



# Reefs at Risk

in the Caribbean

## EXECUTIVE SUMMARY

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## CONTRIBUTING INSTITUTIONS

The Reefs at Risk in the Caribbean project was developed and implemented by the World Resources Institute (WRI) in collaboration with many partner organizations.

### Research Institutions and Universities

- Atlantic and Gulf Rapid Reef Assessment (AGRRA)
- Caribbean Coastal Marine Productivity Program (CARICOMP)
- Centre For Marine Sciences, The University of the West Indies at Mona, Jamaica (CMS-UWI)
- Florida International University (FIU)
- Gulf and Caribbean Fisheries Institute (GCFI)
- National Center for Caribbean Coral Reef Research (NCORE)
- University of Miami (UM)
- University of South Florida (USF)
- University of the West Indies (UWI)

### Nongovernmental Organizations

- Caribbean Conservation Association (CCA)
- Corporación para el desarrollo sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina (CORALINA)
- Environmental Defense
- Fondation pour la Protection de la Biodiversité Marine (FoProBiM)
- Island Resources Foundation (IRF)
- The Nature Conservancy (TNC)
- Reef Environmental Education Foundation (REEF)
- Reef Check
- World Wildlife Fund (WWF)

### Government Agencies and International Organizations

- Global Coral Reef Monitoring Network (GCRMN)
- International Coral Reef Action Network (ICRAN)
- United Nations Environment Programme - Caribbean Environment Programme (UNEP-CEP)
- United Nations Environment Programme - World Conservation Monitoring Centre (UNEP-WCMC)
- U.S. National Aeronautics and Space Administration (NASA)
- U.S. National Oceanographic and Atmospheric Administration (NOAA)
- World Bank / GEF Mesoamerican Barrier Reef System (MBRS) Project
- The World Fish Center

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# Executive Summary

Coral reefs are an integral part of the Caribbean fabric, threading along thousands of kilometers of coastline. Teeming with fish and invertebrate life, these ecosystems provide food for millions of people. Buffering shorelines, they protect the land from the worst ravages of storms. Coral reefs form the foundation of the thriving Caribbean tourism industry, the region's most important economic sector. The reefs supply much of the sand for the region's beautiful beaches and lure divers and snorkelers from far and wide to come and explore the reefs' colorful and mysterious depths. The dazzling array of species living on coral reefs has also attracted the attention of the pharmaceutical industry as a potential source of new drugs and life-saving medical treatments.

Unfortunately, these valuable ecosystems are degrading rapidly under the mounting pressure of many human activities. Coastal development, land clearance, and intensive agriculture all contribute damaging sediment and pollution to coastal waters, while overfishing is changing the ecological balance of coral reef environments. In addition, rising sea temperatures have prompted dramatic "coral bleaching" events in recent years, weakening and killing corals in many areas. At the same time, poorly understood coral diseases have spread rapidly across the region, devastating some of the main reef-building corals. Coral reef degradation and mortality will significantly impact the region's economy through reduced habitat for fish and shellfish, diminished appeal for tourists, and a lessened capacity to protect the shoreline.

Understanding the nature and extent of these threats and their likely economic impacts on the future productivity of Caribbean coral reefs as sources of food, recreation, employment, and biopharmaceuticals is of central importance to conservation and planning efforts. Numerous studies are underway to monitor and assess reef conditions at particular locations in the Caribbean, but data gaps persist and, for the majority of reefs, little information is available. Many such efforts fail to combine ecosystem studies with monitoring of socioeconomic and environmental conditions, making it difficult to link changes in coral condition to specific causes.

## PURPOSE AND GOAL OF REEFS AT RISK IN THE CARIBBEAN

The Reefs at Risk in the Caribbean project was launched to help protect and restore these valuable, threatened ecosystems by providing decision-makers and the public with information and tools to manage coastal habitats more effectively. The project focuses on compiling, integrating, and disseminating critical information on these precious resources for the entire Caribbean region. This information is intended both to raise awareness about the threats to and value of Caribbean reefs and to encourage greater protection and restoration efforts.

Conducted by the World Resources Institute in cooperation with over 20 organizations working in the region, the project represents a unique, region-wide look at the threats facing Caribbean coral reefs. The collaborative process of data gathering and analysis has produced the first regionally consistent, detailed mapping of these threats. The project provides decision-makers and the public with important insights on links between human activities that stress and damage reef organisms and where degradation of reefs could be expected to occur, or may have already occurred. The maps created by the Reefs at Risk project will assist regional and national organizations in setting priorities for conservation and natural resource management. The analytical tools and threat indicators will also allow managers to assess, for the first time, the source and scale of threats affecting those many reef areas for which more detailed monitoring information is unavailable.



