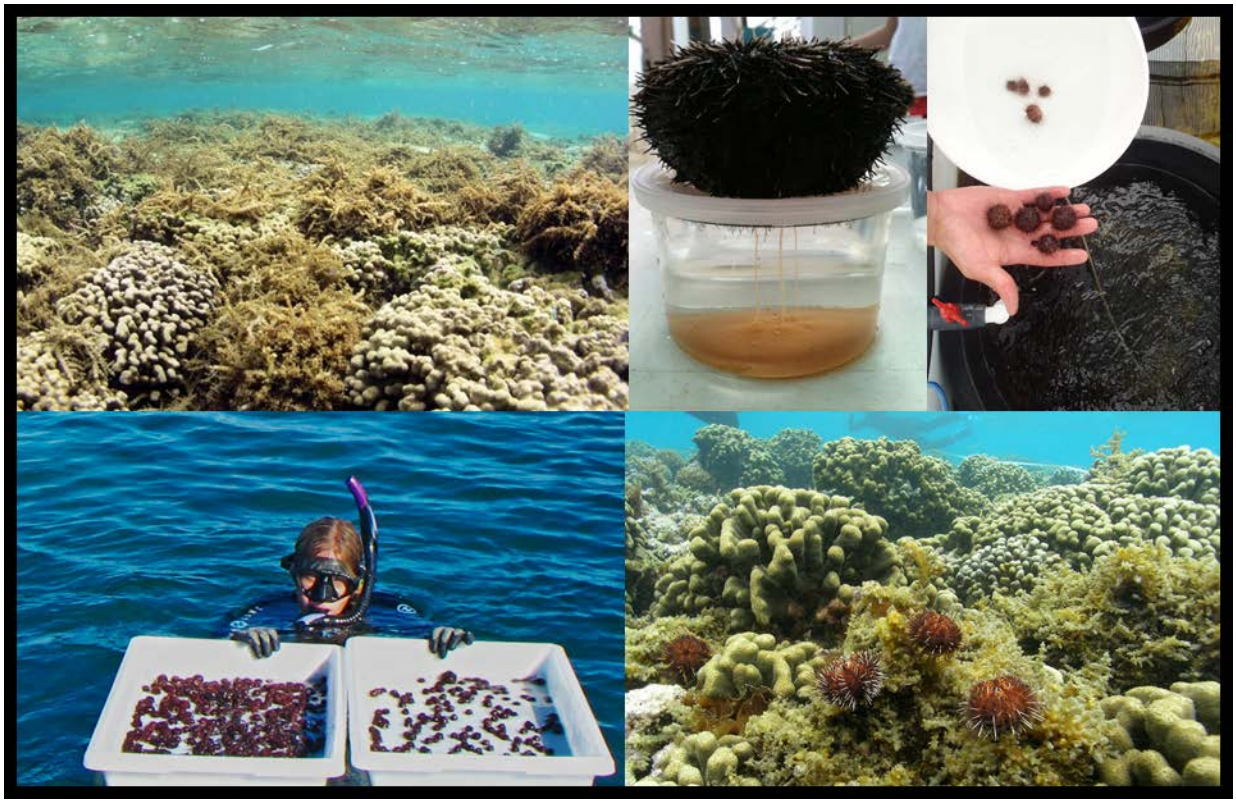
Cape Flattery Settlement Restoration Project: Restoring Reefs in Kāneʻohe Bay



PROGRESS REPORT

Division of Aquatic Resources

Aquatic Invasive Species Team

January-June 2018

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RESTORATION PLAN ACTIONS IMPLEMENTED

During the January to June 2018 reporting period, urchin outplanting continued on new target reefs prioritized for treatment, annual surveys were completed on the initial priority reefs, photo monitoring on the coral reattachment plots was conducted and is currently being processed and analyzed, and reef marker installation has continued on patch reefs throughout Kāneʻohe Bay. Additionally, planning has begun for the Heʻeia watershed restoration.

All initial priority reefs (Reefs 20, 24, 28, 30, 31, 38 and 41) have been stocked with target numbers of urchins. Urchin outplanting has progressed on newly identified priority reefs. These reefs were identified for treatment with urchins by first identifying reefs that had previously been treated, but were either understocked (Reefs 16 & 14) or whose urchins had been translocated to other reefs in the past (Reefs 26, 27 & 29). On these reefs, brief reconnaissance surveys of urchins and algae were conducted to assess the approximate number of urchins required to supplement each reef. After these reefs, three priority areas (P1, P3, and P5A) in the fringing reef areas around the sand bar and near shore were identified and the number of urchins required for each area was determined from survey data collected August 2016. These newly identified areas are scheduled to be resurveyed in August 2018. Urchin outplanting progress on the original and newly added priority reefs can be seen in Table 1 and Figure 1.

