

1. Introduction

On October 20, 2009, the National Marine Fisheries Service (NMFS) received a petition from the Center for Biological Diversity (CBD) to list 83 species of coral as either threatened or endangered under the Endangered Species Act (ESA). In response, NMFS issued a 90-day finding (75 FR 6616, February 10, 2010), which determined that the petition contained substantial information indicating listing may be warranted for all of the petitioned species except *Oculina varicosa* (see the 90-day finding for information included in the petition). Thus, NMFS initiated a status review of the remaining 82 species of corals; *O. varicosa* will not be considered further. NMFS convened a Coral Biological Review Team (BRT) to assess the biological status of each of the 82 corals, and threats to these species with regard to the factors listed under section 4(a)(1) of the ESA. The BRT's Status Review Report (hereafter "BRT Report", cited as Brainard *et al.* 2011) evaluated the status of these species and the risk of extinction faced by each using the best available scientific and commercial data and analyses, including the best available climate change and ocean acidification scenarios. In addition, the Pacific Islands Regional Office (PIRO) staff developed this report on management actions relevant to the species across their their range, including existing regulatory mechanisms and conservation efforts (hereafter "Management Report"). The BRT Report and this Management Report together constitute the comprehensive status review for the 82 coral species.

The purposes of . . . [the ESA] are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in subsection (a) of . . . [Section 2 of the ESA, 16 U.S.C. § 1531(a)], 16 U.S.C. § 1531(b). The U.S. Fish and Wildlife Service (USFWS) and NMFS share responsibility for administering the ESA; NMFS is responsible for determining whether marine, estuarine or anadromous species, subspecies, or distinct population segments are threatened or endangered under the ESA. : *"The term 'species' includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature."* 16 U.S.C. § 1532(16). *"The term 'endangered species' means any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man."* 16 U.S.C. § 1532(6). *"The term 'threatened species' means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.* 16 U.S.C. § 1532(20).

The process for determining whether a species should be listed as threatened or endangered is based upon "the best scientific and commercial data available . . ." 16 U.S.C. § 1533(b)(1)(A). Section 4(a)(1) of the ESA states that:

[t]he Secretary shall . . . determine whether any species is an endangered species or a threatened species because of any of the following factors:

(A) the present or threatened destruction, modification, or curtailment of its habitat or range;

(B) overutilization for commercial, recreational, scientific, or educational purposes;

(C) disease or predation;

(D) the inadequacy of existing regulatory mechanisms; or

(E) other natural or manmade factors affecting its continued existence.

16 U.S.C. § 1533(a)(1). In addition, Section 4(b)(1)(A) of the ESA requires NMFS to take into account conservation efforts being made to protect a species that has been petitioned for listing. § 1533(b)(1)(A). Factors A, B, C, and E above were considered in the BRT Report (Brainard *et al.* 2011). Factor D, and conservation efforts were not considered by the BRT in its report, because a determination whether a species warrants listing under the ESA is the ultimate determination that involves applying the management judgment of the agency (including legal and policy dimensions) to the best available science. Thus, these factors are identified and summarized in this Management Report. Therefore, this report covers existing regulatory mechanisms (factor D) and conservation efforts (section 4(b)(1)(A)).

Existing regulatory mechanisms summarized in this Management Report include international treaties, laws, decrees, executive orders, rules and/or regulations enacted and being implemented by some governing body or official, whether they are international organizations, national governments, state and local authorities, heads-of-state, or other so empowered official, affecting the status of the 82 coral species. Conservation efforts summarized in this report include actions, activities, and programs undertaken by both governmental and non-governmental organizations (“NGOs,” e.g., conservation groups, private companies, academia, etc.) that may eliminate or reduce threats or otherwise improve the status of the 82 coral species identified by the BRT Report.

The first purpose of this report is to identify existing regulatory mechanisms as per ESA Section 4(a)(1)(D) that are or may be affecting the threats contributing to extinction risk for the 82 coral species, to determine whether regulatory mechanisms themselves are inadequate such that they are contributing to the species’ endangerment. This is accomplished by: (1) identification of existing regulatory mechanisms directly or indirectly addressing the most important threats to the 82 species in general; and (2) identification of existing regulatory mechanisms directly or indirectly addressing the local threats to the 82 species in general. The second purpose of this report is to identify conservation efforts with regard to the status of the 82 coral species as per ESA Section 4(b).