PHOTO: TONI PARRAS

Coral reefs — a dazzling array of life.

## METHODS AND LIMITATIONS

Reefs at Risk project collaborators worked to gather and compile data from many sources on Caribbean coral reefs, their condition, the surrounding physical environment, and the social and economic factors associated with human pressure on reef ecosystems. These data were consolidated within a geographic information system (GIS) that includes information on coral reef locations, pressures (i.e., pollution and other observed threats and physical impacts), changes in reef condition, and information on management of reef resources.

Using these data, the project team developed regionally consistent indicators of coral reef condition and threats in four broad categories representing the key stresses to reefs in the Caribbean: coastal development (i.e., pressures from sewage discharge, urban runoff, construction, and tourism development), watershed-based sediment and pollution (i.e., pressures related to soil erosion and runoff of fertilizers and pesticides from farmlands), marine-based pollution and damage (i.e., pressures from shipping and boating, including dumping of garbage, oil spills, discharge of ballast, and physical damage caused by groundings and anchors), and overfishing (i.e., pressure from unsustainable levels of fishing). The reef area considered by this analysis totaled 26,000 square kilometers (sq km), which was divided into 25-hectare units (500 m on a side). For ease of interpretation, each coral reef unit was rated at low, medium, or high threat for each of the four individual threat categories. In medium-threat areas, pressure on reefs is considered sufficiently high to result in degradation within the next 5 to 10 years. In high-threat areas, degradation is likely to occur sooner and potentially be more severe. Substantial input from scientists across the region guided the selection of thresholds for categorizing a given threat level as low, medium, or high. These threat indicators were further calibrated against available data on observed impacts on coral reefs.

The four indicators were then combined into a single, integrated index of overall human pressure on Caribbean reefs. This integrated Reefs at Risk Threat Index reflects the highest threat level (i.e., low, medium, or high) achieved by any of the four individual threats in a given 25-hectare reef unit. To capture the impact of cumulative threats in a single location, units in which three or four of the individual threats were rated as high were categorized as very high in the integrated Reefs at Risk Threat Index. Similarly, for units in which at least three threats were rated as medium, the integrated index was rated as high.

The geographic data sets and threat indicators assembled under this project have also been used in an economic valuation of some of the key goods and services related to coral reefs (fisheries, tourism, and shoreline protection) and the losses that are likely to result from degradation across the Caribbean.

The analysis carried out by the Reefs at Risk project relies on available data and predicted relationships but, like other analytical models, presents a simplified picture of human activities and complex natural processes. The model does not capture all pressures on coral reefs, owing both to limitations of the model and inaccuracies in the geographic data sets used. In addition, two major, region-wide threats to Caribbean coral reefs are not incorporated into the Reefs at Risk analysis: coral diseases and coral bleaching. Because of scientific uncertainty as well as lack of spatial detail in the relevant data sets, it is not currently possible to produce accurate models of the present and future distribution of threats from diseases and bleaching. Existing information, however, suggests that the threats are widespread, potentially affecting coral reefs across the region.

Data sources used in the analysis are listed in Appendix B. Details of the analysis method are available online at

<http://reefsatrisk.wri.org>

## KEY FINDINGS

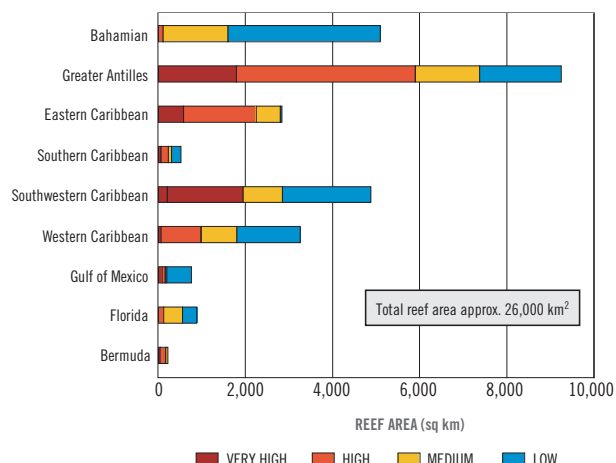
■ **The Reefs at Risk Threat Index indicates that nearly two-thirds of coral reefs in the Caribbean are threatened by human activities.** Integrating threat levels from all sources considered in this analysis (coastal development, watershed-based sediment and pollution, marine-based threats, and overfishing), the Reefs at Risk Threat Index identified about one-tenth of Caribbean coral reefs at very high levels of threat, one-third at high threat, one-fifth at medium threat, and one-third at low threat. Areas with high threat levels include the Eastern Caribbean, most of the Southern Caribbean, Greater Antilles, Florida Keys, Yucatan, and the nearshore portions of the Western and Southwestern Caribbean. In these areas, degradation of coral—including reduced live coral cover, increased algal cover, or reduced species diversity—has already occurred or is likely to occur within the next 5 to 10