The annual monitoring of Flattery priority reefs began on March 19, 2018 and continued through March 29, 2018. The monitoring consisted of SNAP surveys of all initial priority reefs using the same methods as the baseline surveys, which were conducted in March 2016. In an effort to cover the full extent of the algae and urchin treatment, presence absence surveys of *Eucheuma/Kappaphycus* and urchins were added on to the original SNAP methodology. These data are being used to plan maintenance stocking of urchins but are not included in this report. Results of the monitoring are shown in Table 2 and the “Annual Monitoring” section beginning on page 10.

Table 2: Work plan progress

Action	Who is responsible	Timeframe	Progress	Accomplishments	Notes
Conduct baseline monitoring surveys	Monitoring Coordinator, Project Technicians	March – May 2016	Complete	2016 SNAP patch reef assessment completed 4/2016; Marker 12 assessment completed 5/2016	
Prioritize reef restoration efforts	DAR Aquatic Biologist, Trustees	March 2016 - November 2016	Complete	Prioritization complete	Reefs 14, 16, 26, 27, 29, P1, P3, and P5A added to priority list in February 2017.
Outplant native sea urchins to restoration area	Project Technicians, DAR Urchin Hatchery	April 2016 - end of project	In progress	Since the last reporting period, 7,486 urchins have been released on priority reefs	Targets reached for original priority reefs in February 2017. Outplanting continues on newly prioritized reefs.
Bi-annual reporting to the Cape Flattery trustee council	Monitoring Coordinator, DAR Aquatic Biologist	Bi-annual through end of project	In progress	Fifth progress report submitted	
Follow-up monitoring of coral and algae conducted annually	Monitoring Coordinator, Project Technicians	March – April, through end of project	Complete	Follow-up reef monitoring for original restoration reefs completed in March 2018	Monitoring for newly prioritized reefs scheduled for August 2018
Maintenance of outplanted urchins	Monitoring Coordinator, Project Technicians	August 2018- end of project	Upcoming		
Identification of and continuation on future priority reefs	DAR Aquatic Biologist, Trustees	January 2017- end of project	Complete	Reefs 14, 16, 26, 27, 29, and three fringing reef areas identified	

Figure 1: Invasive algae control progress on priority reefs in Kāne'ohe Bay.

Table 3: Reef characteristics and progress on priority reefs in Kāneʻohe Bay.

		2016 SNAP Survey				2018 SNAP Survey					
Priority	**Reef**	**Area Surveyed (m^2)**	**Area of Coral (m^2)**	**Area of *Eucheuma/ Kappaphycus* (m^2)**	**Area of *Gracilaria/ Acanthophora* (m^2)**	**Area Surveyed (m^2)**	**Area of Coral (m^2)**	**Area of *Eucheuma/ Kappaphycus* (m^2)**	**Area of *Gracilaria/ Acanthophora* (m^2)**	**Target number of urchins needed (2 urchins/m^2 of algae)**	**Number of urchins needed to reach target (as of Feb 2017)**
1	**Marker 12**	275,764	149,101	2,684	17,538	255,555	144,698	776	23,611	40,444* (*Increased to 60,000)	0
2	**44**	50,115	46,039	1,257	33	50,533	43,316	591	32	2,580	0
3	**43**	24,833	24,727	1,229	0	23,663	23,422	723	0	2,458	0
4	**41**	25,893	24,752	5,877	173	24,834	24,265	1,785	27	12,100	0
5	**40**	4,645	4,618	784	0	3,309	3,285	556	0	1,568	0
6	**38**	9,707	8,646	692	7	8,498	7,129	495	38	1,398	0
7	**31**	22,233	21,686	182	0	21,117	18,350	6	0	364	0
8	**30**	21,528	20,386	422	0	19,383	19,033	31	0	844	0
9	**28**	16,541	14,530	425	1,942	14,909	14,147	121	330	4,734	0
10	**24**	12,155	10,780	21	0	9,202	8,022	50	5	42	0
11	**20**	3,316	3,284	1	0	2,441	2,396	1	0	2	0
Control	**15**	8,570	8,458	1,753	0	7,789	7,761	2,221	0	N/A	N/A
Control	**9**	32,404	27,162	290	0	29,345	24,307	106	245	N/A	N/A
Control	**23**	5,017	4,996	208	0	3,700	3,681	599	0	N/A	N/A
TOTALS		**517,738**	**369,165**	**15,825**	**19,693**	**493,795**	**346,842**	**8,747**	**11,601**	**91,036**	**0**

