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Molokini Shoal MLCD, “Reefs End”
Pocillopora eydouxi Restoration Project

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Introduction and Background

Hawai‘i is one of the most isolated archipelagos in the world. As a result, Hawai‘i possesses some of the highest marine endemism recorded anywhere on earth. Since Hawai‘i is located in the central Pacific Ocean, Hawai‘i's coral reefs are exposed to large open ocean swells and strong trade winds, which have a significant impact on the structure of coral reef communities (Friedlander et al., 2005). Extratropical storms near the Kuril and Aleutian Islands generate swells toward Hawai‘i from the northwest to north during the boreal winter (Li et al, 2016). The south facing shores experience moderate swells from the year-round Southern Hemisphere Westerlies that are augmented by mid-latitude cyclones in the boreal summer.

Wave energy is one of the most important factors that control coral growth, reef development, and coral island formation. Many coral species can change their shapes to adapt to the external environment (Dao-ru et al., 2013). For instance, encrusting corals are dominant in areas with high wave energy, whereas sensitive branching or lobate type corals occur in areas with low wave energy. Biological diversity of coral reefs is related to the degree of disturbance, such as magnitude and energy (Dollar, 1982). Physical stresses associated with wave energy such as mechanical breakage and scour are important determinants of community structure.

Coral communities normally have a long-life span with slow growth, but changes in their community structure may be subtle, due to their chronic low-grade stress, or catastrophic, in the case of large-scale episodic events (Dollar and Grigg, 2004). These changes may have return periods of many decades. Coral community structure in Hawaiian waters has been shown to respond to storm wave stresses of varying time and magnitude, which is described by the "intermediate disturbance hypothesis (IDH)" (Grigg, 1983). IDH is a model used to describe the relationship between disturbance and species diversity.

Molokini Shoal is a small crescent shaped remnant of a volcanic crater that lies within the ‘Alalākeiki channel between the island of Maui and Kaho‘olawe. In 1977, Molokini Shoal and its surrounding 77 acres were established as a Marine Life Conservation District (MLCD). Molokini Shoal MLCD currently stands as the second most visited Marine Protected Area in the State of Hawaii with a total of 334,036 individuals visiting in 2015 (Filous et al., 2017). The reef area within the Main Hawaiian Islands is estimated to contribute a net beneficial value of $360 million USD per year to the State of Hawai‘i (Cesar, 2004). Molokini Shoal MLCD not only acts as a major drive for local economic enterprises on Maui, but also an environmental tool to stimulate the increase in biomass and diversity inside the Marine Protected Area (Garcia-Rubies, 2013, McClanahan, 2007).

Its crescent shape opens towards the northwest, which results to Molokini Shoal being susceptible to large open ocean swells. During a large west-facing swell in the summer of 2019, it was reported to Maui Ocean Center Marine Institute that several large *Pocillopora eydouxi* specimens were toppled and no longer standing in their natural upright position.

Objectives

Long-term studies based on survey time-series show that benthic assemblages are useful indicators of environmental impact. Because corals are long-lived sessile organisms and are exposed to conditions in the water column, it is important to understand individual coral species' tolerance and adaptation to disturbances.

1. Restoration:

The primary purpose of this study is to reassemble the damaged *Pocillopora eydouxi* specimen fragments and aid in recovering from the disturbance that displaced them from their original location.

2. Research Study:

The secondary purpose of this study is to show how coral colonies and its community in Hawaiian waters will respond to being reattached to its pre-existing position after physical disturbance from wave stress. The data will be used as a test of the intermediate disturbance hypothesis and will help determine effective restoration techniques for future projects within the Hawaiian Islands.

Methodology

Study Site

The study was conducted in a regulated area at Molokini Shoal Marine Life Conservation District (Fig. 1). Molokini is a crescent shaped islet located in the ʻAlalākeiki Channel which is located about three miles off the southwestern coast of Maui, Hawaiʻi. Molokini islet is the southern rim of an extinct volcanic crater. The shallow inner cove slopes off from the shoreline to a depth of approximately 30 meters before dropping off. The sea floor consists of sand patches, coral, and basaltic boulders. A shallow reef, known as "Reef's End," extends from the shoreline northward at the islet's northwestern point in depths ranging from approximately three to one-hundred meters. Access to the site is only by boat, with most charter and tour operations operating out of Lāhainā, Maʻalaea, and Kīhei on Maui.