years. Extensive tracts of reef in the Bahamas, Turks and Caicos Islands, archipelagos off Colombia and Nicaragua, and some reefs off Belize, Cuba, and Mexico were rated as subject to low threats from human activities.

■ **An estimated one-third of Caribbean coral reefs are threatened by coastal development.** Our indicator of coastal development threat identified about one-third of the region's reefs as threatened by pressures associated with coastal development, including sewage discharge, urban runoff, construction, and tourist development. Slightly over 15 percent were rated at high threat and a similar percentage at medium threat. Coastal development pressures were significant along the coastlines of most of the Greater Antilles, Eastern Caribbean, the Bay Islands in Honduras, along parts of the Florida Keys, the Yucatan, and the Southern Caribbean.



## REEF AREA BY SUB-REGION CLASSIFIED BY THE REEFS AT RISK THREAT INDEX

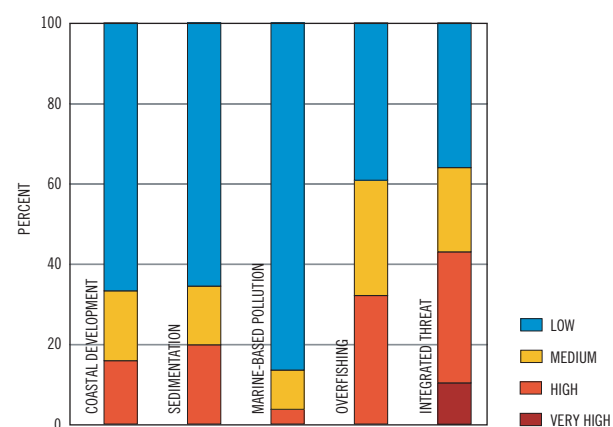


- **Sediment and pollution from inland sources threaten about one-third of Caribbean coral reefs.** Analysis of more than 3,000 watersheds across the region identified 20 percent of coral reefs at high threat and about 15 percent at medium threat from damage caused by increased sediment and pollution from agricultural lands and other land modification. Erosion of agricultural soils, particularly on steep slopes, can produce sediments that block light needed for photosynthesis and eventually smother coral reefs, while pollution from agricultural chemicals such as fertilizers and pesticides can impede coral growth or kill coral. Areas with a large proportion of reefs threatened by watershed-based sediments and pollution were found off Jamaica, Hispaniola, Puerto Rico, the high islands of the Eastern Caribbean, Belize, Costa Rica, and Panama.

- **Marine-based threats to coral reefs are widespread across the Caribbean.** Our indicator of marine-based damage and pollution identified about 15 percent of Caribbean reefs as threatened by discharge of wastewater from cruise ships, tankers and yachts, leaks or spills from oil infrastructure, and damage from ship groundings and anchors. Threat was relatively high in many of the Eastern Caribbean islands, Bermuda, Puerto Rico, Jamaica, Panama, Aruba, and the Netherlands Antilles.

- **Overfishing threatens over 60 percent of Caribbean coral reefs.** Fishing above sustainable levels affects coral reefs by altering the ecological balance of the reef. The removal of herbivorous fish, which consume algae, facilitates algal overgrowth of corals. Declines in coral cover and increases in algal cover have been observed across the region. This analysis identified about one-third of Caribbean reefs at high threat from overfishing pressure and about 30 percent at medium threat. The threat was rated as high on almost all narrow coastal shelves close to human population centers. Fishing pressure was lower in the Bahamas, where the human population is small, and in the Western and Southwestern Caribbean and Cuba, where many reefs are far from the mainland.

