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Decision Support Tool to Promote Long-Term Survival of *Acropora cervicornis* on the Florida Reef Tract

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Disclaimer

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Decision Support Tool to Promote Long-Term Survival of *Acropora cervicornis* on the Florida Reef Tract

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March 2020

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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Mr. Craig N. McLean, Assistant Administrator

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Abstract

To maximize the long-term survival (>10 years) of nursery raised *Acropora cervicornis* corals, a map-based tool was created that ranks locations in the Florida Acropora Critical Habitat based on climate vulnerability. Climate vulnerability is defined both in terms of exposure to future heat stress and the coral's sensitivity as resilience. Suitable sites are determined by a number of factors. Suitable sites must also be within the Acropora Critical Habitat and within the depth range of 5-15 meters, with either hard bottom or coral present. These possible locations are ranked based on projected climate change impacts and a resilience metric based on seven different indicators. These rankings are intended to guide managers of nurseries to outplant locations on a coarser scale. However, where to outplant in these regions should still be determined by the local, small-scale conditions at the substrate.

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1. Introduction

There are currently at least seven coral nurseries in Florida that cultivate the Endangered Species Act-listed "threatened" coral *Acropora cervicornis*. These thousands of corals represent a significant investment in terms of labor and economics (~75 K/year for the University of Miami's effort alone) and are one of the best opportunities to maintain resilient populations of this species. Ideally, these corals should be outplanted to locations where conditions are the most favorable for their long-term (>10 year) survival.

Here we describe an experimental tool designed to help rank suitable outplant locations based on their climate vulnerability, both in terms of exposure to future heat stress and their sensitivity to resilience. Suitable sites are determined by a number of factors. In this report, we only selected sites in the *Acropora cervicornis* Critical Habitat Area within the depth range of 5–15 meters with either hard bottom or coral present (**Figure 1**).

These possible locations are ranked based on projected climate change impacts and a resilience metric based on seven different indicators. The rankings are intended to guide managers of nurseries to outplant locations on a coarser scale. Where to outplant in those regions should still be determined by local, small-scale conditions at the bottom. This tool can aid in two possible ways:

(1) It clearly maps locations that are suitable for outplanting, i.e., locations that have the right depth and substrate, as well as information on water clarity.

(2) It ranks possible locations based on vulnerability, both as exposure to climate change impacts and as resilience.

This is an experimental tool, and feedback is welcome to improve its usability. Collaborations to test the tool by planting corals in both high and low ranking sites, as well as monitoring their health, are also welcome.

