “the astounding decline of coral reef ecosystems” and “an urgent need to address the identified, major factors causing coral declines” (Commission on Ocean Policy, 2004).

The suite of problems facing coral reef ecosystems from land-based sources of pollution is broad and includes sediment, nutrients, and other pollutants from a variety of land-based activities that are transported in surface waters,

runoff, groundwater seepage, and atmospheric deposition into coastal waters. There is compelling evidence that the sources have increased globally as a result of human-induced changes to watersheds (Wilkinson, 2008). On the U.S. islands in the Pacific and Caribbean, significant changes in the drainage basins due to agriculture, deforestation, feral grazing, fires, road building and other construction, and urbanization have in turn altered the character and volume of land-based pollution released to adjacent coral reef ecosystems (ISRS, 2004). Many of these issues are further exacerbated due to specific characteristics exhibited in tropical island areas, all of which create unique management challenges when addressing land-based sources of pollution issues. A few examples include: high levels of rainfall; extreme weather events (hurricanes/typhoons); highly erodible soils; limestone hydrologic features, (Pacific atolls); and in some high islands, (American Samoa, Hawai`i), steep slopes abutting the coastal zone.

Sedimentation, including higher levels of suspended sediment in overlying waters, is commonly acknowledged to be one of the primary causes of coral reef ecosystem

degradation (e.g., Rogers, 1990; Field et al., 2008). The combination of suspended, re-suspended, and deposited sediment act to limit coral growth, feeding patterns, photosynthesis, recruitment, and survivorship, as shown by numerous studies in a variety of settings (Fabricius, 2005). Other impacts of sediment include directly smothering and abrading coral. Although some corals can flourish in turbid water, such reefs are typically less diverse and are more restricted in depth ranges than those in clear water (Fabricius, 2005). To underscore this point, the U.S. Commission on Ocean Policy reported that “pollution and run-off from coastal areas also deprive reefs of life-sustaining light and oxygen” and many Local Action Strategy (LAS) groups of the U.S. Coral Reef Task Force have identified land-based pollution to reefs as a major area of concern.

In addition to sediment, land-based sources of pollution to coral reef ecosystems include pesticides, petroleum hydrocarbons, pharmaceuticals, heavy metals, pathogens, and excess nutrients. These pollutants can cause or exacerbate the deleterious effects of watershed transport of pollutant constituents onto coral reefs (Richmond, 1993). Excess nutrients, including dissolved nitrogen and phosphorus from sewage, wastewater, and fertilizers, promote the growth of algae that compete with juvenile and adult corals for space on benthic reef surfaces and can affect success of coral settlement (Sammarco, 1996) and in extreme cases can result in eutrophication of reef waters. In addition, land-based inputs may both directly contribute land-derived pathogens and/or exacerbate the effect of *in situ* pathogens on coral reef ecosystems.

Finally, the local impacts of land-based sources of pollution work in synergy with global and regional threats such as climate change, land use practices, and freshwater inputs, magnifying the effect of both types of stressors. In particular, the potential for increased frequency and intensity of storm events associated with climate change could exacerbate run-off of sediment and other pollutants (UNFCC, 2002).

The three primary goals of the CRCP’s plan to address land-based sources of pollution include:

- Reduce pollutant loading from watersheds to priority coral reef ecosystems;

- Promote in-water management activities to restore priority coral reef ecosystems that have been adversely impacted by accumulated sediments, nutrients, and algae; and
- Build and sustain management capacity at the local level through local, state, regional, and federal coordination of financial, institutional, and human resources to reduce and prevent the impacts of land-based sources of pollution on coral reef ecosystems.

Partnership with other entities that have jurisdiction over, or have a particular expertise related to, land-based sources of pollution is essential to most effectively address this threat. The NOAA CRCP is committed to work in strong partnership to strategically build upon and enhance on-going activities and to identify new opportunities to make demonstrable progress in decreasing the sources of and impacts from land-based sources of pollution on coral reef ecosystems. What follows are the guiding goals and objectives to establish this new strategic direction.

1 Impacts from Land-Based Sources of Pollution Goal

Reduce pollutant loading from watersheds to priority coral reef ecosystems.

Recognizing the profound link between watershed land use activities and the quality of the near-shore marine ecosystems, reducing or eliminating pollutant loads to coral reef ecosystems from land-based sources is paramount. Because sediment deposition and algal cover often degrade coral reefs, reducing sediment and nutrient loading from urban/agricultural runoff and wastewater discharges should be a primary focus of watershed management activities. Debris, pathogens, and



toxicants, including petroleum hydrocarbons, pesticides, heavy metals, and pharmaceuticals derived from the land are also pollutants of concern.