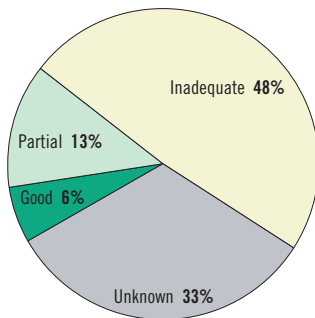
## REEFS AT RISK BY CATEGORY OF THREAT





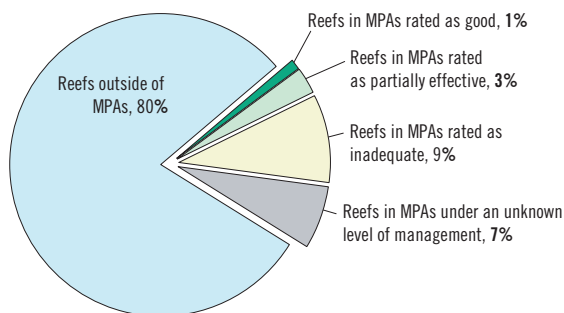
## MANAGEMENT EFFECTIVENESS OF MARINE PROTECTED AREAS (MPAs) AND PROTECTION OF CORAL REEFS

### Management Effectiveness of Caribbean MPAs



*Number of MPAs in the region is approximately 285.*

### Protection of the Caribbean's Coral Reefs



*Area of reefs in the region is approximately 26,000 sq km.*

- **Diseases and rising sea temperatures threaten to damage coral reefs across the Caribbean region.** Although not quantitatively assessed in this project, diseases and warming sea surface temperatures present further, and growing, region-wide threats to Caribbean coral reefs. Diseases have caused profound changes in Caribbean coral reefs in the past 30 years, with very few areas unscathed by disease, even reefs far removed from human influence. One of the region's major reef-building corals has already been devastated by disease. In addition, coral bleaching episodes—the most direct evidence of stress from global climate change on Caribbean marine biodiversity—are on the rise. The complex, synergistic

interactions between disease, climatic change, and other human-induced stresses may heighten the overall level of threat described above.

- **Ineffective management of protected areas further threatens Caribbean coral reefs.** With the growth of tourism, fisheries, and other development in coral reef areas, marine protected areas (MPAs) are an important tool for safeguarding coral reefs. At present, over 285 MPAs have been declared across the Caribbean, but the level of protection afforded by MPAs varies considerably. The Reefs at Risk Project found only 6 percent of MPAs to be rated as effectively managed and 13 percent as having partially effective management. An estimated 20 percent of coral reefs are located inside MPAs, but only 4 percent are located in MPAs rated as effectively managed. MPAs are but one tool available to reduce stress on coastal resources, but are by no means a shelter from all threats. This analysis of MPAs as a management tool is an indicator of the inadequacy of current efforts to manage coastal resources and protect coral reefs.

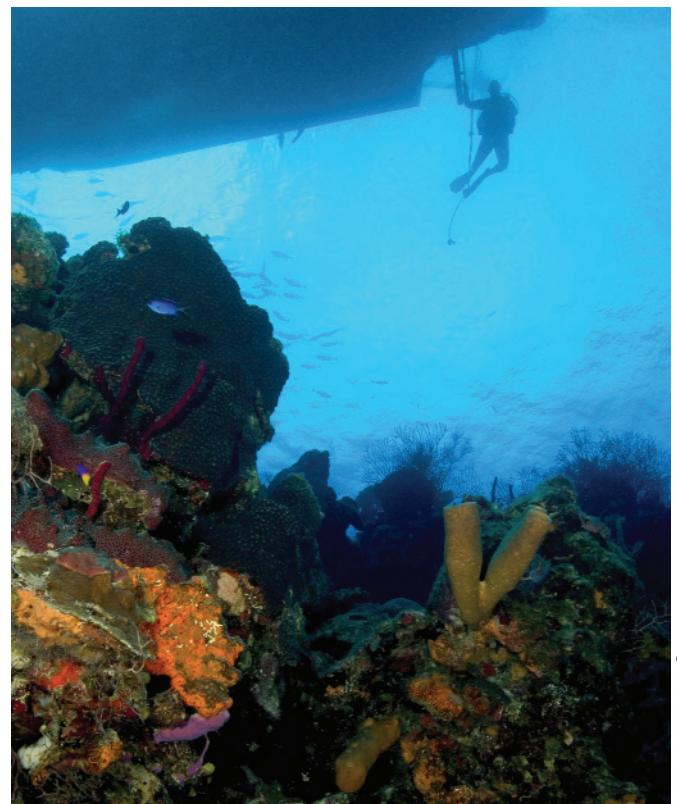


PHOTO: WOLCOTT HENRY ©

The diver entry fee at Bonaire Marine Park helps to support one of the best managed MPAs in the region.



