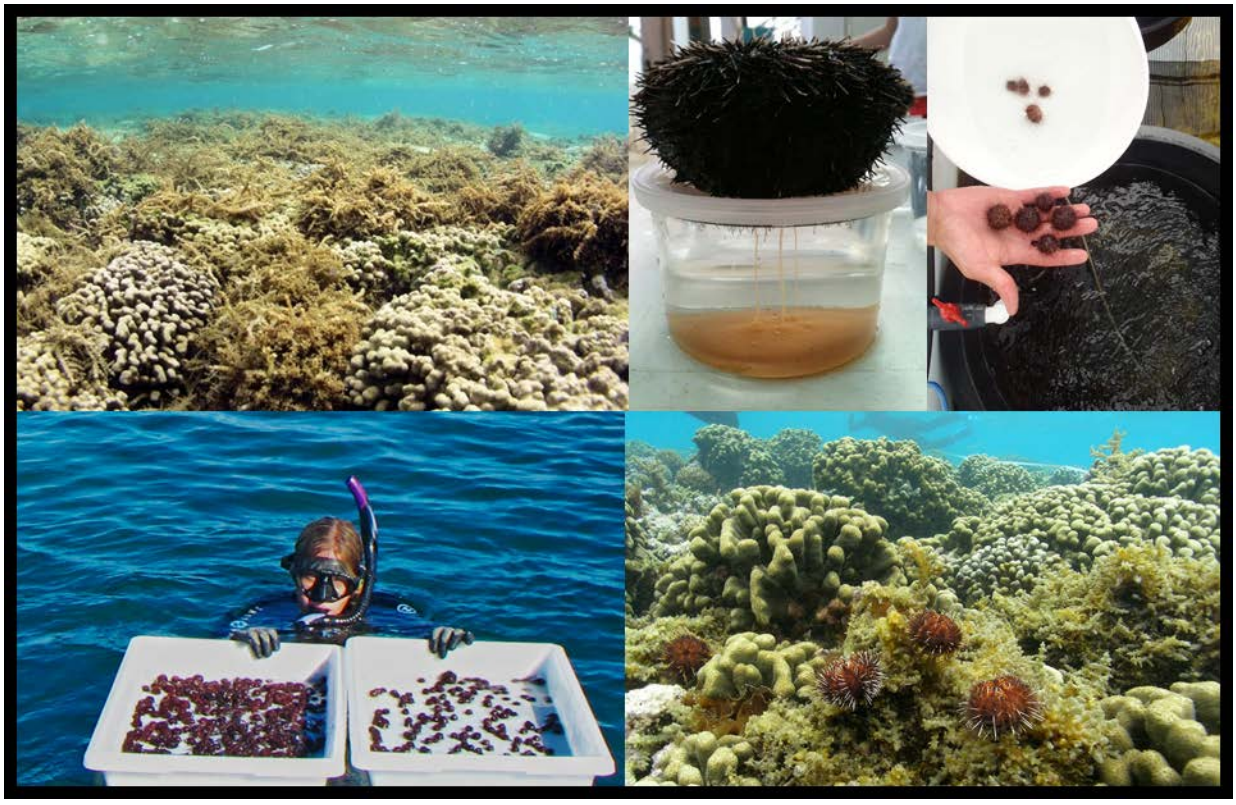
Cape Flattery Settlement Restoration Project: Restoring Reefs in Kāneʻohe Bay



PROGRESS REPORT

Division of Aquatic Resources

Aquatic Invasive Species Team

July – December 2019

Contents

RESTORATION PLAN ACTIONS IMPLEMENTED

The Division of Aquatic Resources (DAR) continued Cape Flattery Mitigation efforts to combat invasive algae in Kāneʻohe Bay during the July – December 2019 reporting period. Urchin outplanting continued on target reefs prioritized for treatment, annual SNAP surveys were completed on the secondary reefs, processing of the photo monitoring on the coral reattachment plots continued, and reef marker maintenance continued on patch reefs throughout Kāneʻohe Bay. Additionally, work has commenced for the Heʻeia watershed restoration plans.

All primary and secondary reefs have been stocked with target numbers of urchins (*Tripneustes gratilla*). Urchin outplanting has progressed to maintenance stocking of reefs based on annual surveys to maintain <5% cover of invasive algae. Urchin outplanting progress on the original and secondary reefs can be seen in Table 1 and Figure 1.

The annual monitoring of Flattery secondary reefs began on August 19, 2019 and continued through August 28, 2019. The monitoring consisted of SNAP surveys of all secondary reefs using the same methods as the baseline surveys, which were conducted in March 2016. To create higher resolution maps of the extent of the algae present and urchin treatments, presence absence surveys of *Eucheuma/Kappaphycus* and urchins were added on to the original SNAP methodology. These data are used to plan maintenance stocking of urchins but are not included in this report. Results of the monitoring are shown in Table 2, Table 3 and the “Annual Monitoring” section beginning on page 9.

Table 1: Work plan progress.

Action	Who is responsible	Timeframe	Progress	Accomplishments	Notes
Conduct baseline monitoring surveys	Monitoring Coordinator, Project Technicians	March – May 2016	Complete	Priority 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. Annual Monitoring for these secondary reefs began August 2018.
Outplant native sea urchins to restoration area	Project Technicians, DAR Urchin Hatchery	April 2016 - end of project	In progress	Since the last reporting period, 19,750 urchins have been released on priority reefs	Initial targets reached for all reefs. Targets updated annually based on survey data.
Bi-annual reporting to the Cape Flattery trustee council	Monitoring Coordinator, DAR Aquatic Biologist	Bi-annual through end of project	In progress	Eighth progress report submitted	
Follow-up monitoring of coral and algae conducted annually	Monitoring Coordinator, Project Technicians	March & August through end of project	In progress	Annual monitoring for restoration reefs completed in March and August 2019	Monitoring scheduled for March 2020. Monitoring Plan is currently being modified and will be submitted to trustees in 2020.
Maintenance of outplanted urchins	Monitoring Coordinator, Project Technicians	August 2018- end of project	In progress	Urchins added to previously stocked reefs as available	
Identification of and continuation on future priority reefs	DAR Aquatic Biologist, Trustees	January 2017- end of project	In progress	Reefs 14, 16, 26, 27, 29, and three fringing reef areas added in 2017	