The health of many U.S. coral reef ecosystems ultimately depends on effective management of land-based activities in adjacent coastal and upland regions. Watershed assessment, planning, and restoration efforts to address land-based sources of pollution should be conducted locally from ridge to reef, preferably in watersheds draining to high quality and/or restorable coral reef ecosystems. Comprehensive watershed management includes the application of land use planning; land conservation; vegetated buffer protection; environmentally sensitive development techniques; storm-water management

(construction and post-construction); wastewater and drinking water management; and stewardship activities. To effectively address the impacts of land-based

sources of pollution on coral reef ecosystems it is essential that, as watershed management plans are developed, updated, and implemented, specific coral reef ecosystem protection measures are incorporated. Implementing best management practices and regulatory controls on the landscape are critical to reducing pollutant loads and improving coral reef ecosystem health.

An important component of watershed management, and hence, our efforts to protect coral reef ecosystems from land-based sources of pollution, is the conservation of the habitats that serve to limit rates of erosion and quantities of transported sediment and other pollutants to adjacent coral reef ecosystems. To support and enhance this buffering capability, preserving the natural state of forests, stream valleys, riparian zones, deltas, wetlands, and mangroves is a key to maintaining hydrologic functions including stream flow and ground water recharge. It is therefore essential to maintain or restore coastal and upland ecosystems as a first line of defense to limiting

land-based pollution inputs and impacts to near-shore and coral reef ecosystems.

Supporting our watershed restoration and protection efforts with strategic research, implementing research applications that have direct management implications, and conducting the necessary performance monitoring are critical components to improving effectiveness in reducing pollutant loads, measuring progress, and incorporating adaptive management regimes.

The objectives outlined in this goal are founded on identifying and working in select coral reef ecosystems that exhibit the greatest potential for recovery upon implementing conservation and management strategies. Identification of these coral reef ecosystems will take into account



watershed activities, pollutant loads, the potential for reducing pollutant loads and land-based sources of pollution, and the vulnerability of the receiving marine ecosystem. Efforts will then focus on working in partnership to implement watershed management plan activities, which include the potential need to conserve and/or restore coastal and upland habitats; conducting strategic and applied research, and monitoring for adaptive management. Managers, communities, and decision-makers need to support a broader and more comprehensive approach to watershed management that includes consideration of coral reef ecosystems. Successful implementation of this goal is inextricably linked with the activities outlined in Goal 3.

Objective L1.1: Identify and prioritize those coral reef ecosystems and associated watersheds, within each jurisdiction, that will benefit the most from implementing management conservation strategies to reduce land-based sources of pollution.

Objective L1.2: Identify and prioritize coastal and upland areas for preservation, protection, and restoration based on the coral reef ecosystems and associated watershed areas identified in Objective 1.1.

Objective L1.3: Implement watershed management plans and relevant Local Action Strategies (LAS) within priority coral reef ecosystems and associated watersheds to improve water quality and enhance coral reef ecosystem resilience. Where needed, develop (or update) watershed management plans that incorporate coral reef protection measures.



Objective L1.4: Promote an integrated effort to fill strategic science gaps that directly inform management decisions related to planning and implementation activities in priority coral reef ecosystems and associated watersheds.

Objective L1.5: Determine the efficacy of management activities through coordinated baseline and performance monitoring to assess progress and adapt management actions as needed.

2 Impacts from Land-Based Sources of Pollution Goal

Promote in-water management activities to restore priority coral reef ecosystems that have been adversely impacted by accumulated sediments, nutrients, and algae.

Coral reefs persist through the dual processes of reproduction and recruitment, which are

dependent on water and substratum quality. Accumulated sediments directly from the adjacent land prevent coral recovery through re-suspension and interference with fertilization, larval development and settlement in corals. Sedimentation and nutrient enrichment can result in shifts from coral dominated to algal dominated systems. In-water management actions such as removal of accumulated sediments and overgrowth of macroalgae can promote coral population replenishment and coral reef health. In some cases these in-water management actions may be needed in lieu of or in addition to reducing pollutant loads from watersheds. In addition to direct, in-water management activities, technologies such as remote sensing can provide important data to support management action.

Prior to any direct, in-water management activities, the reef system should be evaluated and a determination made whether reef restoration is warranted or if controlling land-based sources of pollution inputs is sufficient for reef recovery. Examples of possible in-water management action include altering coastal structures to improve flushing and sediment transport, dredging to remove accumulated sediment from the reef system, and physical removal of harmful macroalgae. Developing marine protected areas, stock enhancement programs, or fishery management actions that support the natural maintenance and ecological integrity of the ecosystem may also support recovery of reefs degraded by pollution. Management actions undertaken will be specific to the particular physical and biological characteristics of the selected coral reef ecosystem. Ultimately, this goal is intended to enhance habitat quality.