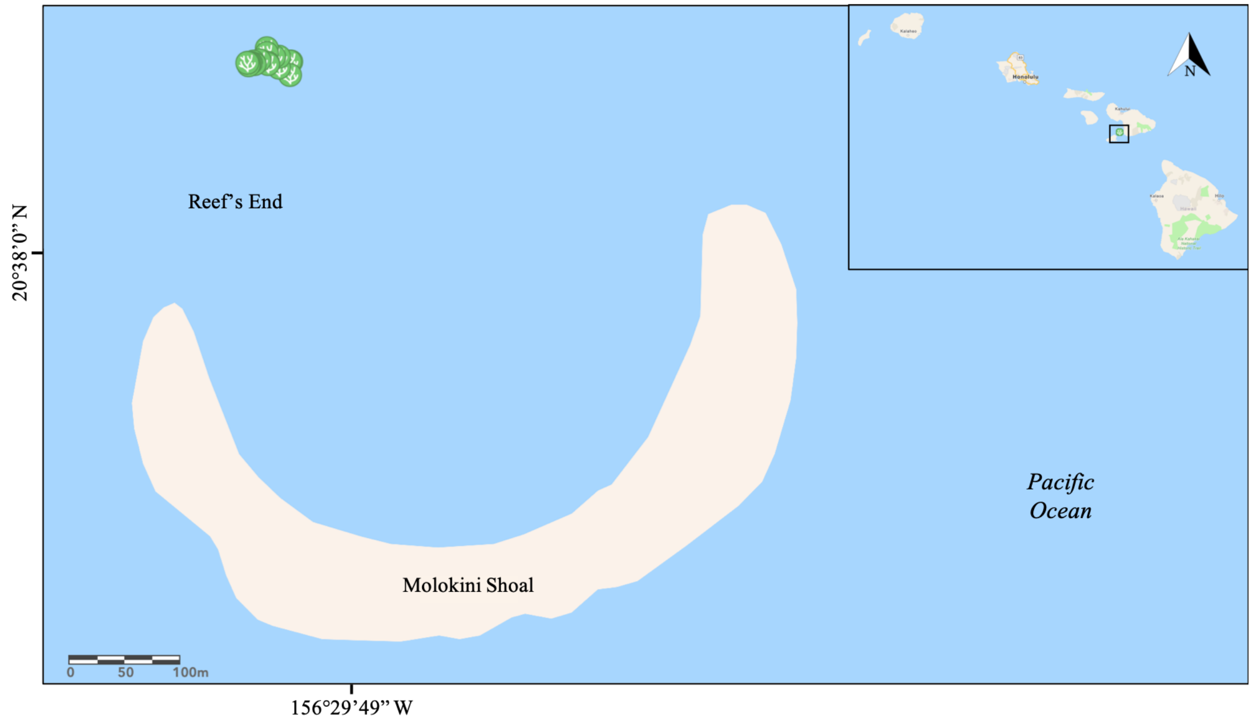


Figure 1. Map of Molokini Shoal MLCD, Hawai'i and coral colonies in the "Reef's End."

Data Collection

The study site consisted of sixteen coral colonies of *Pocillopora eydouxi* (Antler coral) in the "Reef's End" of Molokini (Fig. 2, Table 1). The coral colonies were detached from the benthic substrate by a number of large, west-facing swells earlier in 2019. The colonies were stood upright into their pre-existing positions as accurately as possible for the purpose of restoration. Each fragment was secured to its colony using zip-ties and adhered back to the reef using A-788 splash zone epoxy compound (Z-Spar) in order to affix the fragments to substrates (Fig. 3). After the adhesive was set in place, the zip-ties were removed. A tag number was attached to the substrate next to each colony for identification. After standing upright, each colony was photographed and GPS coordinates were recorded to facilitate future monitoring and documentation. Measurements of each colonies' width and height were recorded. The colonies will be monitored every two months, one year, and three-year post-transplantation for health and growth post-attachment and to ensure that each fragment and colony is secured to the substrate (Table 2).