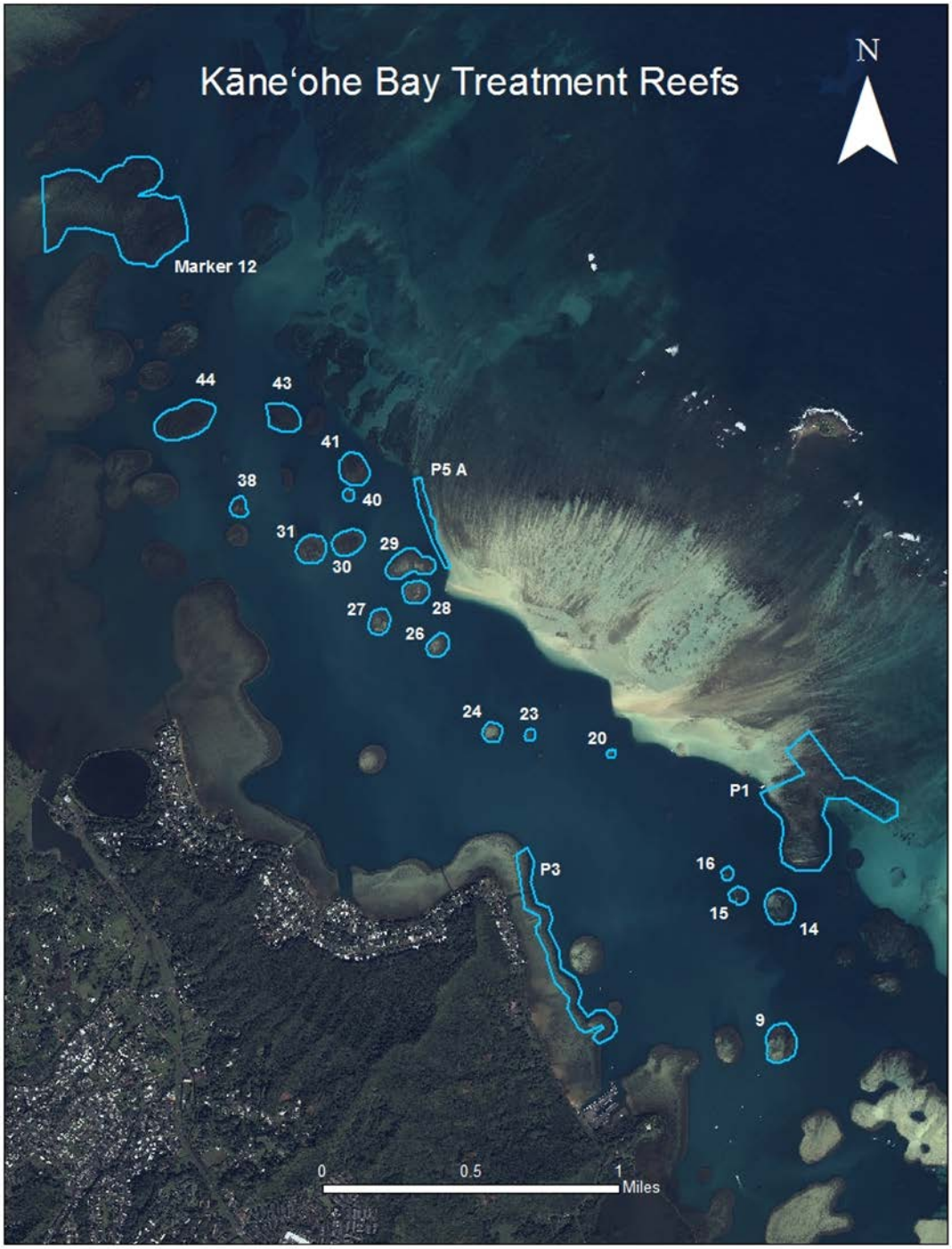


Figure 1: Primary and secondary reefs in Kāneʻohe Bay.

Table 2: Reef characteristics and progress on primary reefs in Kāne'ohe Bay.

		2016 SNAP Survey (March)				2019 SNAP Survey (March)					
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)**	**Initial target number of urchins needed (2 urchins/m^2 of algae)**	**Target number of urchins needed for ongoing maintenance stocking**
1	**Marker 12**	275,764	149,101	2,684	17,538	281,389	176,505	3,088	48,988	40,444* (*Increased to 60,000)	3,176
2	**44**	50,115	46,039	1,257	33	50,533	42,798	1,644	72	2,580	0
3	**43**	24,833	24,727	1,229	0	23,663	23,308	1,693	0	2,458	0
4	**41**	25,893	24,752	5,877	173	24,834	23,689	8,522	56	12,100	0
5	**40**	4,645	4,618	784	0	3,309	3,272	775	0	1,568	0
6	**38**	9,707	8,646	692	7	8,498	7,043	940	1,642	1,398	0
7	**31**	22,233	21,686	182	0	21,117	18,854	188	206	364	376
8	**30**	21,528	20,386	422	0	19,383	18,343	1,936	0	844	972
9	**28**	16,541	14,530	425	1,942	14,909	12,139	523	4,829	4,734	1,046
10	**24**	12,155	10,780	21	0	9,202	8,150	399	18	42	798
11	**20**	3,316	3,284	1	0	2,441	2,438	106	23	2	0
12*	**15**	8,570	8,458	1,753	0	7,789	7,597	3,023	0	N/A	660
13*	**9**	32,404	27,162	290	0	29,578	25,633	1,505	490	N/A	0
14*	**23**	5,017	4,996	208	0	3,700	3,540	790	0	N/A	0
TOTALS		**517,738**	**369,165**	**15,825**	**19,693**	**500,345**	**373,309**	**25,132**	**56,324**	**91,036**	**7,028**

**Reefs 15, 9, 23 were control reefs from 2016 - 2019. Urchin outplanting occurred on these reefs in early 2019 to reduce algae cover to limit the spread of algae from these reefs. Additionally, these reefs were monitored in both Spring and Fall monitoring events.*

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

		2016 SNAP Survey (August)				2019 SNAP Survey (August)				
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 for ongoing maintenance stocking**
1	**14**	24,835	17,247	4,719	4,631	24,835	18,465	3,486	3,286	3,972
2	**16**	3,789	3,762	217	217	3,789	3,371	328	8	0
3	**26**	11,911	10,503	2,191	0	11,911	9,020	785	15	0
4	**27**	12,958	10,804	1,368	33	12,958	9,732	413	67	826
5	**29**	29,816	27,982	566	911	29,816	23,338	903	2,042	1,806
6	**P1**	224,680	140,211	10,747	20,713	224,680	132,446	6,714	24,841	13,428
7	**P3**	92,860	86,751	319	551	92,860	82,088	185	2,827	370
8	**P5A**	19,755	16,882	4,054	2,334	19,755	16,613	2,815	2,773	0
TOTALS		417,128	314,142	24,181	29,390	417,128	295,433	15,629	35,859	20,402

URCHIN HATCHERY

During the period from July – December 2019, Flattery staff conducted four urchin spawning events, resulting in 94 wild urchins being spawned as well as additional urchins spawned from resident AFRC broodstock. 14,100 liters of phytoplankton were produced to feed urchin larvae, and 505 kg of macroalgae were produced to feed juvenile urchins. In total, 3,041,000 larvae were produced and moved into settlement tanks. Of these 84,871 spat, or post-larval urchins, were counted as spat and moved into grow-out tank. 19,750 urchins grew to transplantation size (~10mm) and were released onto priority reefs during this reporting period (Table 4).