This goal, which supports in-water recovery and restoration efforts to remove and mitigate the impacts of accumulated sediments, contaminants, and nutrients in coral reef ecosystems, is intended to complement the land-based watershed project implementation activities as outlined in Goal 1.

Objective L2.1: Identify and prioritize coral reef ecosystems from those prioritized under Objective 1.1 where in-water management activities are needed to promote reef recovery.

Objective L2.2: Develop, test, and



apply existing or new management tools and technologies that demonstrate the ability to support and promote coral reef protection and recovery, including approaches to remove accumulated pollutants and/or macroalgae to restore healthy environmental and ecosystem conditions.

3 Impacts from Land-Based Sources of Pollution Goal

Build and sustain management capacity at the local level through local, state, regional, and federal coordination of financial, institutional, and human resources to reduce and prevent the impacts from land-based sources of pollution on coral reef ecosystems.

Land-based sources of pollution cross multiple jurisdictional boundaries with the authority and responsibility to address them falling to a multitude of governmental and jurisdictional levels. In addition, in many U.S. coral jurisdictions there are varying degrees of community level organization and stakeholder involvement that need to be considered when working to address

land-based sources of pollution. It is therefore necessary to build a framework that facilitates enhanced coordination and promotes consistent and strengthened application and enforcement of laws and authorities intended to address land-based sources of pollution.

To be effective, there are several other enabling factors that need to be considered and addressed. Primarily, in many communities it is necessary to first build the local, regional and federal

capacity, including both staff numbers and level of expertise to effectively implement and enforce new or existing mechanisms to reduce land-based sources of pollution. Second, land-based pollution control measures can be expensive to implement and maintain. Therefore, it is essential that new sources of funding and new mechanisms to cost-share are identified and institutionalized. Finally, information needs to be made available for managers, communities, and political leaders, to empower informed decision-making that appropriately considers potential pollutant impacts to coral reef ecosystems.



Objective L3.1: Ensure that coral reef jurisdictions have adequate resources and capacity to develop and implement management plans, assess water quality and coral reef ecosystem condition, enforce regulations, and evaluate performance.

Objective L3.2: Build partnerships among local, state, federal, and non-governmental entities to identify, leverage, and apply financial and other resources to facilitate improved coastal and upland watershed management to protect coral reef ecosystems from impacts of land-based sources of pollution.

Objective L3.3: Support or help develop intergovernmental mechanisms (appropriately designed for each jurisdiction) to promote effective local management actions and decisions.

Objective L3.4: Ensure that the necessary and consistent regulatory and programmatic framework exists and is enforced to implement watershed management strategies necessary to protect coral ecosystems.

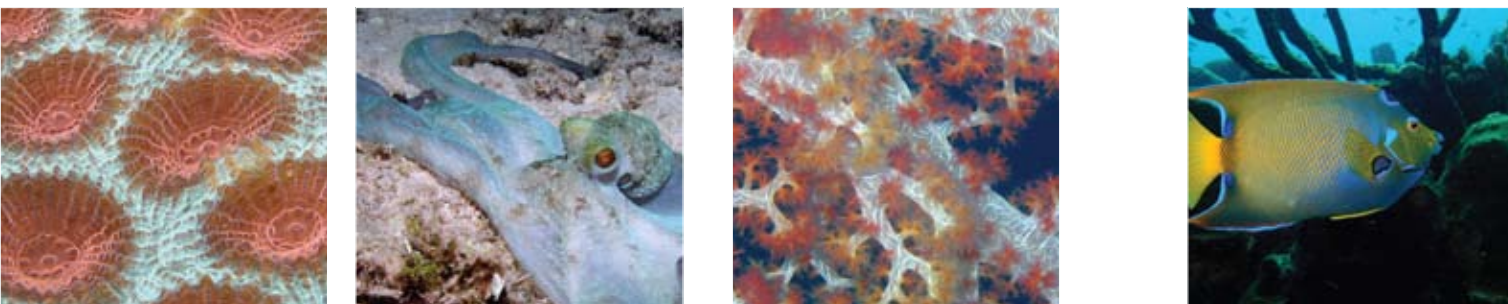
Objective L3.5: Increase public and political awareness and understanding of the ecological and socioeconomic impacts of land-based pollution on coral reef resources to promote better stewardship and informed decisions regarding activities in watersheds that may adversely impact coral reef ecosystems.