1.1 Current Ranges of the 82 Species: Caribbean vs. Indo-Pacific

Of the 82 coral species included in the status review, 7 are located in the Caribbean region while the remaining 75 are located in the Indo-Pacific region. The collective ranges of the 82 species occur in 84 countries (Figure 1, Table 1). The Caribbean and Indo-Pacific regions are highly dissimilar in their physical and geographical characteristics; however, they are both comprised primarily of developing countries (many of them small island developing states (SIDS)) and therefore have socio-economic and political commonalities. Additionally, both regions are vulnerable to the effects of global climate change, particularly coral bleaching events and sea-level rise which are likely to detrimentally affect the regions' natural resources and economies.

For the purposes of this report, the Caribbean region includes the reef tract of south Florida and the Florida Keys, Puerto Rico, the U.S. Virgin Islands (USVI) and all the islands of the wider Caribbean region. The Caribbean is a relatively small and somewhat enclosed system in comparison to the Indo-Pacific. Comprised mostly of SIDS, the Caribbean is the most tourism-dependent region in the world (Niles 2010). Relatively high human population densities and a long history of pervasive human impacts to coral reef systems exist across the region. The World Resource Institute conducted a study to assess the status of coral reefs within the wider Caribbean Region and determined that nearly two-thirds of Caribbean coral reefs are threatened by at least one form of human activity, with continuing threats of region-wide damage due to rising sea temperatures and disease (Burke and Maidens 2004). Additionally, none of the Caribbean's three keystone species indicative of reef health (the corals *Acropora palmata* and *A. cervicornis*, and the urchin *Diadema antillarum*) show significant recovery over decadal time scales (Brainard *et al.* 2011). The region is also susceptible to strengthening storms and hurricanes, and suffers mass bleaching events, hampering ecosystem recovery.

In contrast with the Caribbean, the Indo-Pacific is an enormous region including both the Indian and Pacific Ocean basins. About 80 percent of the world's coral reefs are in the Indo-Pacific, with over half found in five countries or their territories (Indonesia, Australia, Philippines, France, and Papua New Guinea; World Atlas of Coral Reefs). This region hosts a much larger amount of coral diversity than the Caribbean; the Indo-Pacific is home to 700 species, compared to 65 species in the Caribbean. The sheer size and amount of diversity of the Indo-Pacific, combined with vast expanses of ocean has provided a substantial buffer to Indo-Pacific corals from the human induced influences and declines that have manifested across the Caribbean (Brainard *et al.* 2011). Additionally, increased rates of CO₂ uptake in the Northern Atlantic Ocean caused a decrease in resiliency of corals in the wider Caribbean, while corals in the Pacific maintained resilience despite major bleaching events. Moreover, the Indo-Pacific's Coral Triangle is the epicenter of coral biodiversity, containing the greatest number of endemic scleractinian species, while the highest proportions of endemic scleractinians are found in the more remote Indo-Pacific archipelagoes (e.g., 20 percent of Hawaiian scleractinian species are endemic). However, consensus is building that these buffering factors have simply put the Indo-Pacific on a slower journey down a similar road of decline as the Caribbean, rather than a qualitatively different trajectory (Brainard *et al.* 2011).