The hatchery hosted three urchin spat count outreach events at AFRC involving students and colleagues from Windward Community College, The Hawai'i Institute of Marine Biology, Chaminade University, and the University of Hawai'i Marine Option Program. Two additional spat count events took place with Flattery personnel only. 84,871 spat were counted during these four events. This process is still in development, but it has proven helpful in predicting outplant size urchins.

Table 4: DAR Urchin Hatchery metrics for July - December 2019.

	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 phase (x1000)**	**Number of spat moved into grow-out phase**	**Number of hatchery urchins outplanted**
Jul 2019	3700	62	19	1390	10994	0
Aug 2019	3200	71	30	1170	51986	0
Sep 2019	2600	81	22	301	0	2400
Oct 2019	2400	108	23	0	20191	4800
Nov 2019	2200	103	0	180	694	6950
Dec 2019	0	80	0	0	1006	5600
Totals	14,100	505	94	3041	84,871	19,750

URCHIN OUTPLANTING

In total, 19,750 urchins were outplanted onto priority reefs during this period. An additional 1,200 urchins were outplanted to the Waikīkī MLCD marking the commencement of the Kapalama cost-sharing project. Following the February 2017 completion of primary reefs, work progressed on additional secondary reefs (see "Restoration Plan Actions Implemented" section), resulting in target numbers of urchins outplanted being reached on all secondary reefs on December 11, 2018. Control reefs were converted to treatment reefs and targeted for outplanting. Additional maintenance outplanting occurred on primary reefs nearing the 5% algal cover threshold and will continue through the next reporting period. Current target numbers of urchins required for maintenance stocking can be seen in Table 3 and Table 4. Table 5 shows the urchin releases that have occurred from January - June 2019, including the number and destination of the urchins and the hours contributed by Flattery and DAR civil service staff.

Table 5: Urchin outplants for July - December 2019.

Date	Urchin source	Reef Number	Number of Urchins Released	Area treated (m^2)	Work Hours	Flattery team members	DAR team members	Total Hours
9/5/19	Hatchery	R41	900	450	4	3	3	24
9/26/19	Hatchery	R41	1,500	750	4	2	2	16
10/15/19	Hatchery	R41	2,000	1,000	4	2	2	16
10/31/19	Hatchery	R41	2,800	1,400	4	2	2	16
11/8/19	Hatchery	R41	2,800	1,400	4	2	1	12
11/21/19	Hatchery	R40, R41	2,150	1,075	4	2	2	16
11/27/19	Hatchery	R41, R30	2,000	1,000	4	2	2	16
12/13/19	Hatchery	R30, R38, R43	3,600	1,800	4	2	1	12
12/19/19	Hatchery	R20, R44	2,000	1,000	3	2	2	12
Totals			19,750	9,875	39	20	20	156

ANNUAL MONITORING

The annual monitoring of the secondary reefs (listed in Table 3) was conducted from August 19, 2019 to August 28, 2019. Monitoring of the converted control reefs (reefs 9, 15, and 23) occurred on October 1 and 2, 2019 to capture any algae declines after they became treatment reefs. The monitoring of initial reefs (Table 2) was conducted in March 2019 and results for those reefs were discussed in the report for the January 2019 - June 2019 period. Reefs for both monitoring periods are included in the graphs in the following section for an overall view of the monitoring effort throughout the year. The monitoring consisted of SNAP surveys across all reefs as detailed in the Monitoring Plan. Maps showing interpolated coral and invasive algae coverage of each reef monitored can be found in the appendix.

It should be noted that the following numbers are interpolations across the whole patch reef area. High densities of algae cover can be found in smaller areas across individual reefs and algae coverage is not evenly distributed across the reefs.

Coral Coverage

Coral distributions were variable throughout the survey area. Coral cover ranged from 3,731 m^2 to 132, 446 m^2 (Figure 2). This is because the areal extent of each reef surveyed is highly varied. The total area of the secondary restoration area covered by coral was estimated at 295,433 m^2 while the total area of the combined primary and secondary restoration area covered by coral was approximately 668,742 m^2.

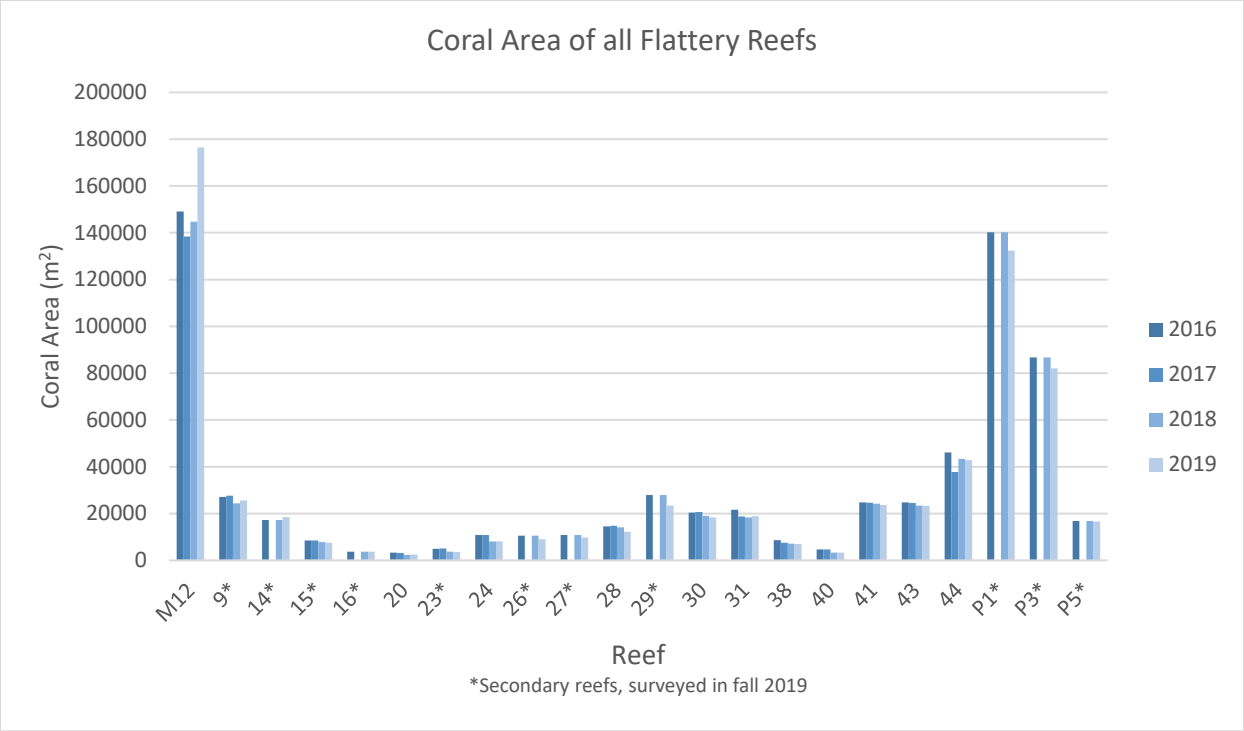


Figure 2: Coral cover (m^2) by reef.