■ **The coastal communities and national economies of the Caribbean region are poised to sustain substantial economic losses if current trends in coral reef degradation continue.**

Coral reefs provide valuable goods and services to support local and national economies, and degradation of coral reefs can lead to significant economic losses, particularly in the coastal areas of developing countries, through loss of fishing livelihoods, malnutrition due to lack of protein, loss of tourism revenues, and increased coastal erosion. Analyses carried out by the Reefs at Risk project indicate that Caribbean coral reefs provide goods and services with an annual net economic value in 2000 estimated at between US\$3.1 billion and US\$4.6 billion from fisheries, dive tourism, and shoreline protection services.

- o Coral reef-associated fisheries in the Caribbean region provide net annual revenues valued at an estimated US\$310 million. *Degradation of the region's coral reefs could reduce these net annual revenues by an estimated US\$95 million to US\$140 million per year by 2015.*
- o Net benefits from dive tourism total an estimated US\$2.1 billion per year in 2000. Dive tourism is high-value tourism, with divers typically spending 60–80 percent more than other tourists. *By 2015, coral reef degradation could result in annual losses of US\$100 million to US\$300 million to the Caribbean tourism industry.* Losses to particular areas within the Caribbean could be proportionately greater, as tourism shifts away from areas where coral reefs have become degraded and toward areas of remaining intact reefs.
- o Coral reefs protect coastal shorelines by dissipating wave and storm energy. The estimated value of shoreline protection services provided by Caribbean reefs is between US\$700 million and US\$2.2 billion per year. *Within the next 50 years, coral degradation and death could lead to losses totaling US\$140 million to US\$420 million annually.*

## CONCLUSIONS AND RECOMMENDATIONS

The coral reefs of the Caribbean, a mainstay of the region's economic and social health, are beset by a wide range of threats resulting from human activities. Degradation of coral reefs damages not only the integrity of these important ecosystems but also the health, safety, and livelihoods of the human societies that depend on them. Although the potential human and economic losses are great, actions to reverse the threats to Caribbean coral reefs can often be undertaken at very low cost, with very high financial and societal returns, even in the short term.

Actions are required across a range of scales—from local to national and international. Such actions include the establishment of better management practices to encourage sustainable fisheries, to protect reefs from direct damage, and to integrate the sometimes conflicting approaches to management in the watersheds and adjacent waters around coral reefs. Fundamental to supporting these actions is wider involvement of the public and stakeholders in the management process, as well as an improved level of understanding of the importance of coral reefs. Better understanding of the economic value of coastal ecosystems and of the linkages between human activities and changes in coral reef condition will further support and underpin the necessary changes in management and will strengthen political and societal support for these changes.

To these ends, we recommend the following specific actions:

### *Create the Will for Change*

- **Raise awareness of the importance, value, and fragility of coral reefs through targeted education campaigns.** Many residents and visitors to the Caribbean fail to realize and understand the connections between their own activities and the health of coral reefs. Educators, universities, nongovernmental organizations (NGOs), and others should help change behavior and build political will for policy change by developing and disseminating educational materials aimed at key audiences, such as community groups, fishers, workers in the tourist industry, tourists, developers, politicians, and students.

- **Factor the economic value of coral reef goods and services into development planning, policies, and projects.** Incorporating information on the economic value of the goods and services provided by coral reefs can help bolster arguments for strengthening and expanding reef protection and management programs. Researchers should undertake additional, regionally consistent economic valuation studies of Caribbean coral reefs, and decision-makers should use the results of these studies to debate the true costs of development options and select development that minimizes damage to reef ecosystems.

### *Build Capacity for Change*

- **Develop local and national expertise for better management of coral reef ecosystems through training of resource managers and decision-makers.** Financial resources, educational levels, and availability of training vary widely across the region, and the small size of many countries undermines their ability to sustain full scientific and administrative capacities. National governments, international organizations, NGOs, and others should support and implement expanded provision of training to coastal resource managers and decision-makers across the region.



