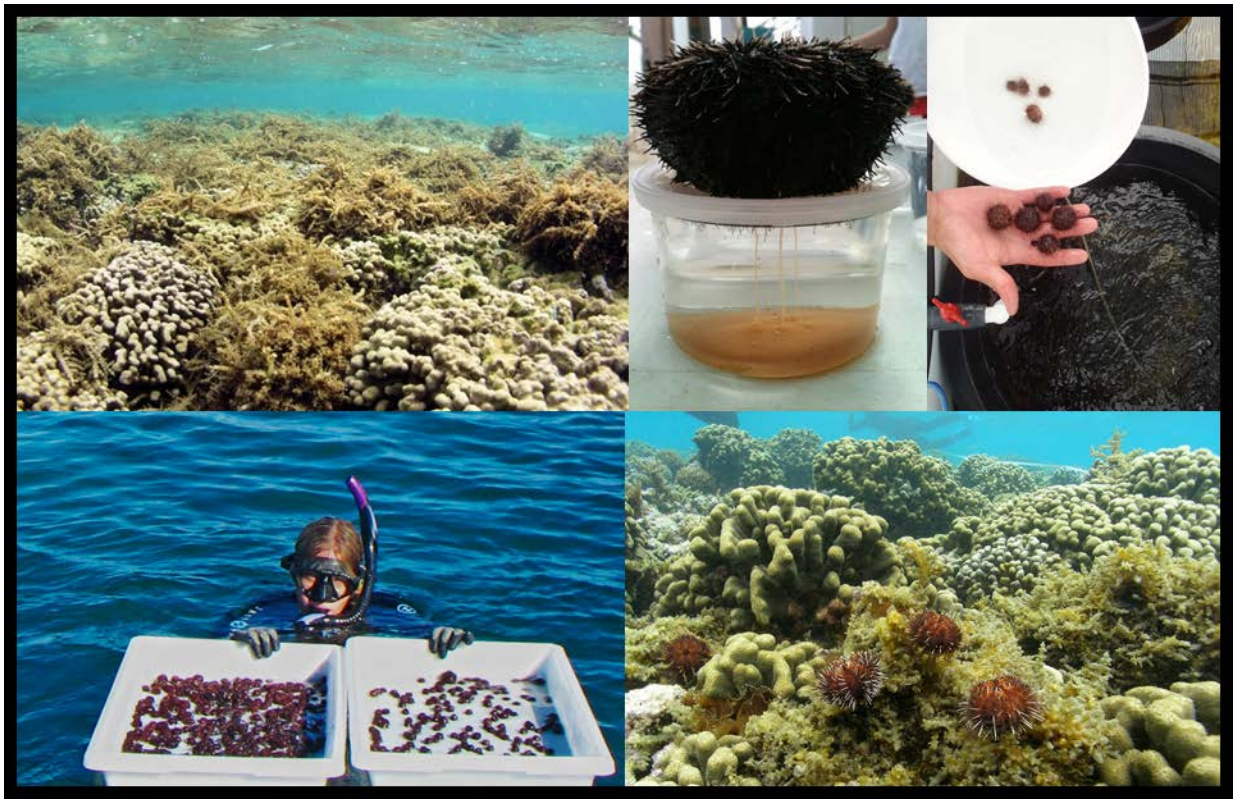
Cape Flattery Settlement Restoration Project: Restoring Reefs in Kāneʻohe Bay



PROGRESS REPORT

Division of Aquatic Resources

Aquatic Invasive Species Team

January-May 2017

TABLE OF CONTENTS

RESTORATION PLAN ACTIONS IMPLEMENTED

During the January to May 2017 reporting period, urchin outplanting targets for priority reefs were reached, additional reefs were prioritized for treatment, and the first annual follow-up monitoring was completed. In addition, work began on a coral reattachment pilot project to utilize corals of opportunity within Kāneʻohe Bay.