Kappaphycus/Eucheuma

The total area of *Kappaphycus/Eucheuma* decreased between 2018 and 2019 on nine of the eleven reefs surveyed in the fall (Figure 3). None of the reefs surveyed in this reporting period showed interpolated algae densities above the target of 5% cover. Reef 14 and reef 15 showed the highest interpolated percent cover of algae of the reefs surveyed at 2.16% and 3.49% respectively.

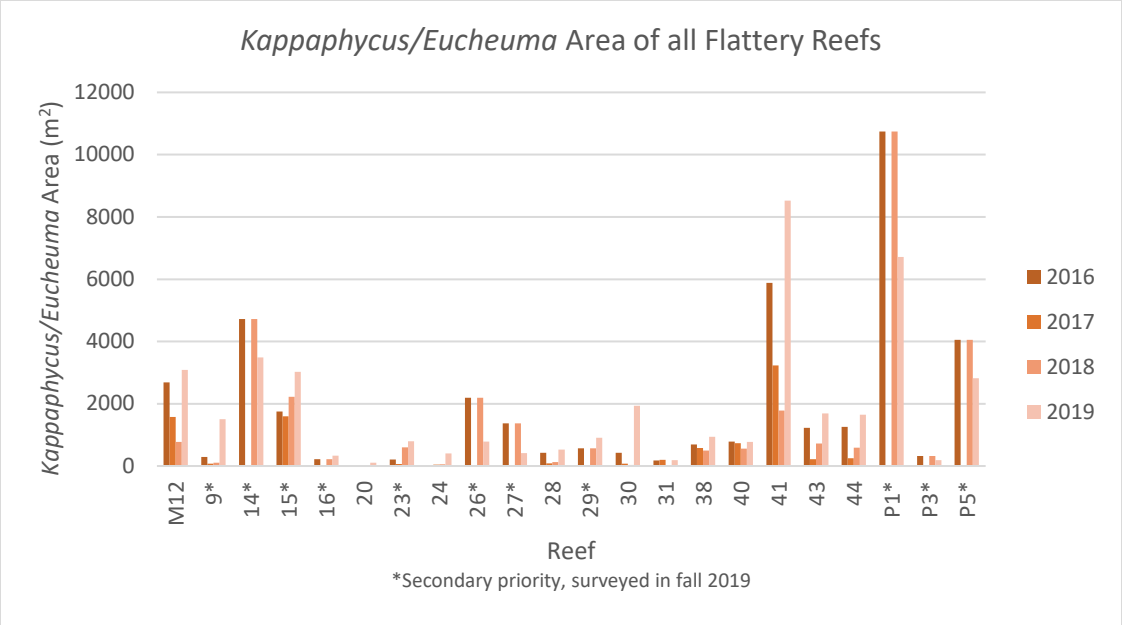


Figure 3: *Kappaphycus/Eucheuma* cover (m^2) by reef.

Reefs 9, 15, and 23 were the only reefs monitored in both spring and fall SNAP surveys (Figure 4). Initial urchin outplantings on these reefs occurred in spring 2019 and algae densities were not yet affected by the biocontrol at the time of the spring surveys. While the fall SNAP surveys showed a general decline in *Kappaphycus/Eucheuma* areal coverage on these reefs, future years' surveys may indicate if this decline can be attributed to ongoing treatment.

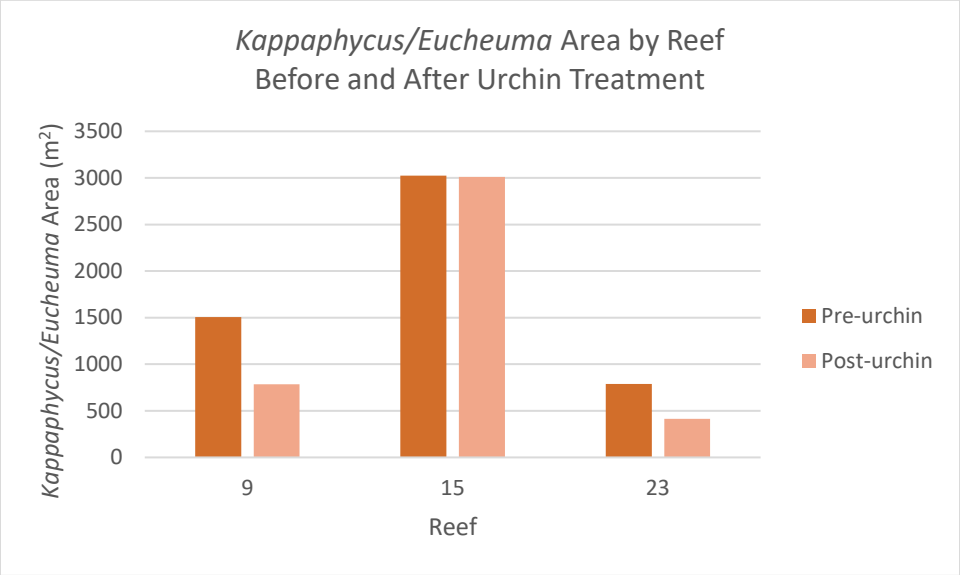


Figure 4: *Kappaphycus/Eucheuma* density on converted control reefs.

Gracilaria/Acanthophora

An increase in *Gracilaria/Acanthophora* was noted on seven of the eleven reefs surveyed in the fall (Figure 6) though areal coverage remained relatively low. *Gracilaria/Acanthophora* is typically seen in higher densities in the fringing reef areas (P1, P3, P5) and is generally found in more rubbly, sandy areas with lower coral cover. For this reason, *Gracilaria/Acanthophora* areas are currently not directly targeted for urchin outplanting. We will continue monitoring these invasive algae to determine if the areas should be targeted for biocontrol in the future.

