

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 U.S. Endangered Species Act. Eight of these species are found in the western Atlantic/Caribbean (indicated by (C) in the list below), and the remaining 75 species are found in the Pacific and Indian Oceans (Indo-Pacific). In alphabetical order, the 83 species included in the petition (using Cairns et al (1999) for the spelling of the species names) are:

<i>Acanthastrea brevis</i>	<i>Astreopora cucullata</i>	<i>Montipora dilatata</i>
<i>Acanthastrea hemprichii</i>	<i>Barabattoia laddi</i>	<i>Montipora flabellata</i>
<i>Acanthastrea ishigakiensis</i>		<i>Montipora lobulata</i>
<i>Acanthastrea regularis</i>	<i>Caulastrea echinulata</i>	<i>Montipora patula</i>
<i>Acropora aculeus</i>	<i>Cyphastrea agassizi</i>	<i>Mycetophyllia ferox</i> (C)
<i>Acropora acuminata</i>	<i>Cyphastrea ocellina</i>	
<i>Acropora aspera</i>		<i>Oculina varicosa</i> (C)
<i>Acropora dendrum</i>	<i>Dendrogyra cylindrus</i> (C)	
<i>Acropora donei</i>		<i>Pachyseris rugosa</i>
<i>Acropora globiceps</i>	<i>Dichocoenia stokesi</i> (C)	
<i>Acropora horrida</i>		<i>Pavona bipartita</i>
<i>Acropora jacquelineae</i>	<i>Euphyllia cristata</i>	<i>Pavona cactus</i>
<i>Acropora listeri</i>	<i>Euphyllia paraancora</i>	<i>Pavona decussata</i>
<i>Acropora lokani</i>	<i>Euphyllia paradivisa</i>	<i>Pavona diffluens</i>
<i>Acropora microclados</i>		<i>Pavona venosa</i>
<i>Acropora palmerae</i>	<i>Galaxea astreata</i>	
<i>Acropora paniculata</i>		<i>Pectinia alcornis</i>
<i>Acropora pharaonis</i>	<i>Heliopora coerulea</i>	
<i>Acropora polystoma</i>		<i>Physogyra lichtensteini</i>
<i>Acropora retusa</i>	<i>Isopora crateriformis</i>	
<i>Acropora rudis</i>	<i>Isopora cuneata</i>	<i>Pocillopora danae</i>
<i>Acropora speciosa</i>		<i>Pocillopora elegans</i>
<i>Acropora striata</i>	<i>Leptoseris incrustans</i>	
<i>Acropora tenella</i>	<i>Leptoseris yabei</i>	<i>Porites horizontalata</i>
<i>Acropora vaughani</i>		<i>Porites napopora</i>
<i>Acropora verweyi</i>	<i>Millepora foveolata</i>	<i>Porites nigrescens</i>
	<i>Millepora tuberosa</i>	<i>Porites pukoensis</i>
<i>Agaricia lamarcki</i> (C)		
	<i>Montastraea annularis</i> (C)	<i>Psammocora stellata</i>
<i>Alveopora allingi</i>	<i>Montastraea faveolata</i> (C)	
<i>Alveopora fenestrata</i>	<i>Montastraea franksi</i> (C)	<i>Seriatopora aculeata</i>
<i>Alveopora verrilliana</i>		
	<i>Montipora angulata</i>	<i>Turbinaria mesenterina</i>
<i>Anacropora puertogalerae</i>	<i>Montipora australiensis</i>	<i>Turbinaria peltata</i>
<i>Anacropora spinosa</i>	<i>Montipora calcarea</i>	<i>Turbinaria reniformis</i>
	<i>Montipora caliculata</i>	<i>Turbinaria stellula</i>

The petition states that all of these species are classified as vulnerable (76 species), endangered (6 species: *Acropora rudis*, *Anacropora spinosa*, *Montipora dilatata*, *Montastraea annularis*, *M. faveolata*, *Millepora tuberosa*) or critically endangered (1 species: *Porites pukoensis*) by the International Union for Conservation of Nature (IUCN). *Montipora dilatata* and *Oculina varicosa* are also on the NMFS Species of Concern list. The petition also purports that all of these species occur in U.S. waters.

