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The Protected Resources Division provides stewardship of protected living marine resources through science-based conservation and management, and the promotion of healthy marine ecosystems.

ENDANGERED SPECIES ACT RECOVERY OUTLINE *Elkhorn & Staghorn Corals*

This document presents a broad outline for the recovery of elkhorn and staghorn corals. A recovery team was assembled for these species, and a recovery plan is being developed. This outline will serve to guide recovery-planning efforts and provide information for consultations and permitting activities until the recovery plan has been finalized and approved.

Listing and contact information for both species:

Scientific Name:	<i>Acropora palmata</i> , <i>Acropora cervicornis</i>
Common Name:	Elkhorn and Staghorn coral (respectively)
Listing Classification:	Threatened under the Endangered Species Act (ESA)
Listing Date:	May 9, 2006 (71 FR 26852)
Lead Agency:	National Marine Fisheries Service (NOAA Fisheries Service)
Lead Office:	Southeast Regional Office, St. Petersburg, Florida
Contact Biologist:	Jennifer Moore, 727-824-5312, Jennifer.Moore@noaa.gov

The general life history and habitat requirements of elkhorn and staghorn corals are well known. The historic range of both species has been determined based on historic quantitative data and recent qualitative data/observations. The most significant uncertainties with respect to setting recovery objectives and prioritizing recovery actions include the lack of specific information on: (1) the current and historical distribution and abundance; (2) reproduction, settlement, and recruitment processes; and (3) the causal factors for disease in each species. These uncertainties are acknowledged as playing a role limiting the initial recovery efforts for these species and should be resolved to the extent possible through the recovery planning process.

RECOVERY STATUS ASSESSMENT

BIOLOGICAL ASSESSMENT:

Recovery implications of the species' demographic and genetic status

Historic records indicate elkhorn (*Acropora palmata*) and staghorn (*Acropora cervicornis*) corals were commonly found in water depths between 1-30 m throughout the wider Caribbean. Survey data from the Atlantic and Gulf Rapid Reef Assessment Program (AGRRA) indicate the historic ranges of both species remain intact. However, staghorn coral is found rarely throughout the range (including areas of previously known occurrence), and elkhorn coral occurs more frequently but in moderation (*Acropora* Biological Review Team (BRT) 2005). Based on a few locations where quantitative data are available, declines in abundance (coverage and colony numbers) for both species are estimated at >97% (*Acropora* BRT 2005).

Elkhorn and staghorn corals both require hard, consolidated substrate free of macroalgae and sediment for attachment and settlement. Both species are heavily dependent upon sunlight for nourishment (Porter 1976, Lewis 1977) and require relatively clear, well-circulated water (Jaap et al. 1989). Optimal water temperatures for elkhorn and staghorn coral range between 25-29°C; they become susceptible to bleaching at temperature extremes and adverse environmental conditions (Ghiold and Smith 1990, Williams and Bunkley-Williams 1990). Habitat suitability and quality are factors impacting recovery of these two species.

Reproduction occurs both through sexual fertilization of gametes and asexually via reattachment of fragments. Both these species have rapid growth rates and high potential for propagation via fragmentation. However, the reduced abundance, density, and colony size result in fewer fragments available for reattachment (*Acropora* BRT 2005). There is substantial evidence suggesting that sexual recruitment of both coral species is compromised (*Acropora* BRT 2005), and some populations may be reproductively isolated (Bruckner 2002). In the absence of sexual recruits, fragmentation can lead to genetically identical colonies that do not self-fertilize. Successful sexual reproduction is critical for recovery of both species (Bruckner 2002).



Recovery is the process by which listed species and their ecosystems are restored and their future is safeguarded to the point that protections under the ESA are no longer needed.

Elkhorn and staghorn corals overall have been found to retain moderate to high levels of genetic diversity (i.e., the ratio of genetically distinct individuals to all colonies in a population or the relative abundance of genetic individuals) in many regions (Baums et al. 2006, 2010, Vollmer and Palumbi 2007). However, low genetic diversity of elkhorn coral occurs on some reefs in the Florida Keys that are comprised primarily of a single genotype (Baums et al. 2005b, 2006). For regions with low genotypic diversity, long-term persistence of the species is compromised due to reduced influx of genetically unique individuals and presumably greater susceptibility to the effects of environmental perturbation. Elkhorn coral populations in the western Atlantic and Caribbean have experienced little to no genetic exchange with populations in the eastern Caribbean (Baums et al. 2005b). Similarly, there is evidence that staghorn coral populations in the western Caribbean are also distinct from the eastern Caribbean (Vollmer and Palumbi 2007). Staghorn coral populations have been found to contain higher population structure than elkhorn coral populations (Baums et al. 2010). Genetic mixing of staghorn coral populations separated by more than 500 km is likely limited, indicating colonization will be dependent on larval influx from local rather than distant populations (Vollmer and Palumbi 2007, Hemond and Vollmer 2010).