This pair of pink anemonefish (*Amphiprion perideraion*) stand out against the tentacles of a bleached anemone at Shark Island, Chuuk Lagoon, Federated States of Micronesia.

Photo Credit: Dave Burdick



DEFINITIONS

Adaptation: Adjustment in human and natural systems in response to actual or expected environmental changes (from IPCC not to be confused with evolutionary adaptation).

Climate Change: Any change in the ocean-atmosphere climate system over time, whether due to natural variability or human activity.

Climate Forecasts: The result of an attempt to produce an estimate of the actual trend or variability of climate in the future (e.g., at seasonal, inter-annual or long-term time scales).

Climate Projections: In contrast to climate forecast, the calculated response of the ocean-atmospheric climate system to scenarios of emissions or concentration of greenhouse gases and aerosols, or of radiative forcing, often based on simulations by climate models.

Coral: Species of the phylum Cnidaria, including — (a) all species of the orders Antipatharia (black corals), Scleractinia (stony corals), Gorgonacea (horny corals), Stolonifera (organpipe corals and others), Alcyonacea (soft corals), and Helioporacea (blue coral), of the class Anthozoa; and (b) all species of the families Milleporidea (fire corals) and Stylasteridae (stylasterid hydrocorals) of the class Hydrozoa.

Coral Reef: Limestone structures composed in whole or in part of living zooxanthellate stony corals (Class Anthozoa, Order Scleractinia), their skeletal remains, or both, and including other coral, associated sessile invertebrates and plants, and any adjacent or associated seagrasses.

Coral Reef Ecosystem: The system of coral reefs and geographically associated species and habitats, including but not limited to mangroves and seagrass habitats, their living marine resources, the people, the environment, and the processes that control its dynamics.

Ecological Network: A set of MPAs that are connected through ecological processes and that share complementary purposes and synergistic protections.

Ecosystem Services: The benefits people obtain from ecosystems. These include provisioning services such as food; regulating services such as flood control and shoreline protection; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth. The concept 'ecosystem goods and services' is synonymous with ecosystem services (adapted from: Millennium Ecosystem Assessment, 2005).



Indicators: An observable, measurable response to change in a specific environmental parameter.

Intervention Measure: An activity or set of activities designed to directly reduce the impact of stressors on coral reef health, usually over small spatial scales (tens of m² to hectares).

Key Coral Reef Species (or Functional Groups): Defined as the composite of species essential to effective ecosystem-based function. Key species/groups may be those most affected by extractive activities, those that serve as indicator or keystone species, or other criteria.

Marine Protected Area: Any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein.



Marine Reserve: A type of MPA within which extractive uses are prohibited (often referred to as a 'no-take' area or 'fully-protected' MPA).

Ocean Acidification: A measurable reduction in ocean pH caused by increased concentrations of CO₂ in seawater. One result is a reduction in the availability of carbonate ions that marine organisms use to build shells and skeletal structures.

Pollutant: dredged spoil, solid waste, incinerator residue, filter backwash, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water (CWA Sec. 502(6)).

Recharge: The movement of water from the land surface, past the zone where it can be taken up by plants, to an underlying aquifer. Also refers to the rate at which new water reaches the aquifer.

Resilience: The capacity of a system to absorb stresses and continue functioning (Levin and Lubchenco 2008).



Risk Assessment: Frequent assessment that integrates the potential impacts posed by climate change to coral reef ecosystems and their dependent human communities, the probability of those impacts increasing in the future, and the vulnerability of those communities (coupled with regional and local stressors like pollution, ecologically unsustainable fishing, and habitat destruction) to determine reef areas and populations most at risk.

Threshold: The level of magnitude of a system process at which sudden or rapid change occurs.

Toxicant: An agent or material capable of producing an adverse response (effect) in a biological system, seriously injuring structure or function or producing death (Rand, Petrocelli, 1985).

Vulnerability: The degree to which a system is susceptible to, and unable to cope with, adverse impacts of stressors. Vulnerability is a function of the character, magnitude, variability, and rate of climate change to which a system is exposed, its sensitivity, and its adaptive capacity.

Watershed: hydrologic unit of land contributing surface runoff and subsurface drainage to a particular water body.

Watershed Management Plan: comprehensive strategy to guide implementation of activities necessary to protect, restore, or maintain water resources.





Coral reef ecosystems provide homes for numerous organisms, like this shrimp living within the polyps of a species of *Goniopora* coral.

Photo credit: Dave Burdick



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