The NMFS issued a 90-day finding (National Marine Fisheries Service, 2010), wherein the petition was determined to contain substantial information for all of the petitioned species except *Oculina varicosa* (see the 90-day finding for information included in the petition). Thus, the NMFS initiated a status review of the remaining 82 species of corals; *O. varicosa* will not be considered further. The NMFS Pacific Islands Regional Office (PIRO) and the Southeast Regional Office (SERO) requested that the NMFS Pacific Islands Fisheries Science Center (PIFSC) and the Southeast Fisheries Science Center (SEFSC) form a Biological Review Team (BRT) to review the status of the 82 candidate coral species. The PIFSC and SEFSC Directors then issued invitations for participation on the BRT.

The NMFS requested the BRT to assess the status of each candidate coral species and the degree of threat to each of the species with regard to the factors listed under Section 4 of the U.S. Endangered Species Act of 1973 (16 *United States Code* 1531-1544, 87 Statute 884), without making recommendations about whether any of the 82 candidate coral species should be listed as threatened or endangered. This Status Review Report provides the BRT's evaluation of the status of each of the 82 candidate coral 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.

1.1 Scope and Intent of 82 Corals Status Review Report

In May 2010, the NMFS convened the 82-Corals BRT, including experts in the fields of coral biology and ecology, physical oceanography, climate change, and population dynamics to prepare a Status Review Report of the 82 candidate coral species as mandated by the U.S. Endangered Species Act. This Status Review Report includes a determination of the risk of extinction for each of the 82 candidate coral species out to the year 2100 based on an evaluation of the best available information and data including the following topics: (1) long-term trends in abundance throughout the species' ranges; (2) potential factors for any declines of the species throughout their ranges (human population and consumption, climate change, ocean acidification, overharvesting, natural predation, disease, habitat loss, etc.); (3) historical and current range, distribution, and habitat use of the species; (4) historical and current estimates of the species' population sizes and available habitats; and (5) knowledge of various life history parameters (size/age at maturity, fecundity, length of larval stage, larval dispersal dynamics, etc.). In evaluating the risks of extinction, the BRT did not make any assumptions about future policy changes or technological advances that could potentially alter the projections used in this analysis.

1.1.1 Background on the Endangered Species Act

The purposes of the U.S. Endangered Species Act are to provide a means to conserve ecosystems on which endangered species and threatened species depend, to provide a program for the conservation of endangered and threatened species, and to take appropriate steps to recover a species. The U.S. Fish and Wildlife Service (USFWS) and the NMFS share responsibility for administering the Endangered Species Act; the NMFS is responsible for determining whether marine, estuarine or anadromous species, subspecies or distinct population segments are threatened or endangered under the Endangered Species Act. To be considered for listing under the Endangered Species Act, a group of organisms must constitute a "species."

The U.S. Endangered Species Act and a 1996 joint USFWS-NMFS policy (U.S. Fish and Wildlife Service and National Marine Fisheries Service, 1996) provide the following definitions and criteria for designation of a population or group of populations:

*"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."*

*"**endangered species**" is defined as "any species which is in danger of extinction throughout all or a significant portion of its range."*

*"**threatened species**" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."*

The NMFS must base its determinations on whether to list species solely on the best available scientific and commercial information. The status of each species is evaluated by estimating the risk of extinction and determining whether the species is an endangered species or a threatened species based on any of the following factors in Section 4(a)(1) of the U.S. Endangered Species Act:

- 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. Inadequacy of existing regulatory mechanisms; or
- E. Other natural or manmade factors affecting the continued existence of the species.

The purpose of this Status Review Report is to provide important information about the status and risk of extinction for each of the 82 candidate coral species for use in making these listing determinations. This Status Review Report does not assess the inadequacy of existing regulatory mechanisms (listing factor D above).