THREATS ASSESSMENT:

How do the threats facing these species affect its recovery prognosis?

The threats facing elkhorn and staghorn corals have been fully described through the listing process. However, during the recovery planning process, the relative importance of individual threats has been reassessed both range-wide and for individual U.S. jurisdictions (Table 1).

The overriding threats to both species are disease, temperature-induced bleaching, physical damage from hurricanes, loss of recruitment habitat, and acidification. These threats are severe, ongoing, synergistic, and have displayed an increasing trend in the recent past. In order to ensure the species do not decline further, actions are needed to determine the causal and mechanistic aspects of these threats to both species. Disease is widespread, episodic, and unpredictable in its occurrence and results in high mortality. Sea-surface temperature is expected to continue to rise over time, causing increased frequency of bleaching episodes, and may exacerbate disease impacts. The number of hurricanes affecting Caribbean reefs has increased over the past two decades, and storm severity is expected to intensify with predicted climate change. Reduced herbivory, habitat modification, and algal proliferation have diminished the availability of hard substrate for recruitment. Increased carbon dioxide concentrations in the atmosphere have already lead to increased acidity (lower pH) while reducing the availability of carbonate ions in sea water that are essential to calcification of the corals' skeletons.



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The recovery plan serves as a road map for species recovery – it lays out where we need to go and how best to get there.

The threats to elkhorn and staghorn corals are further exacerbated by less severe threats (e.g., nutrients, sediments, anchoring, contaminants), which degrade coral condition and increase synergistic stress effects (e.g., bleaching, disease). Actions are needed to reduce the impacts of human activity (e.g., construction, dredging, run-off, water pollution). Curtailment of these less severe local threats may ensure the ability of these corals to withstand the more severe global threats.

CONSERVATION ASSESSMENT:

What steps have been taken to address the species' recovery needs?

Two ESA regulations have been enacted since the listing of elkhorn and staghorn corals in 2006. Protective regulations pursuant to ESA section 4(d) have extended all of the ESA section 9 take prohibitions to both species with exceptions for research and restoration (50 CFR 223.08). Critical habitat was designated in four areas in Florida, Puerto Rico, and the U.S. Virgin Islands, in waters generally from mean low water to 98 ft (30 m), to include that physical feature essential to the conservation of elkhorn and staghorn corals – substrate of suitable quality and availability to support larval settlement and recruitment, and reattachment and recruitment of asexual fragments (50 CFR 226.216).

Further, some fundamental laws, regulations and policies governing U.S. waters not specifically directed toward the conservation of elkhorn and staghorn corals provide various protections for coral reefs. General measures to protect coral reefs such as mooring buoys, navigational markers, and limiting collection of reef organisms assist in the conservation of both staghorn and elkhorn corals. In addition, both corals are protected within the boundaries of several marine protected areas in Florida, Puerto Rico, and the U.S. Virgin Islands.

Numerous governmental and non-governmental agencies, institutions, and organizations are involved in research and conservation of coral reefs. Research has been conducted on both species concerning restoration, reproduction, genetics, and diseases. These entities provide an active conservation constituency integral to the recovery of both species.

SUMMARY ASSESSMENT:

Overall, elkhorn and staghorn corals continue to decline. Currently, each species is only a small percentage of its historic abundance throughout both species' range. The recovery of elkhorn and staghorn corals requires habitat protection coupled with a reduction in threats and time.

Table 1. Assessment of Potential and Present Threats to Elkhorn (Elk) and Staghorn (Stag) Corals Across Their Range and within Each Area under U.S. Jurisdiction.