URCHIN HATCHERY

During the period from January-June 2018, Flattery staff assisted with five urchin spawning events, resulting in 106 wild urchins being spawned. 15,764 liters of phytoplankton were produced to feed urchin larvae, and 716.4 kg of macroalgae were produced to feed juvenile urchins. In total, 8,070,000 larvae were produced and moved into tanks for the settlement and grow-out phases during this reporting period. Of those, 7,476 grew to transplantation size (~10mm) and were released onto priority reefs (Table 3).

Table 3: DAR Urchin Hatchery monitoring metrics for January-June 2018

	Food production		Urchin production		
Date	**Phytoplankton produced (l) (for urchin larvae)**	**Macroalgae produced (kg) (for urchin juveniles)**	**Broodstock urchins**	**Number of larvae moved into settlement/grow out phase (x1000)**	**Number of hatchery urchins outplanted**
Jan 2018	95	58.85	0	0	31
Feb 2018	2,340	109.35	37	0	0
Mar 2018	2,895	131	33	2,380	1,678
Apr 2018	3,000	98	36	2,100	2,000
May 2018	3,555	168.2	0	2,000	1,700
Jun 2018	3,879	151	35	1,590	2,067
Totals	15,764	716.4	106	8,070	7,476

Anecdotal evidence suggests that recent hatchery failures were caused by contaminants in the microalgae culture system. Significant changes were made to the phytoplankton production schedule and procedures in October of 2017. This resulted in minor downstream improvements. However, when the hatchery acquired screened and cleaned up cultures of two algae strains in November, there were immediate improvements in the larval cultures and higher rates of settlement and post-settlement survival. This led to improvements in urchin production totaling about 5,000 urchins released in March, April & May of 2018.

At present, the hatchery is in the process of changing settlement procedures. Historically, urchins were moved from the larval room directly into dual-purpose settlement/grow-out tanks. Tanks were prepared with biofilm coated plates, urchins were moved into these tanks, and that is where they lived until harvest for release. This system has worked in the past, but there were numerous challenges associated with it:

1. Temperature: The hatchery operates at the upper end of this urchin's thermal tolerance. During metamorphosis, water flow is reduced to stabilize pH and retain settlement cues making it difficult to control temperature or allowing temperature to rise in the settlement/grow-out tanks in AFRC Greenhouse.

2. Predictions: It was difficult to make even an approximate post-settlement population count until urchins were near harvestable size.

3. Midge flies: Biofilm growth was performed in the same tank where urchins would be settled. This is problematic because of the resident midge fly population. As biofilms grow, so do the midge populations, when urchins are introduced, midge fly larvae are established. While the midge larvae do not prey upon the urchin larvae and post-larvae, they are a nuisance and they compete for resources.

4. Labor/Space: If only a small number of urchins settle, the entire grow-out tank is occupied until the urchins are of harvestable size. This is waste of space and labor.

New procedures include settling larvae in 51" x 32" x 18" polyethylene totes inside of the larger fiberglass tanks. Settlement plates are conditioned elsewhere and then transferred to the totes just prior to urchin settlement. Two poly tanks fit inside of one 12' x 4' x 2' fiberglass grow-out tank. Water in the larger tank acts as a water bath that keeps the poly tanks cooler. The saltwater well water at AFRC comes out of the tap at 25°C – 26°C. The upper limit of the urchins is 29°C - 30°C. This system allows hatchery staff to reduce or turn off water flow in the settlement totes while the surrounding water mediates temperature. These internal totes are covered with sheets of rigid foam insulation. Tanks are flushed with new seawater for 30-40 minutes daily for up to six days, or until no larvae are observed in the water column. Tanks are flushed continuously after that for the 14 – 20 days.

At three to four weeks post-settlement, plates are removed individually and inspected for post-larvae (spat). Spat are counted and recorded, plates are moved into a new, larger tank for grow-out. A system to photograph the settlement plates and count the post-larvae later is being developed, rather than counting tank-side.

This settlement nursery step achieves several things:

1. Allows to better control temperature during this critical time.

2. Allows settlement quantification 3 - 4 weeks after metamorphosis with some degree of accuracy.

3. Interrupts the chironomid (midge-fly) lifecycle, or at least helps to reduce the number of midge flies in the grow-out cultures.