1.1.2 Candidate species/Species of Concern listing

Each of the 82 coral species included in this Status Review Report are considered to be candidate species under the U.S. Endangered Species Act. “Candidate species” refers to (1) species that are the subject of a petition to list and for which the NMFS has determined that listing may be warranted pursuant to Endangered Species Act Section 4(b)(3)(A), and (2) species for which the NMFS has determined, following a status review, that listing is warranted (whether or not they are the subject of a petition). Further, of the 82 candidate coral species considered in this Status Review Report, only *Montipora dilatata* has previously been identified as a Species of Concern under the Endangered Species Act (National Marine Fisheries Service, 2004). A “species of concern” identifies species about which NMFS has some concerns regarding status and threats, but for which insufficient information is available to indicate a need to list the species under the Endangered Species Act. For example, *Montipora dilatata* was identified as a Species of Concern in 2004 based on the species being very rare, endemic to a small geographic area (Hawai`i), and subject to the following factors for decline: (1) vulnerability to coral bleaching; (2) fresh water kills and exposure at extreme low tide; (3) habitat degradation and modification as a result of sedimentation, pollution, and alien alga invasion; and (4) damage by anchors, fish pots, swimmers, and divers.

1.1.3 The “species” question

When conducting Status Review Reports, BRTs need to determine whether the nominal candidate species in question are in fact “species” as defined by the U.S. Endangered Species Act. Corals are marine invertebrates, not vertebrate species; therefore, individual coral species may not be subdivided into distinct population segments for the purposes of the Endangered Species Act (U.S. Fish and Wildlife Service and National Marine Fisheries Service, 1996). Although scientists have begun using genetic tools to reexamine coral taxonomic issues and identify coral populations, these data are still relatively sparse and generally do not exist across the full geographic ranges for any coral species. For each of the 82 candidate corals considered in this Status Review Report, the status of each species must be considered throughout their entire ranges when evaluating extinction risks. The best available literature relevant to each of the candidate coral species in this petition is examined in Chapter 2 and within the individual species accounts (Chapters 6 and 7).

1.2 The Petition

The purpose of this Status Review Report is to provide important information about the status and risk of extinction for each of the 82 candidate coral species for use by the NMFS in making listing determinations under the U.S. Endangered Species Act. ***The purpose of this Status Review Report is not to evaluate the validity of the specific assertions in the Petition or to provide alternative recommendations for other coral species to be considered for listing.*** However, a brief summary of the Petition is provided here for context.

The petition included descriptions of the morphology, life history, habitat, distribution, and loss estimates over 30 years (20 years into the past and 10 years into the future) for each of 83 petitioned coral species, threats facing each species, and descriptions of the status of coral reef ecosystems of the western Atlantic/Caribbean and Indo-Pacific areas. The petition asserted that each of the 83 petitioned coral species have suffered population reductions of at least 30% over a 30-year period, relying on information from the IUCN. The petition stated that the majority of coral species included in this petition occur in similar habitats in either the western Atlantic/Caribbean or Indo-Pacific basins and face the same threats. Eight of the petitioned species occur in the western Atlantic/Caribbean, and 75 occur in the Indo-Pacific. The

wider Caribbean, according to the petitioner, had the largest proportion of corals classified as being in one of the high extinction risk categories by the IUCN. The petitioner asserted that the Caribbean region suffered massive losses of corals in response to climate-related bleaching and mortality events of 2005, including a record-breaking series of 26 tropical storms and elevated ocean water temperatures. Further, the petitioner asserted that the U.S. Virgin Islands lost 51.5% of live coral cover, and that Florida, Puerto Rico, the Cayman Islands, St. Maarten, Saba, St. Eustatius, Guadeloupe, Martinique, St. Barthelemy, Barbados, Jamaica, and Cuba suffered bleaching of over 50% of coral colonies, citing Carpenter et al. (2008).