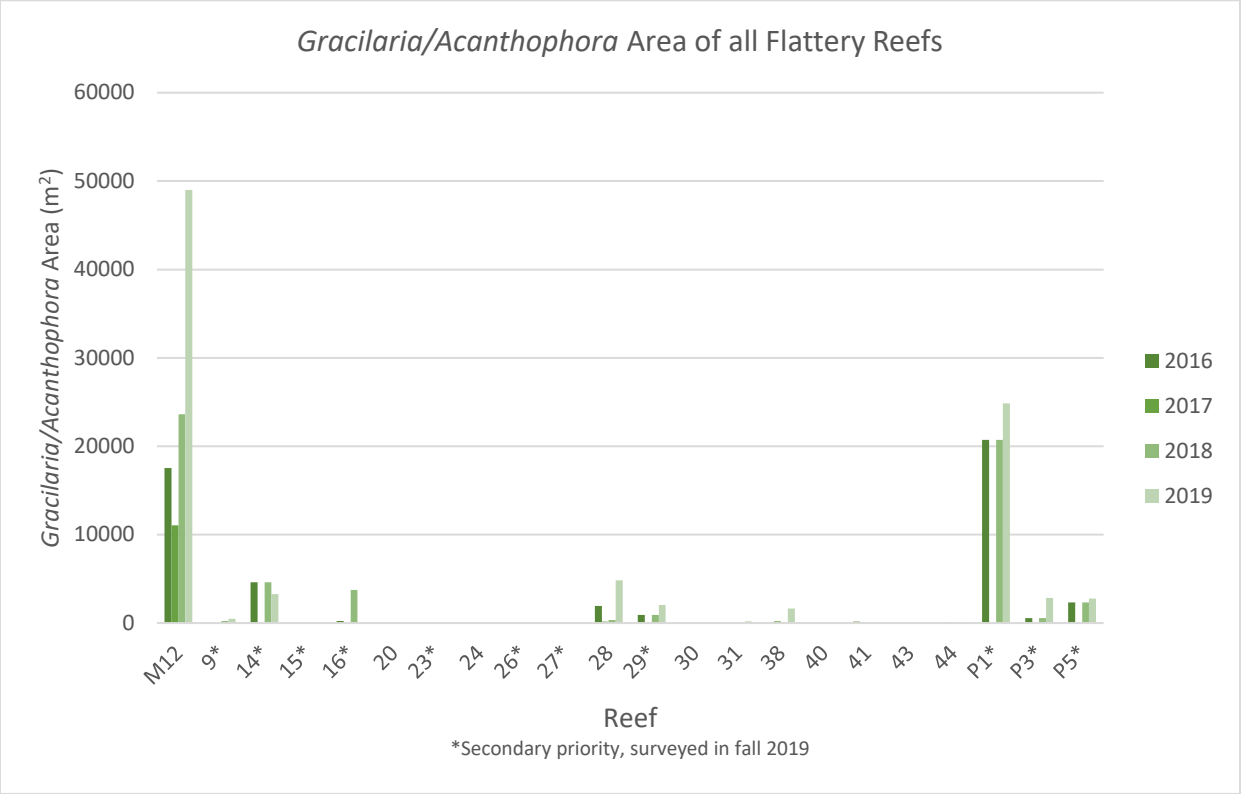


Figure 5: *Gracilaria/Acanthophora* cover (m^2) by reef.

CORAL REATTACHMENT PILOT STUDY

Photos are taken of the coral reattachment plots each May and photomosaics of the plots are currently being processed. Photomosaics can be analyzed to determine coral growth rates and coverage within the plots. Other metrics such as coral volume, linear rugosity, or surface complexity may be calculated based on need or available resources.

Hydrologic Flood Model

A baseline conditions flood model was presented to Kāko‘o ‘Ōiwi, Paepae o He‘eia, and NERR staff who were unable to attend the initial presentation by the U.S. Forest Service. The flood model results are being used to better inform management decisions regarding effects of different magnitude floods (Figure 6). The model displays how flood waters behave from a spatial and temporal context and where the greatest flow shear stresses and velocities occur in and around the He‘eia wetland. This information is currently being incorporated into a working design for the planned road and infrastructure network.

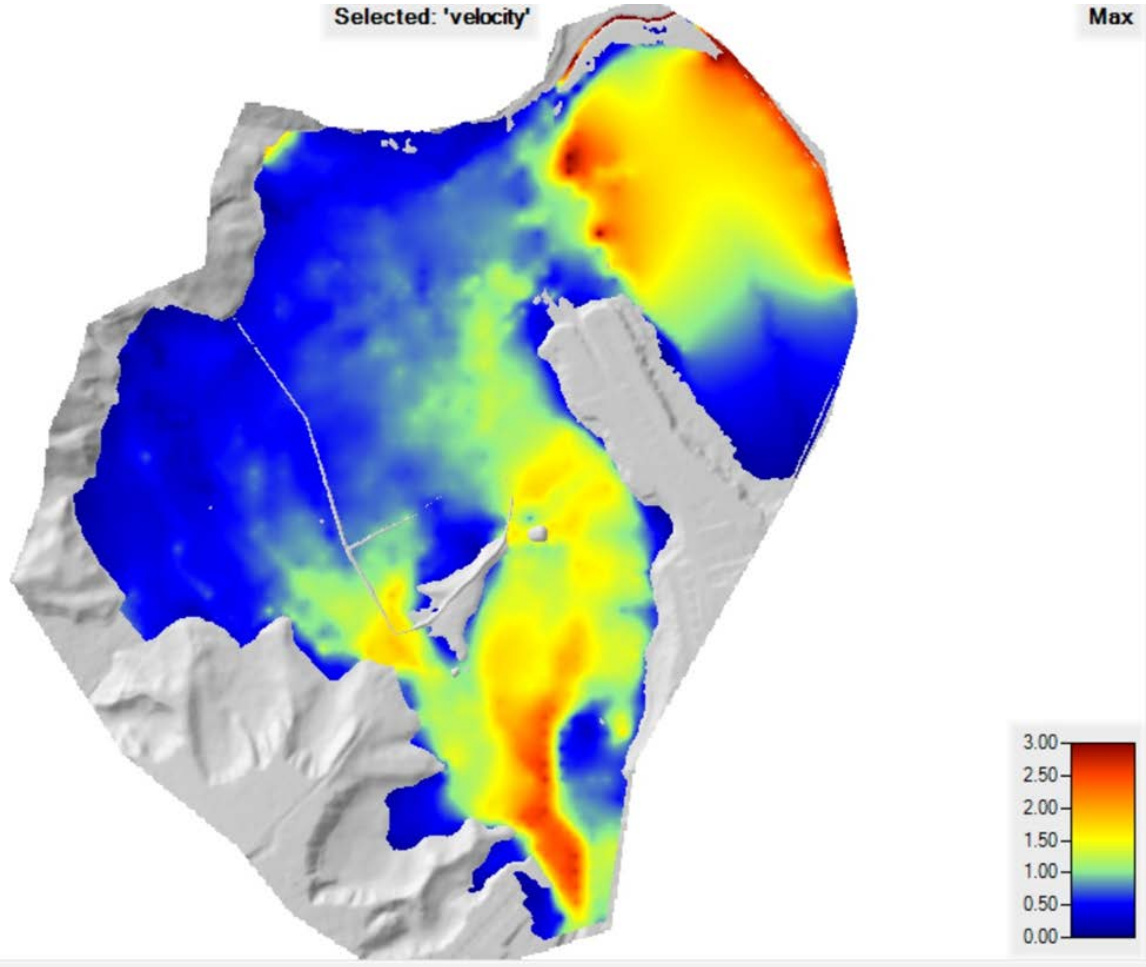


Figure 6: Visual flood model output of stream velocities for the 50yr flood.