4. Reduces labor.

5. Creates a more organized system.

URCHIN OUTPLANTING

In total, 7,486 urchins were outplanted onto priority reefs during this period. The target number of urchins for all initially identified priority reefs was met in February 2017. Following completion of the priority reefs, work progressed on the additional priority reefs (see "Restoration Plan Actions Implemented" section), resulting in target numbers of urchins outplanted being reached on Reefs 14 and 16. Work will continue on the reprioritized reefs and urchins will be deployed on reefs 26 (1,835 urchins), 27 (3,735 urchins), 29 (5,803 urchins), P1 (40,346 urchins), P3 (3,430 urchins), and P5A (122 urchins), respectively (Figure 1). Table 4 shows the urchin releases that have occurred from January 2018-June 2018, including the number and destination of the urchins and the hours contributed by Flattery and DAR civil service staff.

Table 4: Urchin transplants for January-June 2018

Date	Urchin source	Reef Number	Number of Urchins Released	Area treated (m^2)	Work Hours	Flattery team members	DAR team members	Total Hours
1/11/18	Hatchery	14	31	16	2	1	1	4
3/2/18	Hatchery	14	328	164	2	1	1	4
3/22/18	Hatchery	14	1350	675	3	1	1	6
4/6/18	Hatchery	14	2000	1000	4	1	2	12
5/2/18	Hatchery	14	1700	850	4	2	1	12
6/1/18	Hatchery	14	1025	513	3	2	1	9
6/15/18	Hatchery	14	1042	521	3	2	0	6
Totals			7,476	3,723	21			53

ANNUAL MONITORING

The annual monitoring of the priority reefs and control reefs (listed in Table 2) was conducted from March 19 through March 29, 2018. The monitoring consisted of SNAP surveys across all reefs, as detailed in the Monitoring Plan.

Coral

Coral cover remained approximately stable across the three years, with a few small deviations (Figure 2). Notably, Reefs 24, 30, 31, 38, 40, 43, 44, and Marker 12 showed decreases in coral area of > 1000 m^2; however, it is unclear if the decreases in coral area on these reefs is due to an actual decline, or just an artefact due to variations in the area surveyed between the survey years. The decline on Reefs 38 and 44 may be due to a freshwater kill event on these reefs in August 2016. All other deviations were < 1000 m^2.