By February 15, 2017, all remaining priority reefs (Reefs 20, 24, 28, 30, 31, 38 and 41) had been stocked with target numbers of urchins. Following work on these reefs, outplanting began on newly identified priority reefs, leading to target numbers being met on Reef 16. 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 from August 2016. Urchin outplanting progress on the original and newly added priority reefs can be seen in Figure 1.

The annual monitoring of Flattery priority reefs began on March 20, 2017 and continued through March 23, 2017. The monitoring consisted of SNAP surveys of all 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, the “Annual Monitoring” section below, and in the Appendix.

In March 2017, a proposal for a coral reattachment pilot study was presented to the Division Chair for approval. The proposal was approved by the Chair in April 2017, and two pilot plots were deployed in Kāneʻohe Bay between May 10-11, 2017, and initial data were collected May 15-16. Both Flattery staff and the civil service staff attended a 3D-photomosaic training hosted by Scripps Institution of Oceanography on March 6-7, 2017; these methods were incorporated into the coral restoration protocol in order to utilize this cutting-edge technology.

Finally, a technician was hired to the project in January 2017 and began work on March 6, 2017.

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, 15,174 urchins have been released on priority reefs	Targets reached for priority reefs on February 15, 2017. Outplanting has continued on newly prioritized reefs.
Bi-annual reporting to the Cape Flattery trustee council.	Monitoring Coordinator, DAR Aquatic Biologist	May & December through end of project	In progress	Third progress report submitted to trustee council May 2017	
Follow-up monitoring of coral and algae conducted annually.	Monitoring Coordinator, Project Technicians	March – April, through end of project	Complete	Follow-up monitoring for 2017 completed on March 23, 2017	
Maintenance of outplanted urchins	Monitoring Coordinator, Project Technicians	April 2017- 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	