He‘eia Designs

The current road design plan for Kāko‘o ‘Ōiwi was digitized into AutoCad and ArcGIS and is in the process of being input into additional iterations of the hydro flood model. The results will be used as a planning tool to assess critical areas potentially impacted by floods, develop retention areas to capture sediment, identifying and minimizing detrimental effects to aquatic biota from planned infrastructure (Figure 7).

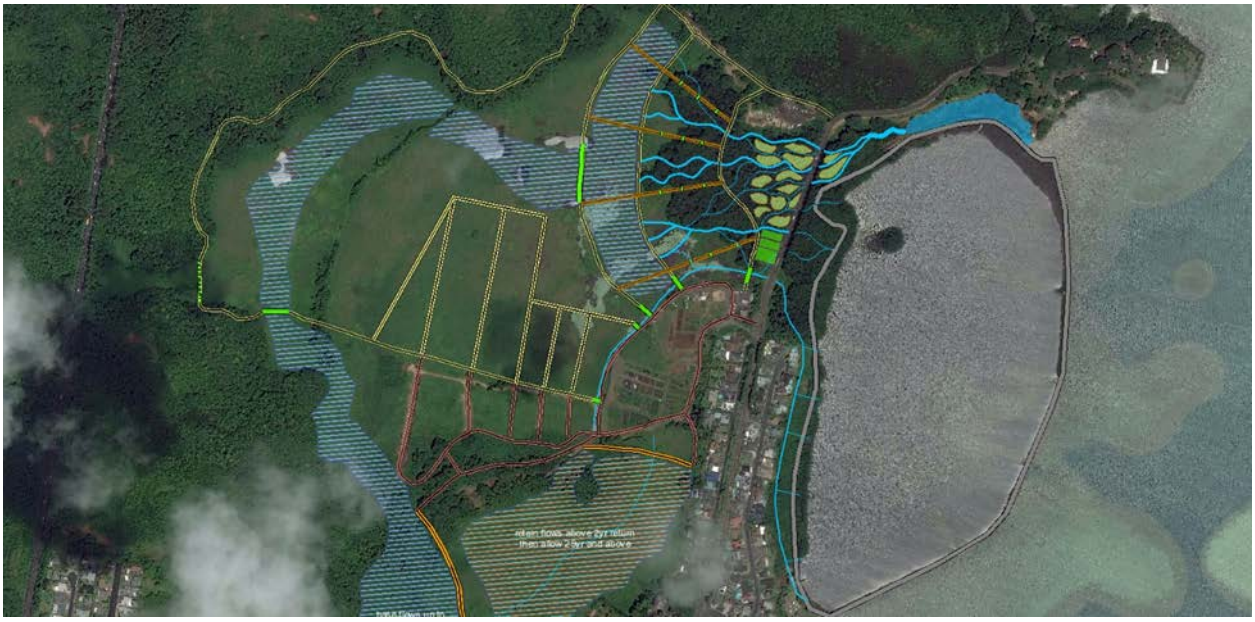


Figure 7: Draft designs for He‘eia wetland.

Aquatic Biota Sampling

A lack of past and current baseline aquatic biota data in He‘eia watershed was identified during an initial review in early 2019. Planning for the collection of aquatic biota data began in 2019 and the first full watershed aquatic survey was conducted in June 2019. The second full aquatic sampling was conducted in December 2019. The sampling took place from the estuary up to just below the headwaters of He‘eia stream. Participants in the planning and data collection included NERR, Kāko‘o ‘Ōiwi, TNC, and DAR staff.

Figure 8: Estuary fish sampling.

Some preliminary findings of aquatic survey:

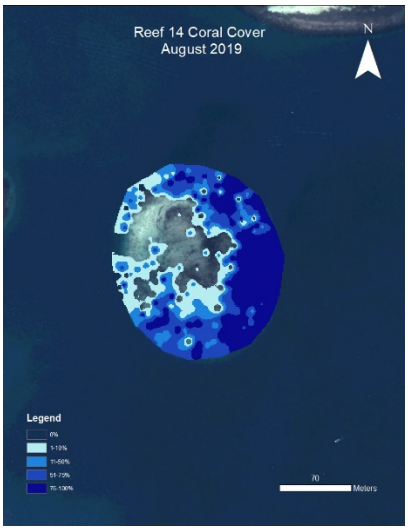
- Native O'opu naniha (*Stenogobius hawaiiensis*) and aholehole (*Kuhlia xenura*) were found to begin to inhabit the wetland where mangrove were removed.
- Native O'opu nakea were found in the faster flowing upstream margins of He'eia wetland and further upstream by the USGS gage at Papahana. None found in the farm ditches or stagnant waters of the main wetland.
- Non-native distribution of some species are limited by a 15' waterfall located in the mid-watershed in the urbanized section. Very high densities of non-native bristlenose catfish *Ancistrus sp.* were found above and below the waterfall.

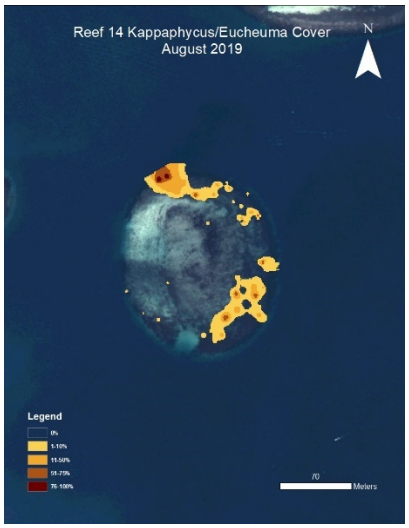
OTHER PROGRESS

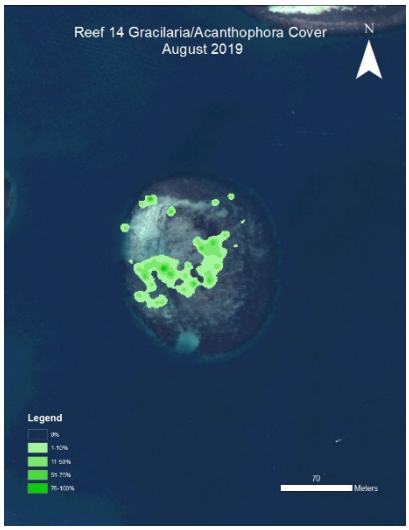
Reef markers continue to be maintained on patch reefs determined to be likely grounding areas by vessels in Kāne'ohe Bay. As of the end of this reporting period, 62 markers have been placed on 33 patch reefs. The installation of markers has received excellent feedback from the Division of Boating and Ocean Recreation (DOBOR) and the boating community. Additional reef markers will be placed around Coconut Island in partnership with the Hawai'i Institute of Marine Biology to clearly mark the regulated fishing areas within the Hawai'i Marine Laboratory Refuge.