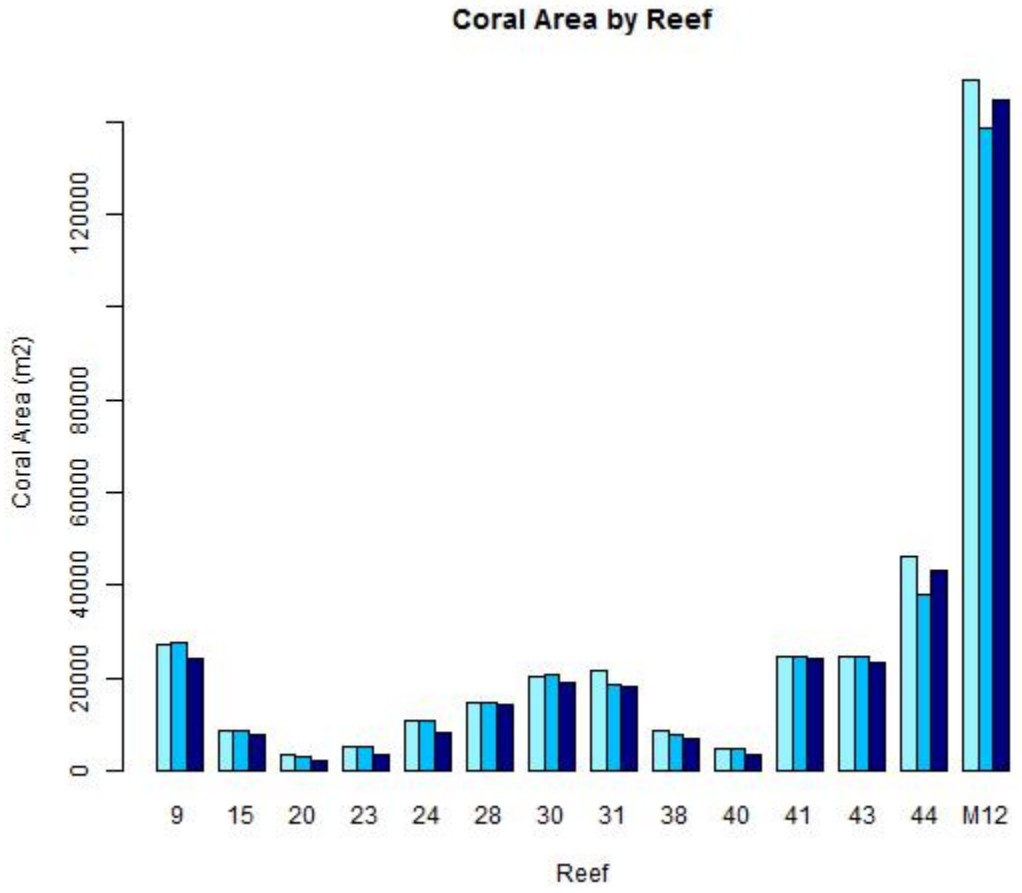

Figure 2: Coral cover (m^2) by reef from the 2016 through 2018 monitoring surveys.

Kappaphycus/Eucheuma

The area of *Kappaphycus/Eucheuma* decreased on all but three reefs between 2016 and 2018 (Figure 3). Reefs 41, 43, 44 and Marker 12 showed the most dramatic changes, all with decreases > 1000 m^2. Reefs 15, 23 and 24 showed an increase in algae cover, although 15 and 23 are controls in which no algae removal or urchin stocking has occurred. Finally, it is interesting to note that while coverage on most reefs has declined since 2016, reefs 9, 15, 23, 24, 28, 43, and 44 have shown slight increases since the 2017 monitoring indicating that perhaps the natural decline observed beginning in 2015 is no longer progressing.

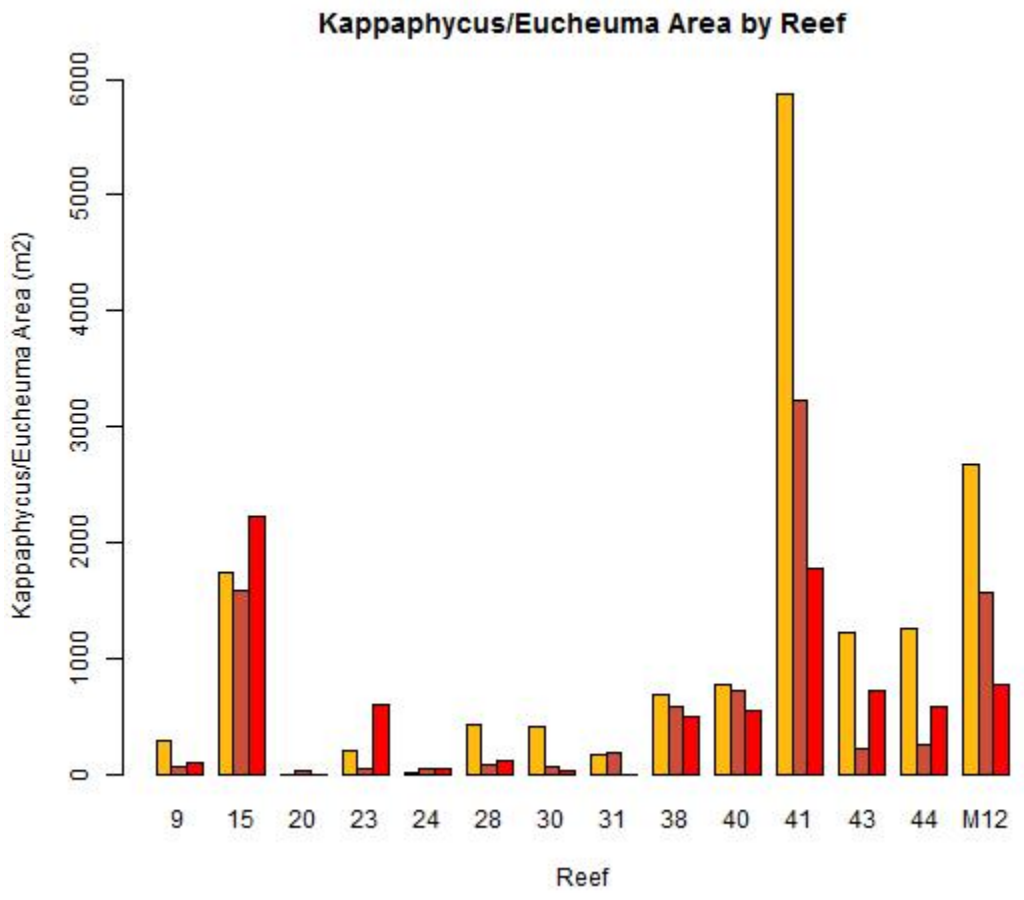

Figure 3: *Kappaphycus/Eucheuma* cover (m^2) by reef from the 2016 through 2018 monitoring surveys.