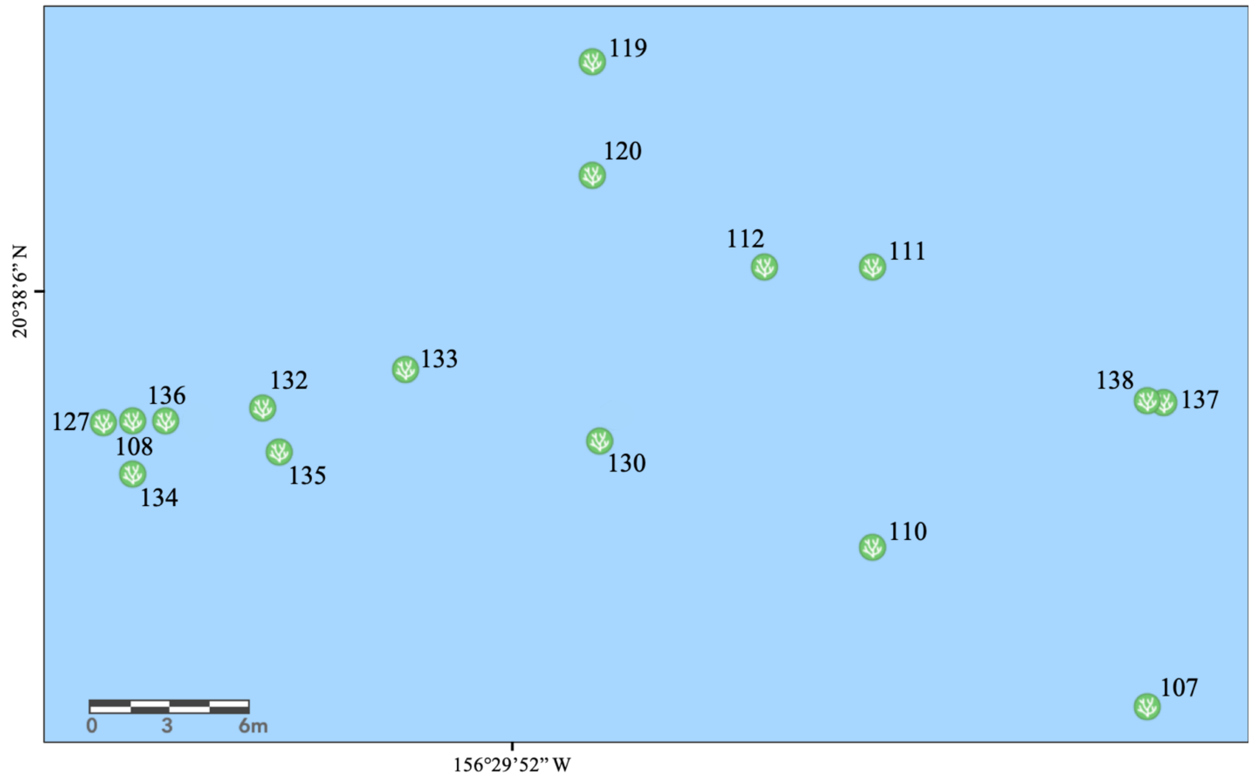


Figure 2. Map of sixteen *Pocillopora eydouxi* colonies in the "Reef's End" of Molokini that were reattached to the benthic substrate and tagged in November 2019.

Table 1. Tag number, GPS coordinates, depth, height, width, and number of fragments of each *Pocillopora eydouxi* colony (n=16) that were reattached to the benthic substrate at Molokini in November 2019.

Tag #	Coral Species	Latitude (°N)	Longitude (°W)	Depth (m)	Height (cm)	Width (cm)	# of Fragments
137	*P. eydouxi*	20.63495410625	-156.49752517186	18.3	22	28	12
138	*P. eydouxi*	20.63495461347	-156.49753100000	18.6	47	65	3
107	*P. eydouxi*	20.63485000000	-156.49753100000	18.3	60	68	3
110	*P. eydouxi*	20.63490427089	-156.49763143119	12.8	92	76	2
111	*P. eydouxi*	20.63500061970	-156.49763139983	14.3	64	60	4
112	*P. eydouxi*	20.63500060001	-156.49767117106	16.8	47	38	1
119	*P. eydouxi*	20.63507063139	-156.49773400762	18.6	72	86	4
120	*P. eydouxi*	20.63503209006	-156.49773399996	16.8	42	60	3
130	*P. eydouxi*	20.63494124099	-156.49773163636	13.4	36	30	1
133	*P. eydouxi*	20.63496551825	-156.49780285354	12.8	49	74	4
132	*P. eydouxi*	20.63495251012	-156.49785455977	11.6	48	76	2
135	*P. eydouxi*	20.63493727329	-156.49784858953	12.5	73	64	2
136	*P. eydouxi*	20.63494760005	-156.49789023804	13.1	35	50	2
108	*P. eydouxi*	20.63494760000	-156.49790223177	12.8	42	56	5
134	*P. eydouxi*	20.63492942680	-156.49790219987	12.5	48	43	2
127	*P. eydouxi*	20.63494751159	-156.49791336892	11.6	94	102	5

Table 2. Restoration project timetable at Molokini Shoal from October 2019 - December 2022.