APPENDIX

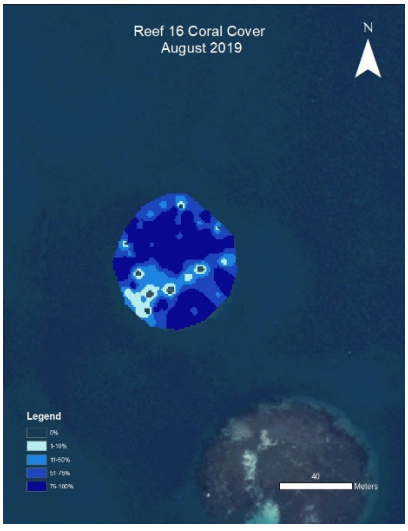
Reef 14

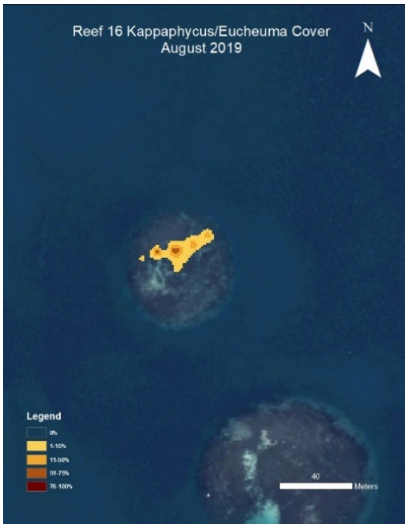


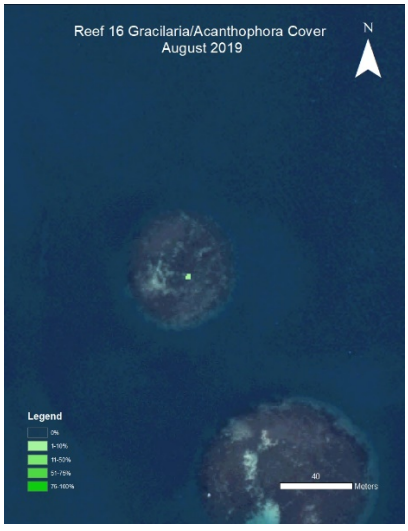




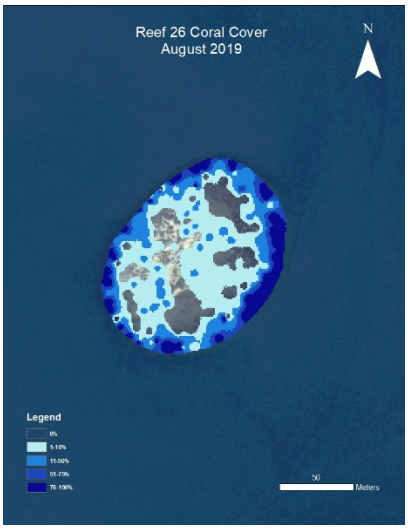
Reef 16

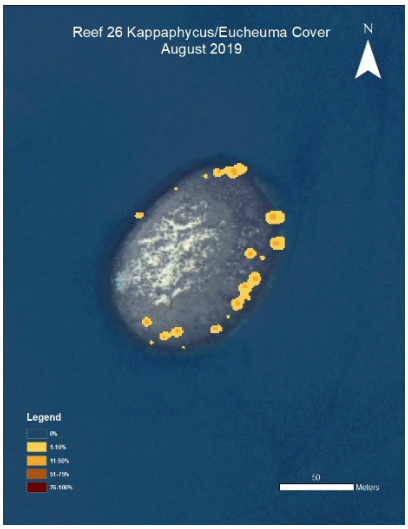


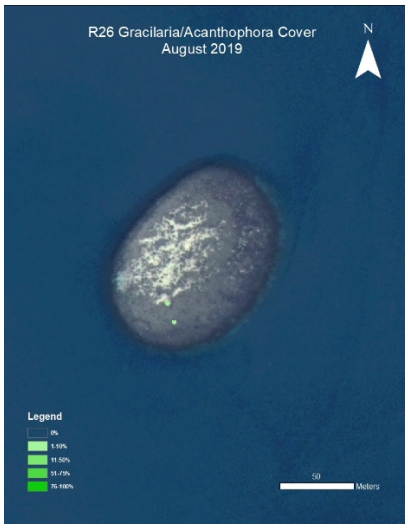




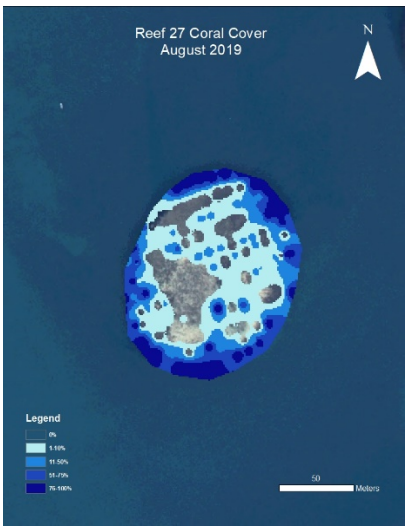
Reef 26

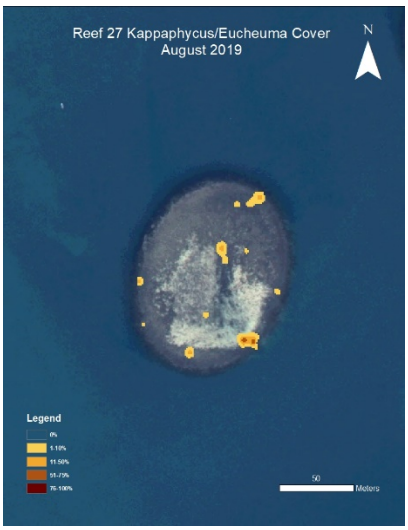


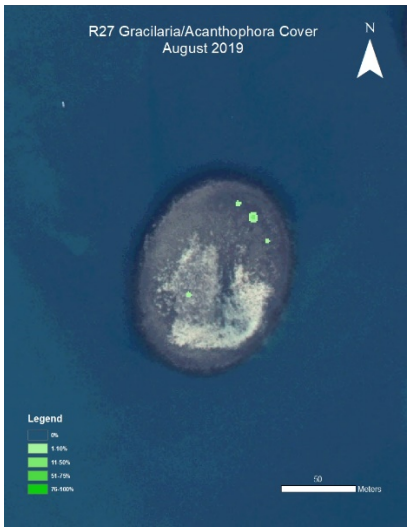




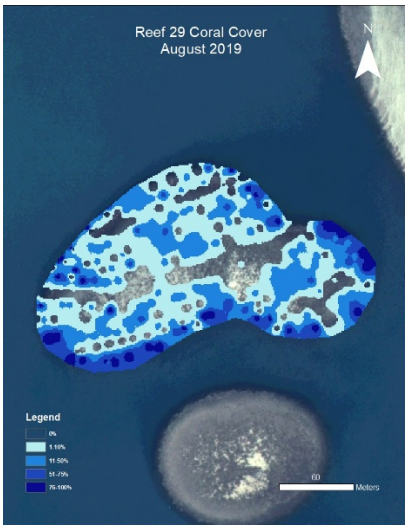
Reef 27

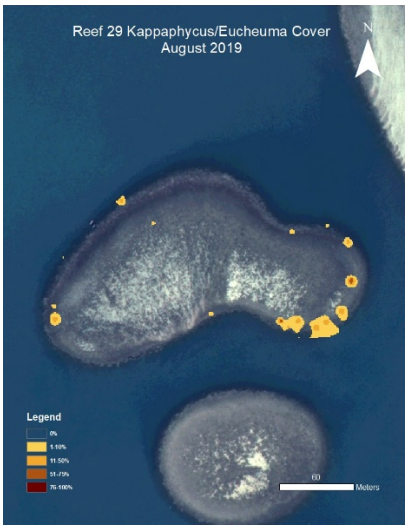


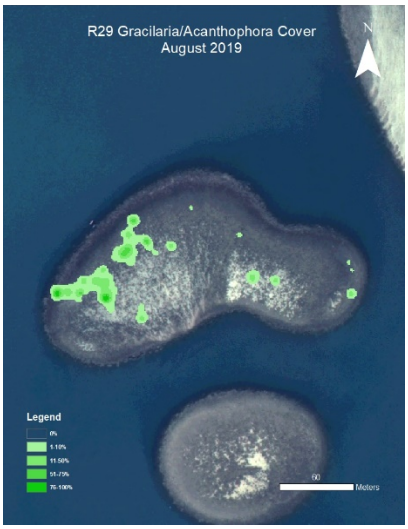




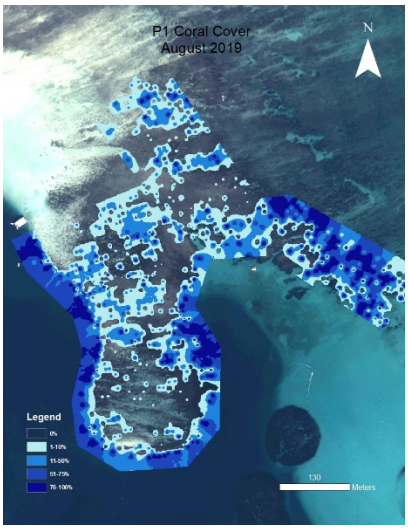
Reef 29

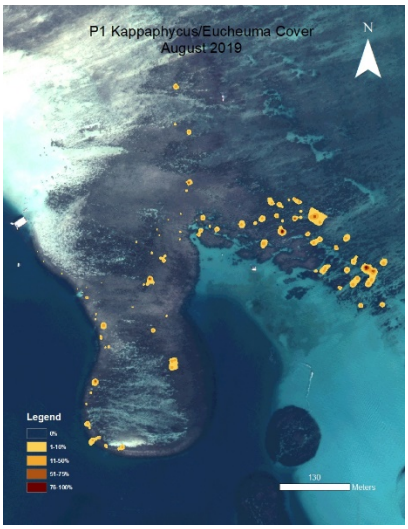

Reef 29 Coral Cover
August 2019
N
Legend
0%
1-10%
11-50%
51-75%
76-100%
60
Meters

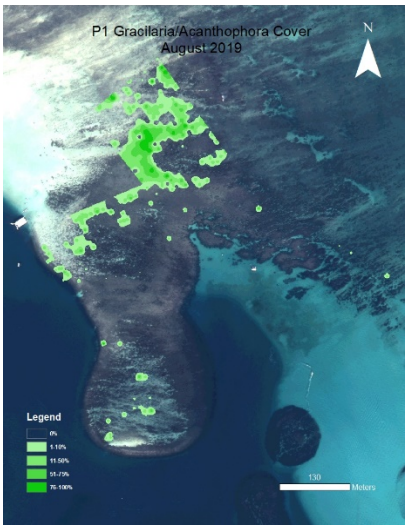

Reef 29 Kappaphycus/Eucheuma Cover
August 2019
N
Legend
0%
1-10%
11-50%
