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Potential habitat of *Acropora* spp. on Florida reefs

Katherine E. Wirt [a,b,*], Pamela Hallock [a], David Palandro [b,1], Kendra L. Daly [a]

[a] College of Marine Science, University of South Florida, St. Petersburg, FL, USA
[b] Florida Fish and Wildlife Conservation Commission, St. Petersburg, FL, USA

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A B S T R A C T

Elkhorn and staghorn corals (*Acropora palmata, Acropora cervicornis*) were listed as threatened species under the Endangered Species Act in 2005. The decline of these species beginning in the late 1970s is unprecedented given the vital role they historically played as major builders of western Atlantic and Caribbean coral reefs. The goal of this study was to create potential-habitat maps for *A. palmata* and *A. cervicornis* that would show areas in which these species currently exist, as well as areas that would be suitable for their (re)establishment, using a database of reported *in situ* observations and existing mapped data. Using the mapped coral reef and hardbottom classifications throughout the Florida reef tract, potential-habitat maps were generated using buffers that incorporated 95% and 99% of reported observations of colonies of *Acropora* spp. The potential-habitat maps were produced based on benthic substrates throughout the Florida reef tract using GIS software. Locations of 99% of *A. palmata* observations and 84% of *A. cervicornis* observations coincided with previously mapped coral reef or hardbottom habitat. These results indicate that potential habitat for *A. palmata* is currently well defined and that potential habitat for *A. cervicornis* is more variable and has a wider range than that for *A. palmata*. This study provides a novel method of combining datasets at various geographic spatial scales and may be used to inform the current NOAA critical habitat map. One of the most important differences between the current NOAA critical habitat map and the new potential-habitat map is observed in the southeast Florida region, where *A. cervicornis* appears to be thriving outside of mapped reef areas and at latitudes considered marginal for hermatypic corals. Thus, the potential habitat extends further north than the previous critical habitat - and encompasses additional habitat for *A. cervicornis* and potentially for *A. palmata*.

Introduction

Corals of the genus *Acropora* have commonly epitomized coral reefs worldwide because of their typical distribution in shallow water (making them more accessible and therefore more familiar) and characteristic branching morphologies. Two species occur in the western Atlantic and Caribbean region, *Acropora cervicornis* (Lamarck 1816) and *Acropora palmata* (Lamarck 1816).

The precipitous decline of *Acropora* spp. in the western Atlantic and Caribbean is a major issue in discussions of coral-reef conservation. Their formal listing as threatened in 2005 (*Acropora* Biological Review Team, 2005) highlighted the concern for these historically major reef-building corals, bringing attention to the overall decline in reef-building corals over the past several decades. Fortunately, their shallow distributions make them more accessible and more amenable to mapping techniques based on satellite or aircraft based remote sensing.

Recent threats to Acropora populations

Unfortunately for Florida reef communities, a series of disturbance events have impacted the *Acropora* spp. populations for several decades. Several of the more notable disturbances include the spread of white-band disease through Atlantic and Caribbean *Acropora* populations beginning around 1976 (Gladfelter, 1982), a cold-water event in 1976–77 (Davis, 1982; Porter, Battey, & Smith, 1982; Roberts, Rouse, Walker, & Hudson, 1982), a region-wide *Diadema* (sea urchin) die-off in 1983 (Lessios, 1988), widespread mass-bleaching events in 1983 (Jaap, 1985), 1987 (Lang et al., 1992), and 1998 (Hoegh-Guldberg, 1999) as well as numerous hurricane events (Lirman & Fong, 1996). In addition,

* Corresponding author. 100 8th Avenue Southeast, St. Petersburg, FL 33701, USA. Tel.: +1 727 502 4862.
E-mail address: kwirt@mail.usf.edu (K.E. Wirt).
[1] Current address: ExxonMobil Upstream Research Company, Houston, TX, USA.

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the increase of frequency in these disturbances has limited the recovery of extensive *Acropora* thickets in most of the Florida reef tract.

Human population growth poses a variety of threats to coral reef ecosystems, including nutrient enrichment, diminished water clarity, inhibition of calcification by phosphates, biotic replacement, and increased bioerosion (Hallock & Schlager, 1986; Simkiss, 1964; Smith, Kimmerer, Laws, Brock, & Walsh, 1981; Weiss & Goddard, 1977). Nevertheless, significant thickets of *A. cervicornis* have been reported in shallow nearshore water off Fort Lauderdale (Thomas, Dodge, & Gilliam, 2000), at or near the latitudinal limits of the species. These populations are believed to be among the largest and northernmost in the continental USA and are a potential source of propagules for the repopulation or replenishment of threatened populations in south Florida habitats (Vargas-Angel & Thomas, 2002).

Extensive populations of *A. palmata* are notably absent from southeast Florida habitats, although isolated colonies have been found (Banks et al., 2008). Unfortunately for these populations, the reefs of the southeast Florida reef tract receive considerably less management than reefs in the Florida Keys and Dry Tortugas (Causey et al., 2002).