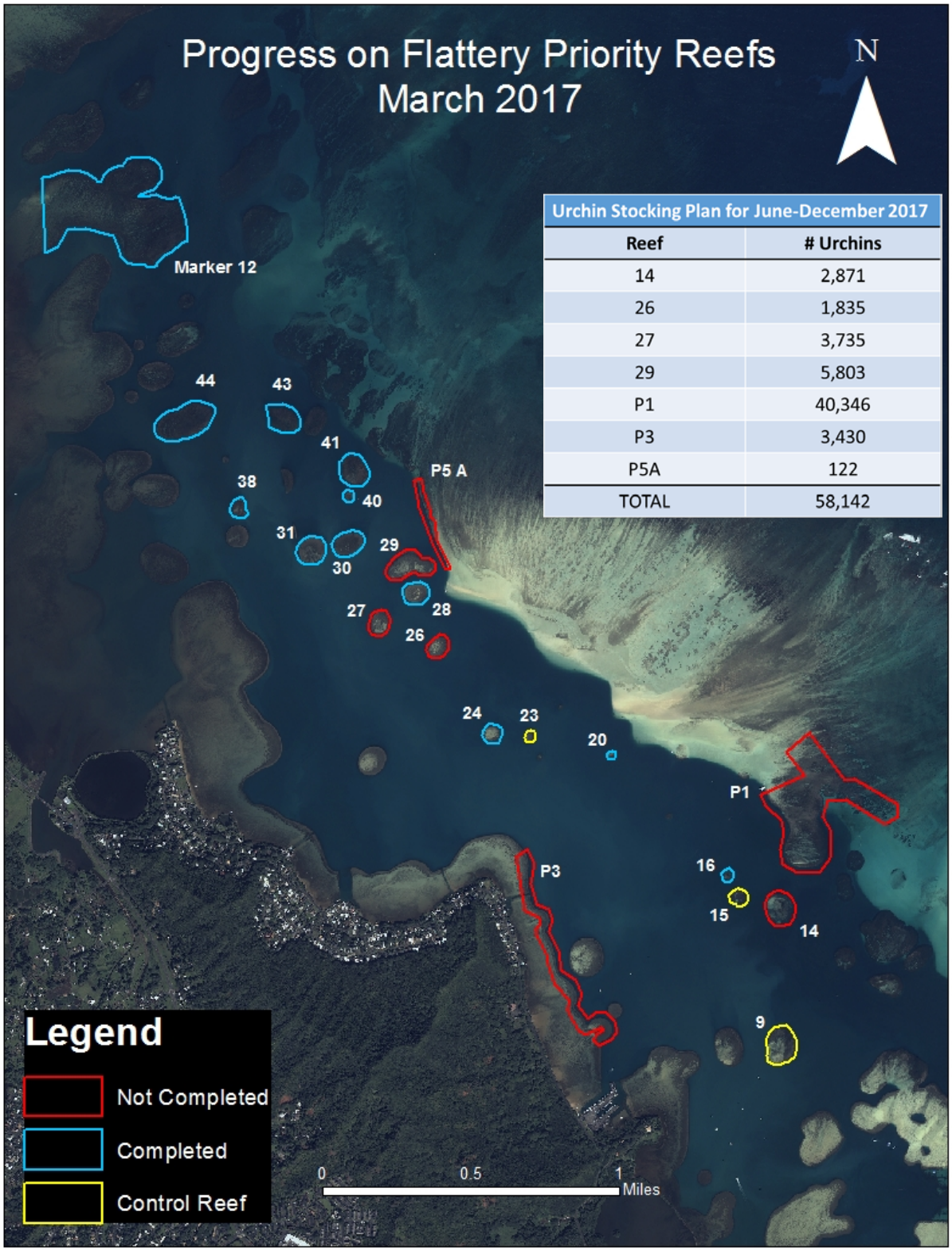


Figure 1: Invasive algae control progress on priority reefs in Kāneʻohe Bay.

		2016 SNAP Survey				2017 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 May 2017)**
1	**Marker 12**	275,764	149,101	2,684	17,538	255,897	138,459	1,579	11,074	40,444* (*Increased to 60,000)	0
2	**44**	50,115	46,039	1,257	33	50,425	37,827	252	99	2,580	0
3	**43**	24,833	24,727	1,229	0	24,833	24,833	218	0	2,458	0
4	**41**	25,893	24,752	5,877	173	25,893	24,618	3,227	13	12,100	0
5	**40**	4,645	4,618	784	0	4,645	4,615	733	0	1,568	0
6	**38**	9,707	8,646	692	7	9,707	7,603	582	210	1,398	0
7	**31**	22,233	21,686	182	0	23,233	18,736	193	0	364	0
8	**30**	21,528	20,386	422	0	21,528	20,663	75	0	844	0
9	**28**	16,541	14,530	425	1,942	16,541	14,802	88	167	4,734	0
10	**24**	12,155	10,780	21	0	12,176	10,787	46	0	42	0
11	**20**	3,316	3,284	1	0	3,316	3,166	27	29	2	0
Control	**15**	8,570	8,458	1,753	0	8,570	8,463	1,594	0	N/A	N/A
Control	**9**	32,404	27,162	290	0	32,014	27,653	73	0	N/A	N/A
Control	**23**	5,017	4,996	208	0	5,017	5,009	60	9	N/A	N/A
TOTALS		**517,738**	**369,165**	**15,825**	**19,693**	**493,795**	**346,842**	**8,747**	**11,601**	**91,036**	**0**

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

URCHIN HATCHERY

In order to rear *Tripneustes gratilla* in the hatchery, wild broodstock urchins are harvested to collect gametes. During the period from January-May 2017, Flattery staff assisted with 4 urchin spawning events, resulting in 123 wild urchins being spawned. For each spawning event, staff collect adult urchins from the wild and transport them to the hatchery at the Ānuenue Fisheries Research Center. There, Flattery staff assist with spawning the urchins and collecting gametes so that the spawning event can be completed quickly and efficiently.

From January-May 2017, 16,611 liters of phytoplankton were produced to feed urchin larvae, and 379.11 kg of macroalgae were produced to feed juvenile urchins. In total, 8,411,000 larvae were produced and moved into tanks for the settlement and grow-out phases during this reporting period. Of those, 15,174 (0.18%) grew to transplantation size (~10mm) and were released onto priority reefs.