Gracilaria/Acanthophora

Gracilaria/Acanthophora cover remained low on all reefs previously exhibiting low cover in 2016 (Figure 4). In 2016, Reefs 28, 41 and Marker 12 were the only reefs with >100 m^2 of *Gracilaria/Acanthophora* cover. Of those, Marker 12 is the only reef to show an overall increase. Reef 9, which is an untreated control reef, had no *Gracilaria/Acanthophora* cover over the first two years, but now has some *Gracilaria/Acanthophora* cover present (245 m^2). The total *Gracilaria/Acanthophora* cover on all reefs except Marker 12 remains low despite these small increases.

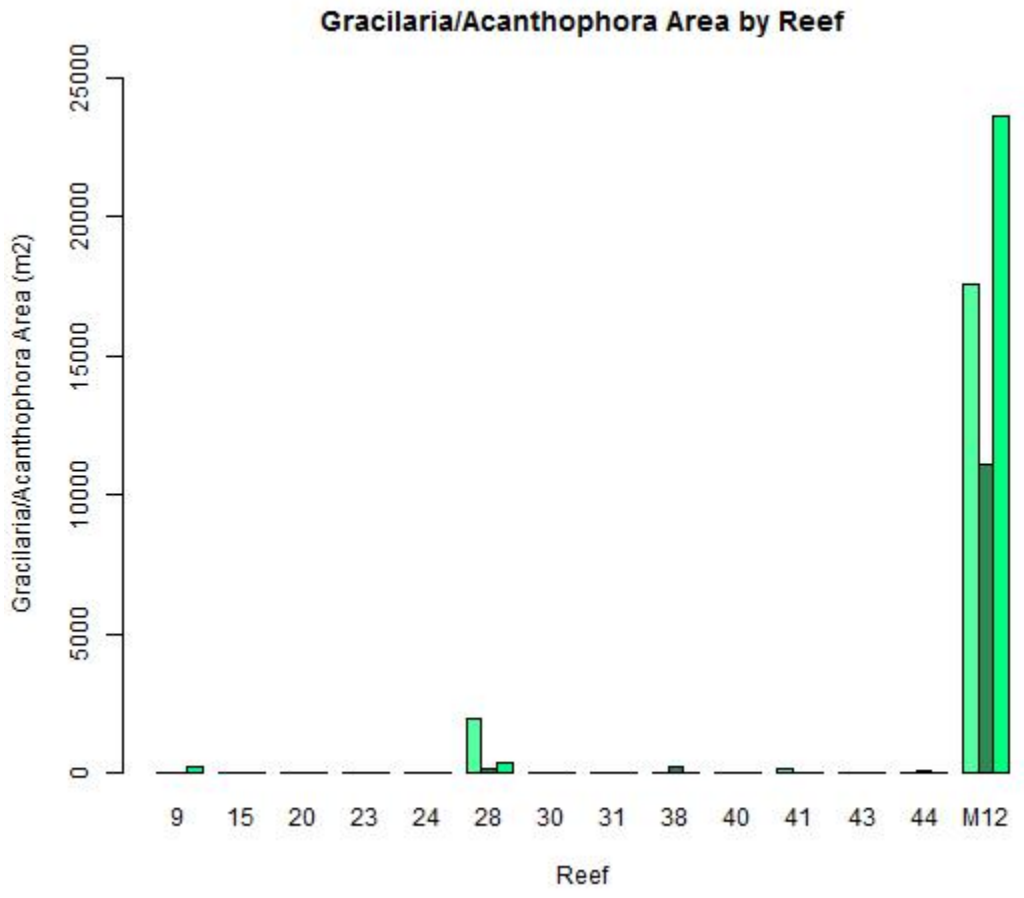

Figure 4: *Gracilaria/Acanthophora* cover (m^2) by reef from the 2016 through 2018 monitoring surveys.

CORAL REATTACHMENT PILOT STUDY

In March 2017, a proposal for a coral reattachment pilot study, was submitted to the Division hair for approval. The project uses “corals of opportunity”- loose fragments generated by boat groundings, invasive algae, or other outside forces - to restore denuded areas in Kāne‘ohe Bay. The pilot study is aimed at assessing methodology and identifying the most successful species and fragment size for successful restoration. In addition, the pilot study integrates cutting-edge technology using still photography and Agisoft software to create 3D photomosaics of the restoration plots over the course of the experiment, to create a visual representation of coral growth and reef complexity over time, which can be used for data collection, presentations, and outreach.