Activity	Timeline
Pre-implementation survey and photo documentation of coral colonies at Molokini Shoal	10/2019
Reattachment of coral colonies, photo documentation, and data collection	10/2019 – 12/2019
Post-implementation site visits every two (2) months, including photo documentation	01/2020 – 12/2020
Post-documentation of coral colonies one (1) year post-transplantation	12/2020
Post-documentation of coral colonies three (3) years post-transplantation	12/2022

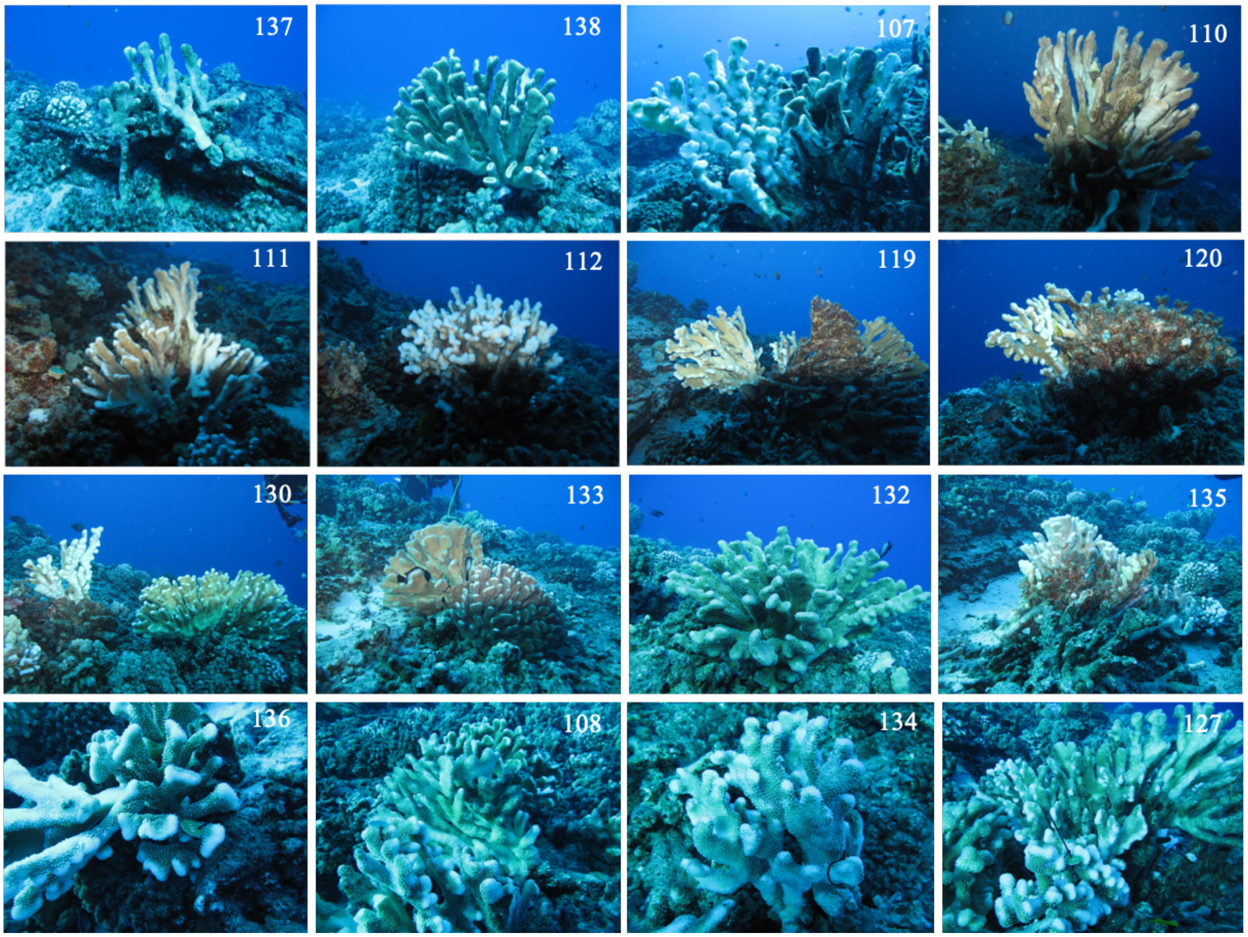
No organisms were removed from Molokini Shoal MLCD; each coral colony or fragment was reattached or left in place. All collection equipment and diving gear was inspected and disinfected before transplanting effort, to mitigate the spread of aquatic invasive species, disease, or parasitic organisms. No gear (tools, air tanks, hoses, etc.) were placed on coral colonies during activities.

Photo Documentation

Photos were taken of each coral colony sample before reattachment of coral fragments and post-attachment (Fig. 4) to the benthic substrate. A photo was taken of each coral from top and side views. The photo documentation is used to analyze the health and growth of the colonies post-attachment. Photos of each colony were taken during monthly surveys to track its progress.

Figure 3. MOCMI team members work to secure coral fragments. Photo: David Fleetham

Figure 4. Photo documents of each coral colony (n=16) post-attachment in November 2019.



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