Threat/Stress	Impedes Recovery?	ESA Listing Factor	Range-wide		Florida Keys		Southeast Florida		Puerto Rico		USVI	
			Stag	Elk	Stag	Elk	Stag	Elk	Stag	Elk	Stag	Elk
Disease	Yes	C	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+
Temperature	Yes	E	5	5	5	5	5	5	5	5	5	5
Loss of Recruitment Habitat	Yes	A	4	4	4	4	4	4	4	4	4	4
Inadequacy of Existing Regulatory Mechanisms	Yes	D	4	4	4	4	4	4	4	4	4	4
Natural Abrasion and Breakage of Species	Yes	E	4	4	4	4	4	4	4	4	4	4
Carbon Dioxide and Acidification	Yes	E	4	4	4	4	4	4	4	4	4	4
Depensatory Population Effects	Yes	E	3	3	3	3	3	5	3	3	3	3
Sedimentation	Yes	E	3	3	1.5	1.5	3	3	3	4	3	4
Predation	Yes	C	3	3	2	3	2	2	3	4	3	3
Anthropogenic Abrasion and Breakage of Habitat	Yes	A	2	2	2	2	2	2	3	3	3	3
Anthropogenic Abrasion and Breakage of Species	Yes	E	2*	2*	2	2	3	2	3	3	3	3
Nutrients	Yes	E	SBU	SBU	SBU	SBU	SBU	SBU	SBU	SBU	SBU	SBU
Contaminants	Yes	E	SBU	SBU	SBU	SBU	SBU	SBU	SBU	SBU	SBU	SBU
Natural Abrasion and Breakage of Habitat	No	A	2	2	2	2	2	2	2	2	2	2
Offshore Gas and Oil Exploration	No	A, E	1	1	1.5	1.5	1.5	1.5	1	1	1	1
Sea Level Rise	No	A	1	1	1	1	1	1	1	1	1	1
Overharvest	No	B	1	1	1	1	1	1	1	1	1	1
Overgrowth Competition	No	E	1	1	1	1	2	1	1	1	1	1
Sponge Boring	No	E	1	1	1	1	1	1	1	2	1	1
African Dust	No	E	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Alien Species	No	E	P	P	P	P	P	P	P	P	P	P

NOTES:

Elk = elkhorn coral
 Stag = staghorn coral

ESA Listing Factors
 A = Present or threatened destruction, modification or curtailment of habitat or range
 B = Overutilization for commercial, recreational, scientific or educational purposes
 C = Disease or predation
 D = Inadequacy of existing regulatory mechanisms
 E = Other natural or manmade factors affecting continued existence

0-2 = Low
 3 = Medium
 4-5 = High
 5+ = High and main cause of initial decline
 SBU = Threat is believed to be significant, but ranking is UNKNOWN relative to other threats
 P = potential threat, not known to be a threat at the current time, but could plausibly become a threat

* Range-wide, this threat is ranked as 2, but in U.S. jurisdictions, it is ranked as 3 overall

PRELIMINARY RECOVERY STRATEGY



PREPLANNING DECISIONS

A recovery plan is being prepared for elkhorn and staghorn corals pursuant to section 4(f) of the Endangered Species Act. The scope of the plan will include the two species and their habitat.

An Acropora Recovery Team has been assembled to develop the recovery plan. Members include Dr. Andy Bruckner, Ms. Chantal Collier, Dr. C. Mark Eakin, Ms. Graciela García-Moliner, Mr. Doug Gregory, Mr. Aaron Hutchins, Ms. Meagan Johnson, Ms. Terri Jordan-Sellers, Dr. Brian Keller, Dr. Bill Kruczynski, Dr. Craig Lilyestrom, Dr. Margaret W. Miller, Mr. Tom Moore, Dr. John Ogden, Dr. Kim Ritchie, Mr. Ed Tichenor, and Dr. Cheryl Woodley. The recovery team will coordinate their planning efforts with the Southeast Regional Administrator of NOAA Fisheries.

RECOVERY PRIORITY NUMBER WITH JUSTIFICATION:

Elkhorn and staghorn corals should be assigned a recovery priority of 3, based on high magnitude of threats, low to moderate recovery potential, and the potential for economic conflicts.

RECOVERY VISION STATEMENT:

Numerous populations of elkhorn and staghorn corals, including thickets, should be present across the historical range and be large enough to support successful reproduction, protect the genetic diversity, and maintain the ecosystem function. Threats to these species and their habitat must be sufficiently abated to ensure a high probability of survival into the future.

BRIEF ACTION PLAN:

The focus of the initial phase of recovery will be addressing the most pressing knowledge gaps that impact recovery, reducing threats to the species and their habitat, and improving population abundance and genetic diversity. Given that many of the important threats to the recovery of elkhorn and staghorn corals are not directly manageable, the recovery strategy must pursue simultaneous actions to:

- a) Improve understanding of population abundance, trends, and structure through monitoring and experimental research.
- b) Reduce greenhouse gas emissions to curb warming and acidification impacts and possibly disease threats.
- c) Determine coral health risk factors and their inter-relationships and implement mitigation or control strategies to minimize or prevent impacts to coral health.
- d) Reduce locally-manageable stress and mortality sources (e.g., predation, anthropogenic physical damage, acute sedimentation, nutrients, contaminants).
- e) Develop and implement appropriate strategies for population enhancement, through restocking and active management, in the short to medium term, to increase the likelihood of successful sexual reproduction and to increase wild populations.
- f) Implement ecosystem-level actions to improve habitat quality and restore keystone species and functional processes such as herbivory to sustain adult colonies and promote successful natural recruitment in the long term.

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