The proposal was approved in April 2017, and two 5 m x 5 m restoration plots were deployed on denuded areas of the P1 fringing reef priority site (Figure 5) and Marker 12 on May 10-11, 2017. Initial data were collected May 15-16. In total, approximately 860 fragments of opportunity were reattached, measured, and photo documented for photomosaic analysis.

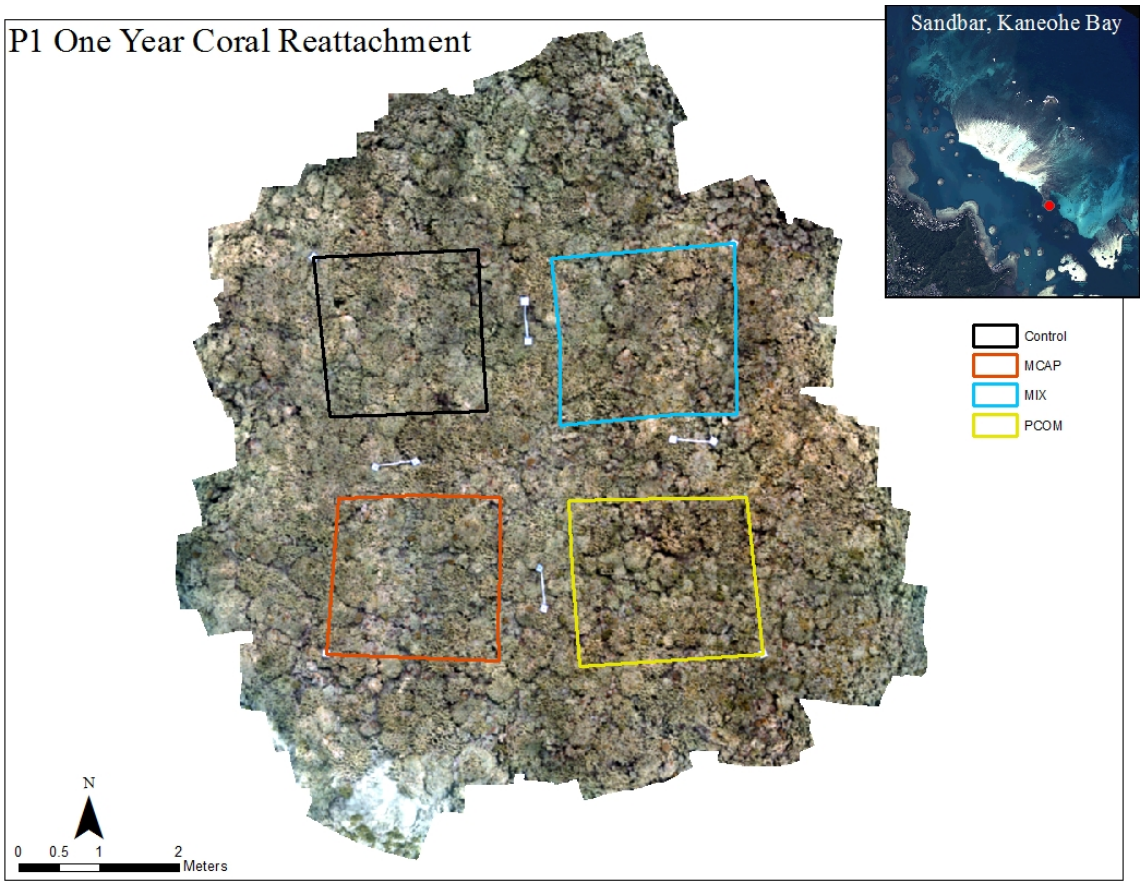

Figure 5: Processed photomosaic of the P1 fringing reef priority site.

The photomosaics are currently being processed and analyzed through high resolution images of each plot (Figure 6). The deployment of the pilot project highlighted the feasibility of collecting and reattaching coral fragments, helped test out methodology, and provided information for future restoration activities. Following the current pilot project, the team is looking to begin testing the feasibility of reattaching larger sloughed off coral fragments.