Table 3: DAR Urchin Hatchery monitoring metrics for January-May 2017

	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 2017	2,202	63.70	38	0	7524
Feb 2017	2,874	75.25	0	1,845	5787
Mar 2017	4,482	109.80	33	0	1517
Apr 2017	3,583	77.74	25	3,510	346
May 2017	3,470	52.62	27	3,056	0
Totals	16,611	379.11	123	8,411	15,174

URCHIN OUTPLANTING

In total, 15,174 urchins were outplanted onto priority reefs during this period. The target number of urchins for all of the initially identified priority reefs was met on February 15, 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 Reef 16. Currently, Reef 14 is in progress; once the target number of urchins are met on Reef 14, 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 2017-May 2017, 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-May 2017

Date	Urchin source	Reef Number	Number of Urchins Released	Area treated (m^2)	Work Hours	Flattery team members	DAR team members	Total Hours
1/4/17	Hatchery	41, 38	4400	2200	4	1	3	16
1/19/17	Hatchery	38, 31, 30, 28	3124	1562	5	1	4	25
2/2/17	Hatchery	28	3600	1800	4	1	4	20
2/15/17	Hatchery	28, 24, 20, 16	2187	1094	5	1	1 + 2 Kupu	20
3/8/17	Hatchery	14	1517	759	3	2	3	15
4/4/17	Hatchery	14	346	173	2	1	3	8
Totals			15,174	7,588	23			104

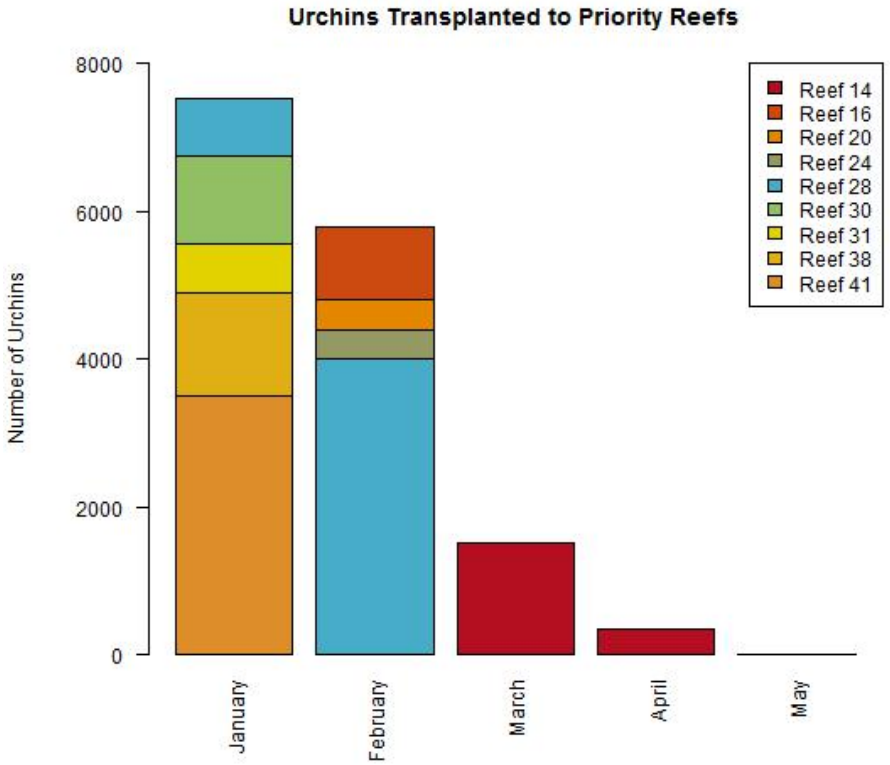


Figure 2: Number of urchins outplanted to priority reefs by month from January-May 2017.