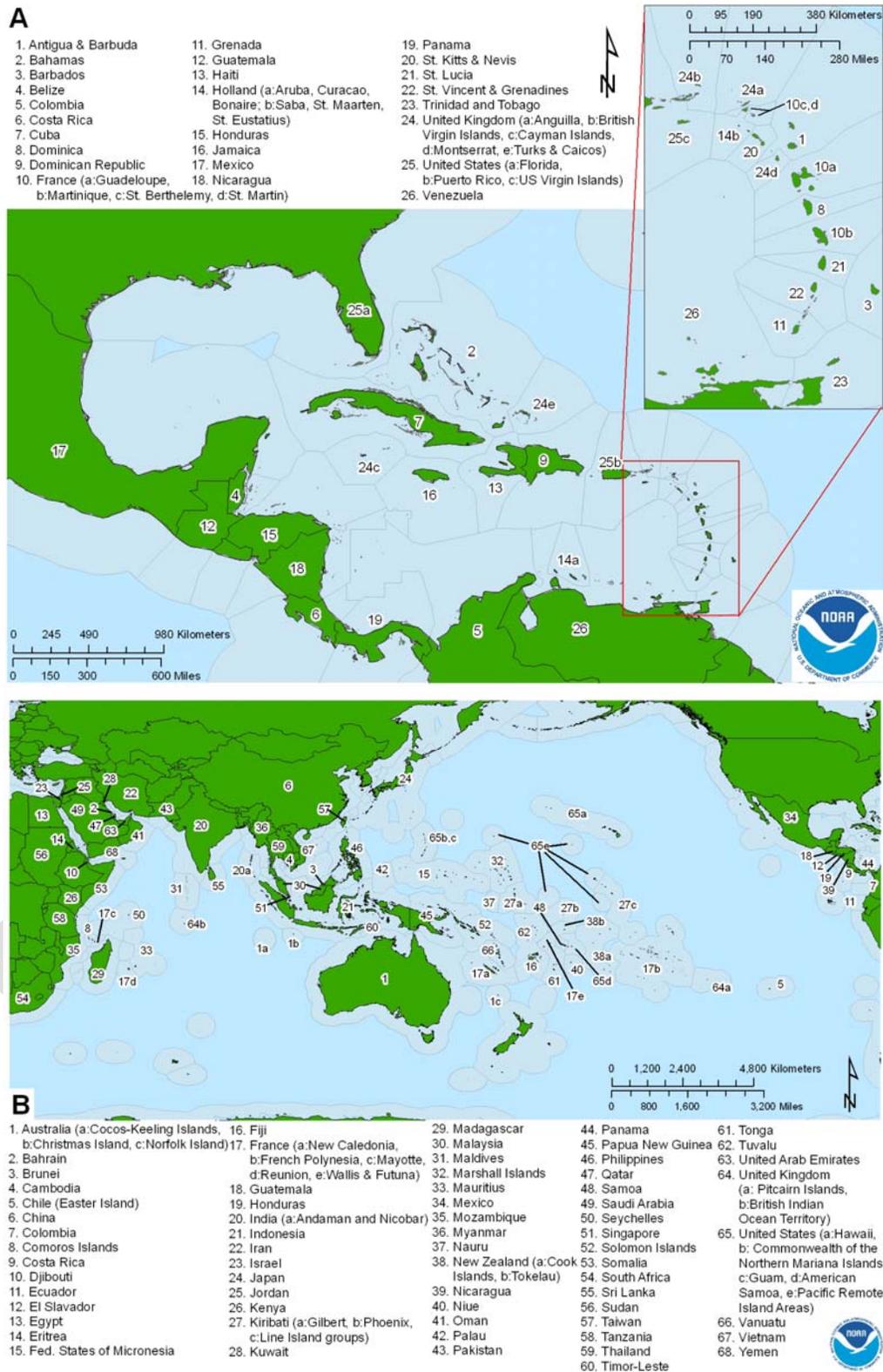


Figure 1. The 84 countries within ranges of the 82 coral species in A. Caribbean Region (26 countries), and B. Indo-Pacific Region (68 countries). Ten countries include areas in both regions (Columbia, Costa Rica, France, Guatemala, Honduras, Mexico, Nicaragua, Panama, U.K., and U.S.).

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A. Caribbean Region	B. Indo-Pacific Region	
Antigua & Barbuda	Australia ¹	Mozambique
Bahamas	Bahrain	Myanmar
Barbados	Brunei	Nauru
Belize	Cambodia	New Zealand ²
Colombia	Chile (Easter Island)	Nicaragua
Costa Rica	China	Niue
Cuba	Colombia	Oman
Dominica	Comoros Islands	Palau
Dominican Republic	Costa Rica	Pakistan
France ³	Djibouti	Panama
Grenada	Ecuador	Papua New Guinea
Guatemala	El Salvador	Philippines
Haiti	Egypt	Qatar
Holland ⁴	Eritrea	Samoa
Honduras	Fed. States of Micronesia	Saudi Arabia
Jamaica	Fiji	Seychelles
Mexico	France ⁵	Singapore
Nicaragua	Guatemala	Solomon Islands
Panama	Honduras	Somalia
St. Kitts & Nevis	India	South Africa
St. Lucia	Indonesia	Sri Lanka
St. Vincent & Grenadines	Iran	Sudan
Trinidad & Tobago	Israel	Taiwan
United Kingdom ⁶	Japan	Tanzania
United States ⁷	Jordan	Thailand
Venezuela	Kenya	Timor-Leste
	Kiribati	Tonga
	Kuwait	Tuvalu
	Madagascar	United Arab Emirates
	Malaysia	United Kingdom ⁸
	Maldives	United States ⁹
	Marshall Islands	Vanuatu
	Mauritius	Vietnam
	Mexico	Yemen

¹ Includes Australia colonies of Cocos-Keeling Islands, Christmas Island, and Norfolk Island.