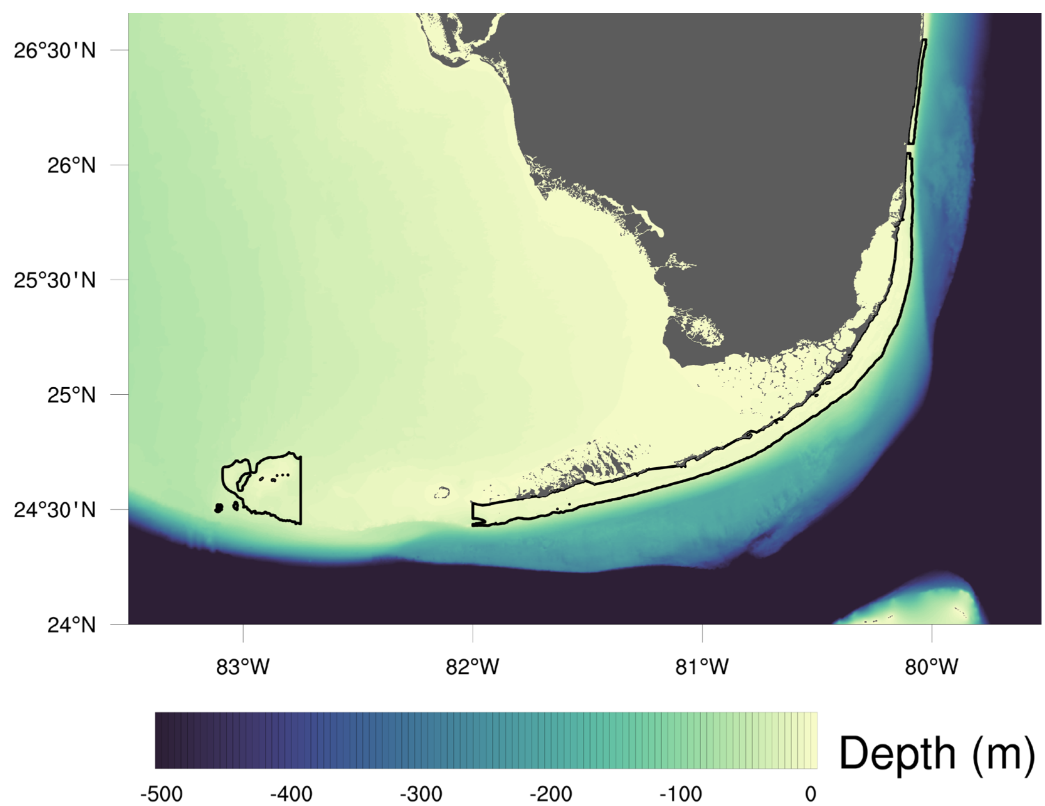

Figure 1. Map of south Florida showing the Florida reef tract with a black outline denoting the Acropora Critical Habitat. Water depth (in meters) is derived from the General Bathrymetric Chart of the Oceans model (2019 version).

2. Data Sources

To rank candidate sites for outplanting, two types of criteria were used—binary (yes/no) and continues criteria. The binary criteria included:

(1) Acropora Critical Habitat

(2) Depth

(3) Coral hard bottom

(4) Turbidity

The continues criteria included:

(1) The relative resilience of the location.

(2) The projected climate change impact, i.e., the year of onset for annual severe bleaching conditions.

To determine the depth range to use and what sites to include, we referred to a map on the Florida Fish and Wildlife Conservation Commission's website that shows the presence and absence locations of *Acropora cervicornis* in the tropical Atlantic Ocean and Caribbean Sea. The website can be accessed at http://geodata.myfwc.com/datasets/acropora-presence-or-absence-locations.

2.1. Acropora Critical Habitat

The Endangered Species Act requires a critical habitat to be mapped for every species listed as either threatened or endangered. Critical habitat is defined as the areas that contain physical and/or biological features considered essential to the conservation of a species that might need management actions or protections. For *Acropora cervicornis*, critical habitat consists of substrate of suitable quality and availability to support larval settlement and recruitment, as well as the reattachment and recruitment of asexual fragments in water depths shallower than 30 meters (see https://myfwc.com/research/habitat/coral/news-information/threatened-acroporid-corals/). A report entitled *Caribbean Acropora Restoration Guide: Best Practices for Propagation and Population Enhancement* (Johnson *et al.,* 2011) states that site selection for *Acropora cervicornis* outplanting should occur in the NOAA-National Marine Fisheries Service Acropora Critical Habitat.

2.2 Depth

Bathymetry was derived from the use of the General Bathymetric Chart of the Oceans (GEBCO, version 2019), 15-arc second bathymetry model. This model uses a database of ship track soundings with an interpolation where there are no soundings guided by satellite-derived gravity data (i.e., http://www.gebco.net).

2.3 Coral Hard Bottom

From a shapefile with coral and hard bottom habitats in Florida, only polygons marked as "coral reefs" were selected as candidate sites. The other polygons were marked as "probable hard bottom" or "hard bottom" (see http://geodata.myfwc.com/datasets/coral-and-hard-bottom-habitats-in-florida).

2.4 Turbidity

Science quality ocean color data were obtained from the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor aboard the Suomi National Polar-orbiting Partnership or Suomi NPP satellite (see https://coastwatch.noaa.gov/cw/satellite-data-products/ocean-color/science-quality/viirs-snpp.html). The coefficient for attenuation of downwelling irradiance, Kd(490), was used as an indicator of water clarity (**Figure 2**). All monthly data from 2012-2018 were averaged to determine typical water clarity at *Acropora cervicornis* locations.

2.5 Relative Resilience

The relative resilience of reef sites is determined from a collaboration co-funded by NOAA's Coral Reef Conservation Program, the Florida Department of Environmental Protection, and The Nature Conservancy's Florida office (Maynard *et al.,* 2017). This study maps areas of high and low resilience to climate change. Seven indicators are used to assess relative resilience: coral cover, macroalgae cover, bleaching resistance, coral diversity, coral disease, herbivore biomass, and temperature variability. The data come from reef field monitoring surveys conducted in 2016, excepting temperature variability, which is satellite derived (NOAA Pathfinder v5.1 sea surface temperature data, 1982-2012). Here we used the normalized resilience scores, with all seven indicators weighted equally.