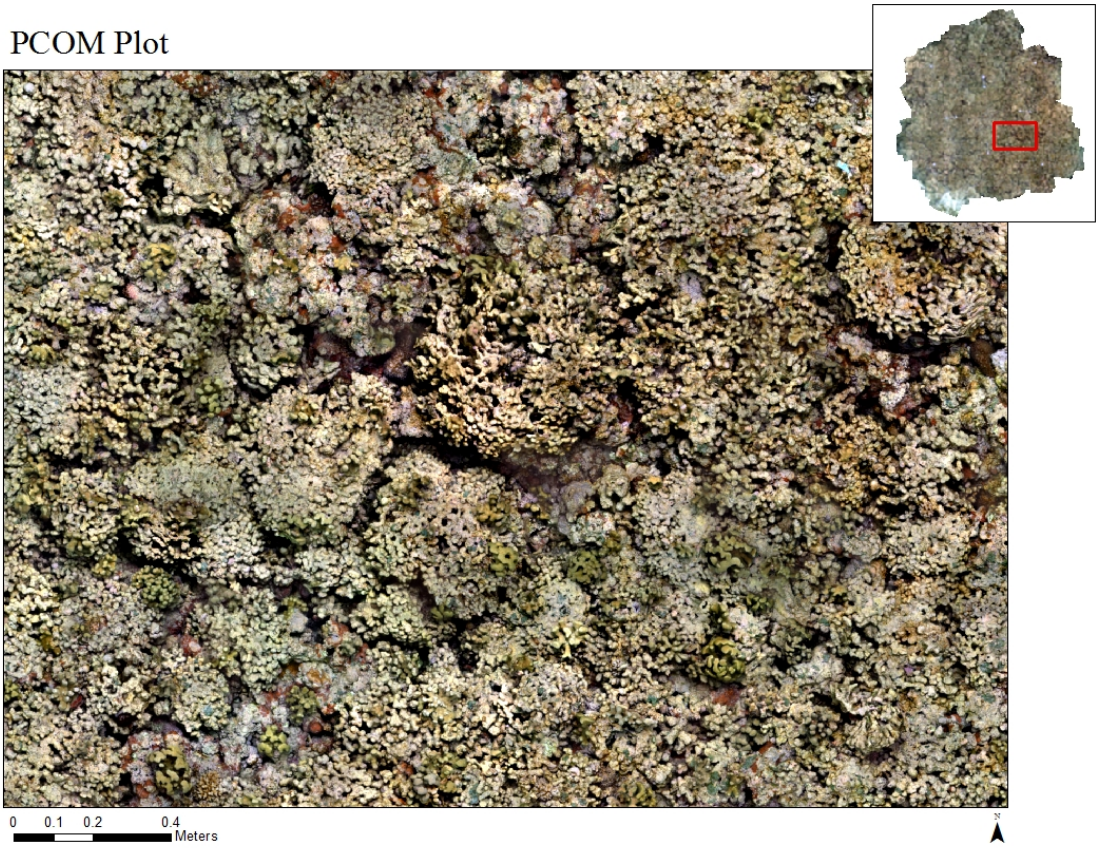

Figure 6: *Porites compressa* plot at the P1 fringing reef priority site.

HE‘EIA WATERSHED RESTORATION

A He‘eia Watershed Restoration Coordinator was hired in May. The immediate focus is on restoration details in the current mangrove removal area and road construction areas crossing the stream. Additional elevation data is needed to more accurately estimate volumes for fill/removal and to design constructed wetland/estuary features. NOAA is scheduled to supplement the existing elevation data with an on-site survey beginning on August 15.

The Forest Service contract with the Enterprise Restoration group is delayed because of some accounting codes that need to be generated from the Forest Service Region 5 office. Once this contract

is completed the Restoration group will assist with the hydraulic modeling, design, cost estimates, and any contracting package needed for the constructed wetland restoration area.

Other work planned for the next six months include:

1. Identifying potential sediment sources throughout the watershed and prioritizing potential restoration alternatives to address sedimentation into He‘eia stream, fish pond, and reef.

2. Planning and conducting an aquatic survey of fish and biota in He‘eia from the mangrove removal area upstream to USGS stream gage. Filling data gap since currently no known surveys have been done in this area. This data will be used to assist fish passage design plan throughout the wetland area and upstream.

3. Assisting with culvert placement and hydraulic capacity of culverts to accommodate various flood flows.

OTHER PROGRESS

Reef markers continue to be placed on patch reefs determined to be likely grounding areas by vessels in Kāne‘ohe Bay. To date, 46 markers have been placed on patch reefs. The installation of markers has received excellent feedback from DOBOR and the boating community. Additional markers are slated to be installed in the coming months.

Figure 7: Reef marker installed on patch reef in Kāne‘ohe Bay.