Habitat requirements of Atlantic and Caribbean Acropora spp.

The habitat requirements for *A. palmata* and *A. cervicornis* are well known. *Acropora palmata* has sensitive environmental requirements including that of clear, well-circulated water of normal marine salinity; a solid substrate; and moderate water temperatures [optimally 25–29 °C, without extreme seasonal variation (Jaap, Lyons, Dustan, & Halas, 1989, pp. 1–31)]. The presence of a solid substrate such as coral reef or hardbottom is vital for coral recruits to bind to during settlement (Harrison & Wallace, 1990). Before 1970 in much of the Caribbean, *A. palmata* was the dominant coral in wave-exposed and high-surge reef zones, typically at depths less than 10 m (Adey & Burke, 1976). *A. cervicornis* was found at shallow to medium depths, as deep as 30 m, in brightly lit areas (Fenner, 1988). *A. cervicornis* thickets in shallow reef flats and patch reefs were common before the 1980s (Dustan, 1985; Shinn, Lidz, Halley, Hudson, & Kindinger, 1989). However, the full extent of historical, present, and potential habitat for these two species along the Florida reef tract has not been well documented.

Recent studies of habitat distributions of both species found *A. cervicornis* distribution to be wider than that of *A. palmata,* with colonies found on a variety of habitats, including mid-channel and offshore patch reefs, as well as inner reef-tract sites (Miller, Chiappone, Rutten, & Swanson, 2008). Miller et al. (2008), following spatially extensive surveys performed in 2007, estimated that there are 13.8 ± 12.0 million *A. cervicornis* colonies and 1.6 ± 1.4 million *A. palmata* colonies in the Florida Keys. Most of these colonies, however, have not been documented, and so, while habitat types have been speculated upon, most have not been verified by observation.

Objectives and potential significance

The objectives of this study are:

1) Evaluate the accuracy of reported observations and current benthic habitat maps of the Florida reef tract, and,
2) using reports of existing colonies of *A.* palmata and *A. cervicornis*, determine the distribution of potential habitat on the Florida reef tract and to create potential-habitat maps showing areas in which these species exist, as well as areas that would be suitable for their re-establishment.

The results of this research have the potential to be used to define where conservation actions will be most effective. With existing populations mapped, the results will also aid in preventing the destruction of the limited areas in which these species occur. This study also provides the basis for future potential and critical habitat maps which will be necessary for additional species of coral likely to be placed on the Endangered Species List.

Methods

Field area

The reef tract was subdivided into three regions, southeast Florida, the Florida Keys and the Dry Tortugas (Fig. 1). Previous studies defined the terminus of the Florida Keys reef tract as Fowey Rocks (Jaap, U.S. National Coastal Ecosystems Team, & U.S. Minerals Management Service Gulf of Mexico OCS Region, 1984; Shinn et al., 1989; Vaughan, 1914) as such the boundary between the Florida Keys region and the southeast Florida region was set off Biscayne Bay near Fowey Rocks. This study defines "southeast Florida" (SE Florida) as the portion of Florida's continental shelf that extends from Martin County to Biscayne Bay, where the southeast Florida reef tract begins (Banks, Riegl, Shinn, Piller, & Dodge, 2007). The region of the Florida reef tract extending from Fowey Rocks to the Marquesas Keys is referred to as "the Keys," Dry Tortugas National Park and surrounding areas will be referred to as the "Dry Tortugas" (Fig. 1).

Data

The Florida Fish and Wildlife Research Institute (FWRI) received reports of *Acropora* spp. location data along the Florida reef tract, from Martin County to the Dry Tortugas. Observations of *Acropora* spp. were reported from surveys between 1996 and 2009 by a wide range of groups, agencies and institutions, including but not limited to the Coral Reef Evaluation and Monitoring Project (CREMP), University of Miami, National Coral Reef Institute (NCRI), and The Nature Conservancy (TNC), as well as by independent SCUBA divers. Abundance data for an area were converted to presence-or-absence data, i.e., whether a species was present or absent at a location on the survey date. All location data points included latitude, longitude, date of sighting, and species, if inhabited.

These data were then converted to GIS shapefiles and used to populate an *in situ* observation map of reported *Acropora* spp. presence using ESRI's ArcGIS software. The database was then split into three categories: *A. palmata* presence, *A. cervicornis* presence, and absence of both. All data were then quality checked, and any points occurring outside of logical regions removed, as described below. While locations of surveys that did not detect *Acropora* spp. are important, they were not addressed in this study. All results pertain to locations where surveys detected one or both species of *Acropora*.

Benthic habitat maps

The benthic habitat of most of the Florida reef tract has been mapped, thanks to the efforts of several groups in South Florida including FWRI, the National Oceanic and Atmospheric Administration (NOAA), Dade County, and Nova Southeastern University/NCRI. Mapping techniques, source data and classification schemes varied slightly among regions, but were similar enough to be used together in mapping benthic habitat throughout the reef tract.