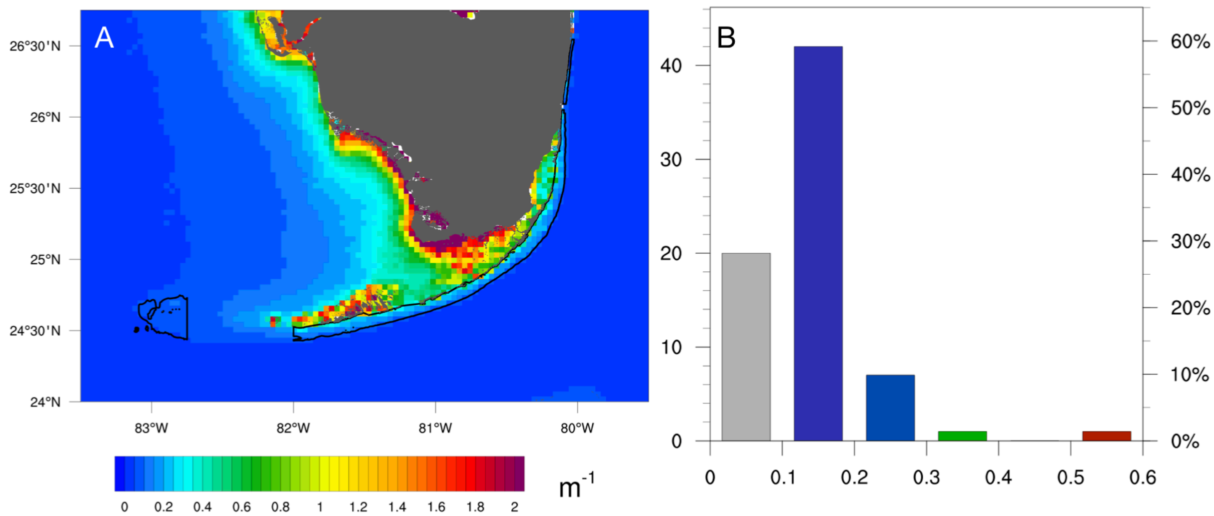

Figure 2. (a) Diffuse attenuation coefficient, Kd(490) in m⁻¹, in the Florida reef tract with the Acropora Critical Habitat outlined in black, and (b) histogram of Kd(490) for all locations with *Acropora cervicornis* in the Acropora Critical Habitat.

2.6 Projected Climate Change Impact

Projected climate change impact refers to the year when in the following decade a pixel experiences 8 degrees of heating weeks or more annually. The year when annual severe bleaching conditions start is used as an indicator for projected climate change impact (van Hooidonk *et al.,* 2016). In this report, the statistically downscaled results that represent conditions as expected under a business-as-usual emissions scenario, i.e., RCP 8.5, was used.

3. Results

There are 17,786 pixels of roughly 0.45 km × 0.45 km in the Acropora Critical Habitat. Of these, only 72 have reported *Acropora cervicornis* present. This represents 0.40 percent of the total area of the critical habitat in Florida. The reported depth for *Acropora cervicorni*s ranges from 2–25 meters, with only 2.7 percent below 20 meters depth and 4.2 percent deeper than 15 meters (**Figure 3**). Since the feasibility and practicality of outplanting at deeper depths is greatly reduced, e.g., the maximum bottom time while diving is more than halved between 20 and 30 meter depths, only locations shallower than 15 meters should be considered.

Over 7.0 percent (1,257) of all pixels in the Acropora Critical Habitat have corals present as substrate. Of these locations, 827 have a reported depth that is shallower than 15 meters. These locations are all possible candidate sites for outplanting.

Turbidity ranges from 0.04–2.53 m^{-1} in the Acropora Critical Habitat. Of all the *Acropora cervicornis* present in the critical habitat, 97 percent reside in clear water with a diffuse attenuation coefficient for downwelling irradiance at 490 nm of less than 0.25 m^{-1}. The average turbidity is 0.14 m^{-1} at locations with *Acropora*.

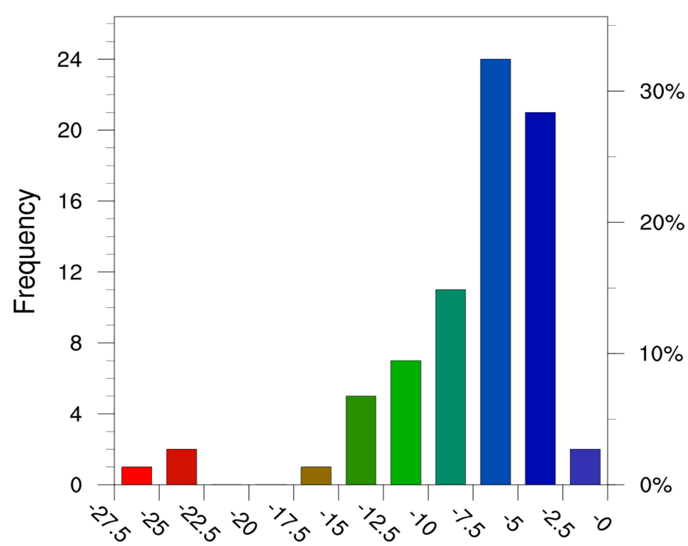

Figure 3. Histogram of the depth range (in meters) of pixels in the Acropora Critical Habitat area with *Acropora cervicornis* present.