PHOTO: KELVIN GUERRERO

Sharing ideas, knowledge, and success stories is fundamental to developing management capacity.

- **Encourage free flow and exchange of information and experience about management and protection of coral reef resources.** Across the Caribbean, there are examples of excellence in management, training programs, govern-

ment and community involvement, research, and monitoring. International NGOs and intergovernmental agencies should facilitate increased sharing of information and expertise among countries, among government agencies, and among scientists and management agencies.

- **Facilitate stakeholder participation in decision-making about management and protection of coral reef resources.** The absence of community inclusion and participation has played a key role in the failure of many reef management efforts. National governments and resource managers need to apply collaborative and cooperative approaches to coral reef management, making sure to involve all stakeholder groups.
- **Create the systems of governance required for effective management of coral reefs.** In many cases, the activities of different groups, agencies, or even international bodies concerned with management of marine resources overlap and even conflict. National governments can facilitate good governance of the coastal zone by carrying out national assessments of the institutional and legal framework for executing policy and updating institutional and legal frameworks where necessary.
- **Integrate socioeconomic and environmental monitoring to increase understanding of coastal habitats.** Good management requires continued access to information about natural resources and how they change over time and in response to natural and human influences. The scientific community and resource managers should move toward monitoring programs that integrate human, physical, and ecological data.
- **Use the Reefs at Risk indicators and apply the analytical methodology at finer resolutions to support decision-making on coral reef management.** The analysis and tools developed under this project provide a valuable and low-cost means of understanding potential pressures on coral reefs. National, provincial, and local resource agencies should contribute to the development of similar

indicators at a finer scale to help increase confidence in and support for wise management decisions.

### *Improve Management*

- **Develop sustainable fisheries through education, stakeholder involvement, and reduced intensity of fishing practices.** Fishing is exceeding sustainable levels in most Caribbean countries. National governments should work with resource users and other stakeholder groups to implement sustainable fishing policies and practices. Licensing, incentives for sustainable practices, and penalties for illegal fishing can help reduce the intensity of fishing practices. The establishment of “no take areas” or “marine fishery reserves” can be adopted, in part, as a strategy to replenish depleted fish stocks. Critical to the success of such reserves will be involving and educating stakeholders and providing alternative income generation.
- **Apply holistic approaches to coastal zone management.** Successful management of coral reef ecosystems entails dealing effectively with multiple influences and threats, many of which can be traced to activities taking place at considerable distances from the reefs themselves. National governments need to provide incentives for agencies with disparate mandates and conflicting agendas to share information and work together effectively.
- **Expand Marine Protected Areas and improve their management effectiveness in safeguarding coral reef ecosystems.** Marine Protected Areas (MPAs) are an important component of comprehensive coastal-area management; however, only a small percentage of coral reefs are located within designated MPAs and only a small percentage of MPAs are rated as fully or partially effective. National governments, donors, NGOs, and the private sector need to support expansion of MPAs to cover additional coral reefs and to provide assistance to strengthen the management effectiveness of many existing MPAs.

- **Develop tourism sustainably to ensure long-term benefits.** Tourism is vital to the Caribbean region, but unplanned, unrestricted development can severely damage coral reefs. Decision-makers should take steps to limit such damage, including education of tourists and development of certification schemes, accreditation, and awards for good environmental practices as incentives for environmentally sensible development.
- **Implement good marine practices to restrict dumping of waste at sea and the clearing of ballast waters.** Regional bodies, national governments, NGOs, and the private sector should work together to develop best practices (for example, in the cruise industry). Ports, harbors, and marinas need to offer pump-out and waste treatment facilities for vessels of all sizes.

### *International Action*

- **Ratify and implement international agreements.** International agreements are an important tool for setting targets and achieving collective goals. National governments should not only sign but also implement important international agreements addressing the threats evaluated in this study, including the Cartagena Convention (addressing land-based sources of pollution, oil spills, and protected areas and wildlife), the United Nations (UN) Convention on the Law of the Sea (on ocean governance), MARPOL (on marine pollution), and the UN Framework Convention on Climate Change.
- **Promote international cooperation and exchange.** Even in the absence of international legal instruments, regional collaboration on issues such as fisheries and watershed management could greatly reduce some threats. International NGOs, intergovernmental agencies, and funding organizations can actively support cooperation and exchange to promote synergy and foster partnerships to protect Caribbean coral reefs.





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