² Includes New Zealand colonies of Cook Islands and Tokelau.

³ Includes French territories of Guadeloupe, Martinique, St. Barthelemy, St. Martin.

⁴ Includes Dutch territories of Aruba and Netherlands Antilles.

⁵ Includes the French territories of New Caledonia, French Polynesia, Mayotte, Reunion, Wallis and Futuna

⁶ Includes British territories of Anguilla, British Virgin Islands, Cayman Islands, Montserrat, and Turks & Caicos Islands.

⁷ Includes Florida and U.S. territories of Puerto Rico, Navassa, and U.S. Virgin Islands

⁸ Includes British colonies of Pitcairn Islands and British Indian Ocean Territory

⁹ Includes Hawaii, Commonwealth of the Northern Mariana Islands, Territories of Guam and American Samoa, and the US Pacific Island Remote Area

1.2 Threats to the 82 Species

The Coral BRT identified 19 threats to reef-building corals in general, including the 82 coral species (Table 2), and gave each threat a ranking of high, medium, low or negligible (or combinations of two, i.e. “low-medium”) in terms of the overall importance of the threat to the 82 coral species. That is, rankings are dependent on each threat’s perceived significance in terms of posing extinction risk to the 82 coral species collectively across their ranges (Table 2). Ocean warming, disease, and ocean acidification are the highest ranked threats. The detrimental trophic effects of fishing (i.e., over-fishing) received a medium ranking, and land-based sources of pollution (sedimentation and nutrients) and sea-level rise received rankings of low-medium. All of the remaining threats received rankings of low or negligible (Brainard *et al.* 2011).

Table 2. Threats considered by the BRT in assessing extinction risks to the 82 coral species, including the BRT’s estimate of each threat’s relative importance (Brainard *et al.* 2011).

Threat	Importance
Ocean Warming	High
Disease	High
Ocean Acidification	Med-High
Reef Fishing – Trophic Effects	Medium
Sedimentation	Low-Medium
Nutrients	Low-Medium
Sea-Level Rise	Low-Medium
Toxins	Low
Changing Ocean Circulation	Low
Changing Storm Tracks/Intensities	Low
Predation	Low
Reef Fishing – Habitat Impacts /Destructive Fishing Practices	Low
Ornamental Trade	Low
Natural Physical Damage	Low
Human-induced Physical Damage	Negligible-Low
Aquatic Invasive Species	Negligible-Low
Salinity	Negligible
African/Asian Dust	Negligible
Changes in Insolation	Probably Negligible

The threats identified above in Table 2 and summarized below in Section 1.2.1 are generalized for all reef-building corals, including the 82 coral species, based on the “Threats to Coral Species” section of the BRT Report (Chapter 3, Brainard *et al.*, 2011). This generalized description of threats to reef-building corals does not necessarily account for variation in the importance of threats to each of the 82 coral species. As described in Section 1.2.2 below, the “Individual Species Accounts” sections of the BRT Report provide evaluations of the most important threats for each of the 82 species (Chapter 6 for Caribbean species, Chapter 7 for Indo-Pacific species, Brainard *et al.*, 2011).

1.2.1 Threats Affecting Coral Species Generally

The threats listed in Table 2 can be divided into threats related to greenhouse gas emissions, and threats related to a variety of more localized human activities.

1.2.1.1 Threats Related to Greenhouse Gas Emissions

The BRT rated ocean warming, coral disease, and ocean acidification as the highest importance threats to the 82 coral species (Table 2). Ocean warming results in bleaching of adult coral colonies, wherein corals expel their symbiotic zooxanthellae in response to stress. Corals can withstand mild to moderate bleaching; however, severe, repeated, or prolonged bleaching can lead to colony death. Ocean warming is also a primary cause of increased prevalence and severity of coral diseases, for example by causing pathogens to grow faster and be more virulent. Ocean acidification may reduce coral calcification, leading to reduced coral growth rates and increased mortality, among many other detrimental effects. The effects of ocean warming, disease, and ocean acidification on corals can occur together, compounding their overall effects. These three high importance threats are described in detail in the BRT Report (Brainard *et al.*, 2011).

As a result of increasing anthropogenic greenhouse gases (GHGs) in the atmosphere since the Industrial Revolution, sea surface temperatures are rising, including in waters around many coral reefs (i.e., ocean warming). Ocean warming is a primary driver of coral bleaching and disease. Also as a result of increasing atmospheric GHGs, specifically the increasing concentrations of CO₂ in the atmosphere, a corresponding change occurred in the partial pressures of CO₂ in the surface ocean, resulting in reduced pH (i.e., ocean acidification). The relationship of GHGs to ocean warming and ocean acidification is described in detail in the BRT Report (Brainard *et al.*, 2011).