After sub-setting for the depth range and obtaining a resilience score, there are 4,992 locations. Of these locations, 664 have coral reef as substrate in the Acropora Critical Habitat. The normalized resilience score ranges from 0.54–1, with an average score of 0.85.

The projected year of annual severe bleaching at 827 locations above 15 meters depth with coral reef substrate in the Acropora Critical Habitat locations ranges from 2035 to 2059, with the average year of onset for annual severe bleaching as 2047.

4. The Decision Support Tool

To rank the candidate locations for outplanting, we used both the normalized resilience and the year of annual severe bleaching. Here, they were added with equal weights. To do this, the resilience score was scaled to a range of 0–5. The year of annual severe bleaching was also scaled to 0–5.

Resilience was scaled linearly, with the lowest score (0.54) set to 0 and the highest score set to 5 (**Figure 4**):

$$\text{Resilience score} = (\text{resilience} - 0.54) \times 10.87$$

The year of annual severe bleaching occurrence was also scaled linearly (**Figure 5**):

$$\text{Annual severe bleaching score} = (\text{year} - 2035)/4.8$$

Both scores are unidirectional, i.e., a score of 0 represents a negative indicator, while a score of 5 is a positive indicator. **Figure 6** shows a histogram of the total ranking score, with both resilience and the year of annual severe bleaching having equal weight.

The tool consists of five map layers (i.e., depth, turbidity, resilience, year of annual severe bleaching, and outplanting score) that can be viewed in Google Earth Pro (desktop version) and downloaded for free from https://www.google.com/earth/desktop/. Google Earth Pro enables selection of each layer with a radio button and also allows for searches by place name (e.g., Key Largo) or by latitude and longitude (**Figure 7**).

These five layers are also available as high-resolution images and netCDF files. An Excel table, with all 827 locations ranked by latitude and longitude, is also available.

All files can be downloaded from ftp://ftp.aoml.noaa.gov/ocd/pub/ruben.van.hooidonk/acropora_tool.

Questions or comments about this decision support tool should be directed to ruben.van.hooidonk@noaa.gov.

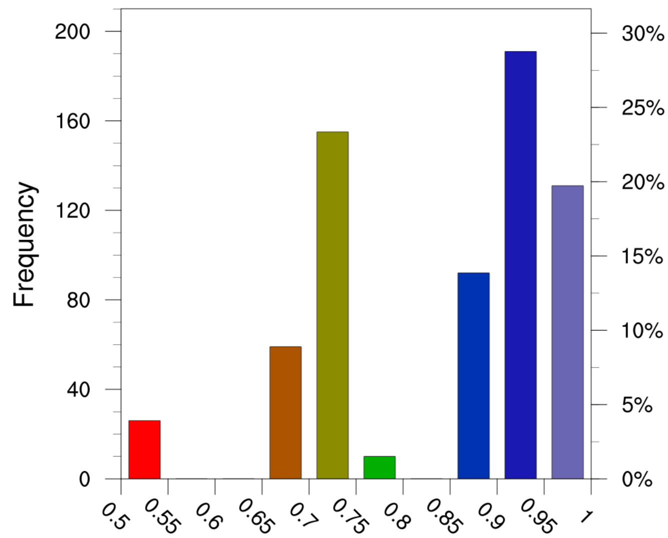

Figure 4. Histogram of normalized resilience scores for locations with coral reef substrate in the Acropora Critical Habitat shallower than 15 meters.