The petition described factors that it asserted have led to the current status of these corals, as well as threats that it asserted the species currently face, categorizing them under the Section 4(a)(1) factors. The petition focused on habitat threats, asserting that the habitats of the 83 petitioned coral species, and indeed all reef-building coral species, are under threat from several processes linked to anthropogenic greenhouse gas emissions, including increasing seawater temperatures, increasing ocean acidification, increasing storm intensities, changes in precipitation, and sea-level rise. The petition also asserted that these global habitat threats are exacerbated by local habitat threats posed by ship traffic, dredging, coastal development, pollution, and agricultural and land-use practices that increase sedimentation and nutrient loading. The petition asserted that this combination of habitat threats has already affected coral reef ecosystems on a global scale, and that these threats are currently accelerating in severity such that the quantity and quality of coral reef ecosystems are likely to be greatly reduced in the next few decades.

The petitioner cited Gardner et al. (2003) in asserting that, over the three decades prior to the 2005 events, Caribbean reefs had already suffered an 80% decline in hard coral cover, from an average of 50% to an average of 10% throughout the region. The abundance and trend information presented by the petitioner for each species was limited to an estimate of the percentage loss of its habitat and/or population over a 30-year period (including 20 years into the past and 10 years into the future), as assessed by the IUCN. However, the petition also asserted that these corals face significant threats. To support this assertion, the petitioner cited Alvarez-Filip et al. (2009) in noting the dramatic decline of the three-dimensional complexity of Caribbean reefs over the past 40 years, resulting in a phase shift from a coral-dominated ecosystem to fleshy macroalgal overgrowth in reef systems across the Caribbean.

The petitioner noted that, in the NMFS (2008) critical habitat designation for elkhorn (*Acropora palmata*) and staghorn (*Acropora cervicornis*) corals in the Atlantic, the NMFS identified chronic overfishing of herbivorous species and the die-off of 95% of the long-spined sea urchins (*Diadema antillarum*) across the region in the early 1980s as primary factors in this ecological shift (National Marine Fisheries Service, 2008). Based on that same critical habitat designation, the petitioner concluded that “in the absence of grazing pressure from herbivorous fish and urchins, fast growing algae, macroalgae, and other epibenthic organisms easily outcompete coral larvae by preempting available space, producing toxic metabolites that inhibit larval settlement, and trapping excess sediment in algal turfs.” The petitioner cited Gledhill et al. (2008) in asserting that ocean acidification led to a decrease in mean sea surface aragonite saturation state in the greater Caribbean region between 1996 and 2006. The petitioner stated that Hoegh-Guldberg et al. (2007) found marked reductions in resilience accompanied by increased grazing requirements to facilitate reef recovery after modeling the effects of a 20% decline in coral growth rate in response to ocean acidification on a Caribbean forereef.

The petitioner cited Bruno and Selig (2007) in stating that 75% of the world’s coral reefs can be found in the Indo-Pacific, which, as cited in the petition, stretches from the Indonesian island of Sumatra in the west to French Polynesia in the east. Further, the petitioner cited the same source, saying that as recently as 1000 to 100 years ago, this region probably averaged about 50% coral cover, but 20%–50% of that total has been lost since the 1980s. The petitioner asserted, citing again Bruno and Selig (2007), that this reduced coral cover was relatively consistent across 10 subregions of the Indo-Pacific in 2002–2003. The petitioner suggested that although these corals have recovered in the past (Colgan, 1987), anthropogenic stressors are increasing the frequency and intensity of mortality events and interfering with the natural ability of coral communities to recover (McClanahan et al., 2004a; Pandolfi et al., 2003). The petitioner cited Sheppard (2003) in explaining that the future of Indian Ocean reefs was a particular concern because over 90% of corals on many shallow water reefs died in 1998 in response to elevated sea surface temperatures, and because average temperatures in the Indian Ocean are expected to rise above 1998 levels within a few decades. The petitioner cited the same source in concluding that as elevated sea surface temperatures and associated climate-induced mass mortality events occur more frequently, it becomes less likely that there will be enough time between events for Indian Ocean reefs to recover.