1.2.1.2 Local Threats Affecting Coral Species Generally

The BRT also identified threats to corals from more localized human activities. Reef fishing (trophic effects, habitat impacts), land-based sources of pollution (sedimentation, nutrients, toxins, and salinity), predation, ornamental trade, physical damage, aquatic invasive species, and African/Asian dust (Table 2), are described in detail in the BRT Report (Brainard *et al.*, 2011). Only three of these local threats are rated by the BRT as up to medium in importance: trophic effects of reef fishing, and two types of land-based pollution (sedimentation and nutrients; Table 2). Trophic effects of fishing occur when herbivorous reef fish, such as parrotfish, are heavily fished down to the point where the absence of their grazing pressure allows algae to outcompete and exclude coral settlement and even overgrowth of corals. Sedimentation and nutrients are land-based pollutants: human activities in coastal watersheds introduce sediment and nutrients into the ocean by a variety of mechanisms, including river discharge, surface runoff, groundwater seeps, and atmospheric deposition (Brainard *et al.*, 2011). Other local threats are rated as low or negligible in importance to the 82 coral species (Table 2), including other types of land-based sources of pollution (toxins, salinity), ecological processes (predation, invasive species), reef fishing (habitat damage), ornamental trade, and physical damage (natural and human) (Brainard *et al.*, 2011).

1.2.2 Individual Threats to Each of the 82 Species

Within the context of the general threats summary (Chapter 3 of BRT Report; Brainard *et al.*, 2011), the BRT evaluated threats to each of the 82 species (Chapter 6 and 7 of BRT Report;

Brainard *et al.*, 2011). Information is not available to determine the relative importance of all 19 general threats (Table 2) to each of the 82 species. However, the BRT used the best available information to describe the susceptibility of each species to the three most important general threats (bleaching from ocean warming, coral disease, ocean acidification), as well as the susceptibility of each species to as many of the local threats for which information was available.

2. Existing Regulatory Mechanisms

2.1 Regulatory Mechanisms Addressing GHG Emissions

The two major types of existing regulatory mechanisms addressing GHG emissions are international treaties and conventions (Section 2.1.1), and national laws and regulations. For the latter, national laws and regulations are described for the top 25 GHG emitters in the world (Section 2.1.2).

2.1.1 International Regulatory Mechanisms Addressing GHG Emissions

2.1.1.1 Background

The World Meteorological Organization (WMO) held the First World Climate Conference from February 12-23, 1979 in Geneva. As one of the first major international meetings on climate change, it was essentially a scientific conference attended by scientists from a wide range of disciplines. In addition to the main plenary sessions, the conference organized four working groups to look into climate data, the identification of climate topics, integrated impact studies, and research on climate variability and change. The Conference led to the establishment of the World Climate Program and to the creation of the Intergovernmental Panel on Climate Change (IPCC) by WMO and the United Nations Environment Program (UNEP) in 1988. The World Climate Program facilitates, among other things, the effective collection and management of climate data and the monitoring of the global climate system, including the detection and assessment of climate variability and changes. The IPCC, on the other hand, does not conduct scientific research on various aspects of climate change; rather they compile, review, and summarize all relevant scientific literature that will help inform policy makers dealing with climate change mitigation and adaptation. They are both scientific bodies that were created to fulfill a global need for a clear, broad, and balanced scientific view of what is happening to the world's climate.

The Second Climate Conference was held again in Geneva from October 29 to November 7, and represented an important step towards a global climate treaty. The initial task for the IPCC as outlined in the UN General Assembly Resolution 43/53 of 6 December 1988 was to prepare a comprehensive review and recommendations with respect to the state of knowledge of the science of climate change; social and economic impact of climate change, possible response strategies, and elements for inclusion in a possible future international convention on climate. The scientific evidence summarized in the first IPCC Assessment Report (1990) succeeded in bringing climate change and its potential consequences to the forefront as an important topic for countries to address, as evidenced by the continued international efforts and actions described below. Eventually, developments at this second World Climate Conference led to the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) that was finalized and opened for signature at the Earth Summit in Rio in 1992. World Climate Conference-3 (WCC-3) was held in Geneva, Switzerland, August 31 to September 4, 2009. Its