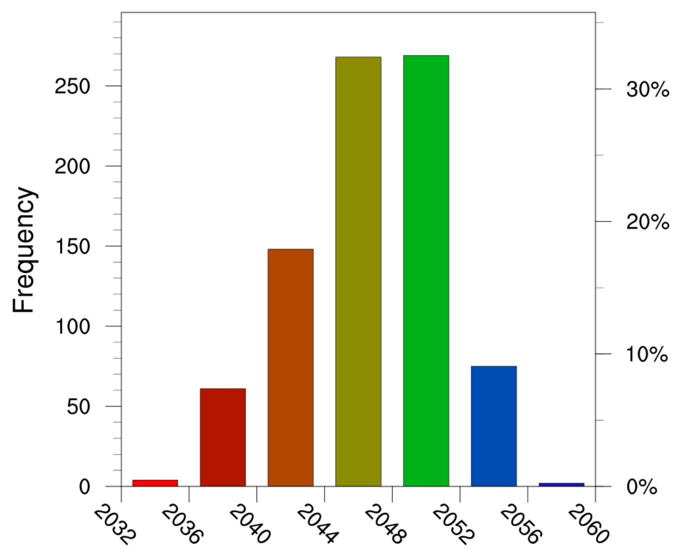

Figure 5. Histogram of the year of onset of annual severe bleaching for locations with coral in the Acropora Critical Habitat shallower than 15 meters.

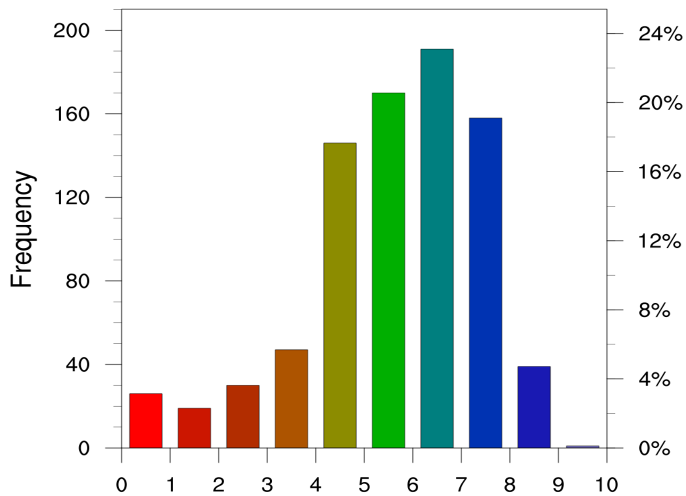

Figure 6. Histogram of the total ranking score, with both resilience and the year of annual severe bleaching having equal weights.

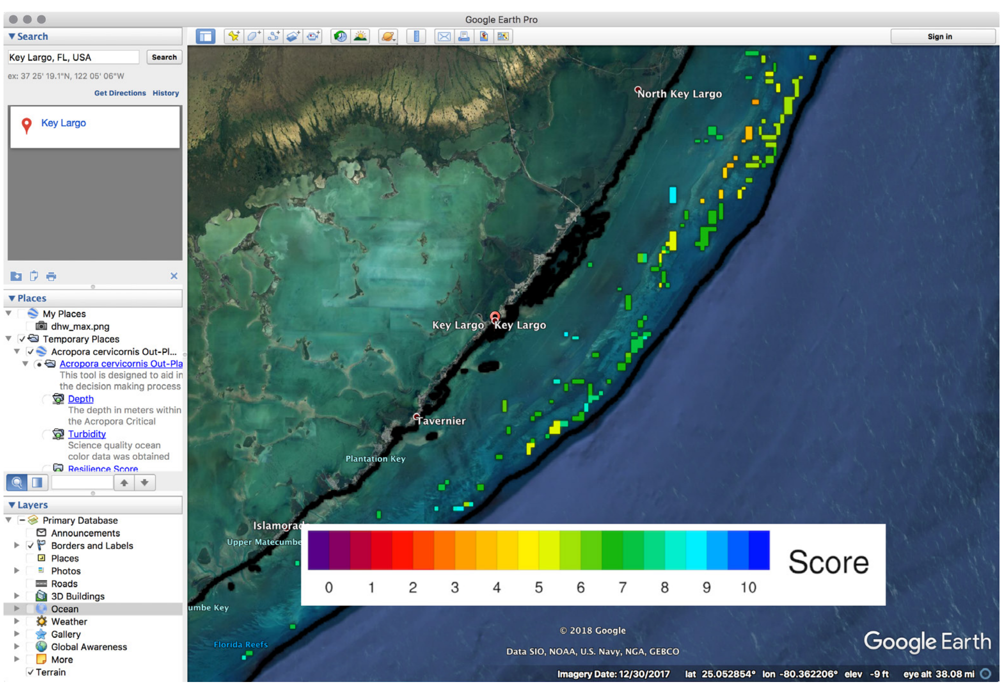

Figure 7. Screen shot of the tool showing the outplanting score layer around Key Largo, Florida.

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