51-75%
76-100%
60
Meters


R29 Gracilaria/Acanthophora Cover
August 2019
N
Legend
0%
1-10%
11-50%
51-75%
76-100%
60
Meters

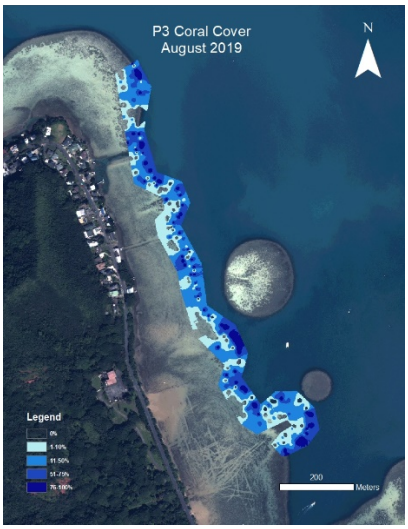
P1


P1 Coral Cover
August 2019
N
Legend
0%
1-10%
11-50%
51-75%
76-100%
130
Meters


P1 Kappaphycus/Eucheuma Cover
August 2019
N
Legend
0%
1-10%
11-50%
51-75%
76-100%
130
Meters


P1 Gracilaria/Acanthophora Cover
August 2019
N
Legend
0%
1-10%
11-50%
51-75%
76-100%
130
Meters

P3


P3 Coral Cover
August 2019
N
Legend
200
Meters

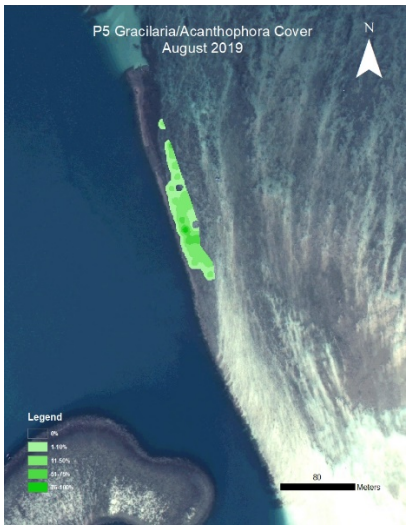

P3 Kappaphycus/Eucheuma Cover
August 2019
N
Legend
200
Meters


P3 Gracilaria/Acanthophora Cover
August 2019
N
Legend
200
Meters

P5


P5 Coral Cover
August 2019
N
Legend
80
Meters


P5 Kappaphycus/Eucheuma Cover
August 2019
N
Legend
80
Meters


P5 Gracilaria/Acanthophora Cover
August 2019
N
Legend
80
Meters