ANNUAL MONITORING

The annual monitoring of the priority reefs and control reefs (listed in Table 2) was conducted from March 20-23, 2017. The monitoring consisted of SNAP surveys across all reefs, as detailed in the Monitoring Plan. Note that due to the continuous nature of Marker 12 (as opposed to the discrete area of the patch reefs), a different total area was surveyed (Table 2), therefore the areas of each metric cannot be directly compared across years for this reef without redefining the boundary and reanalyzing the 2016 survey data.

Coral

Coral cover remained approximately stable across the two years, with a few small deviations (Figure 3). Notably, Reefs 31, 38, 44, and Marker 12 showed decreases in coral area of > 1000 m^2; however, it is unclear if the decrease in coral area on Marker 12 is due to an actual decline, or just an artefact of the smaller survey area. The decline on Reefs 38 and 44 may be due to a freshwater kill event on these reefs in August 2016. All other deviations, positive or negative, were < 1000 m^2. The distribution of coral across the survey area for the 2017 survey can be seen in Figure 4, with individual maps by reef in the Appendix.

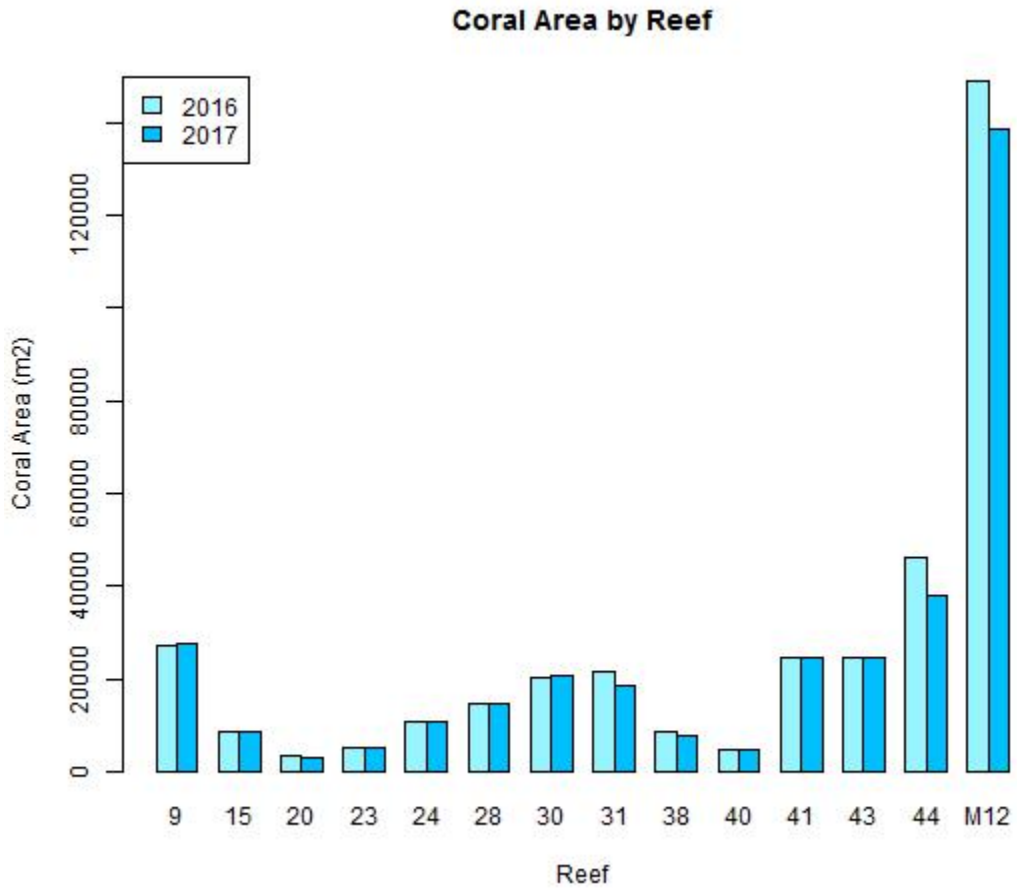


Figure 3: Coral cover (m^2) by reef from the 2016 and 2017 monitoring surveys.

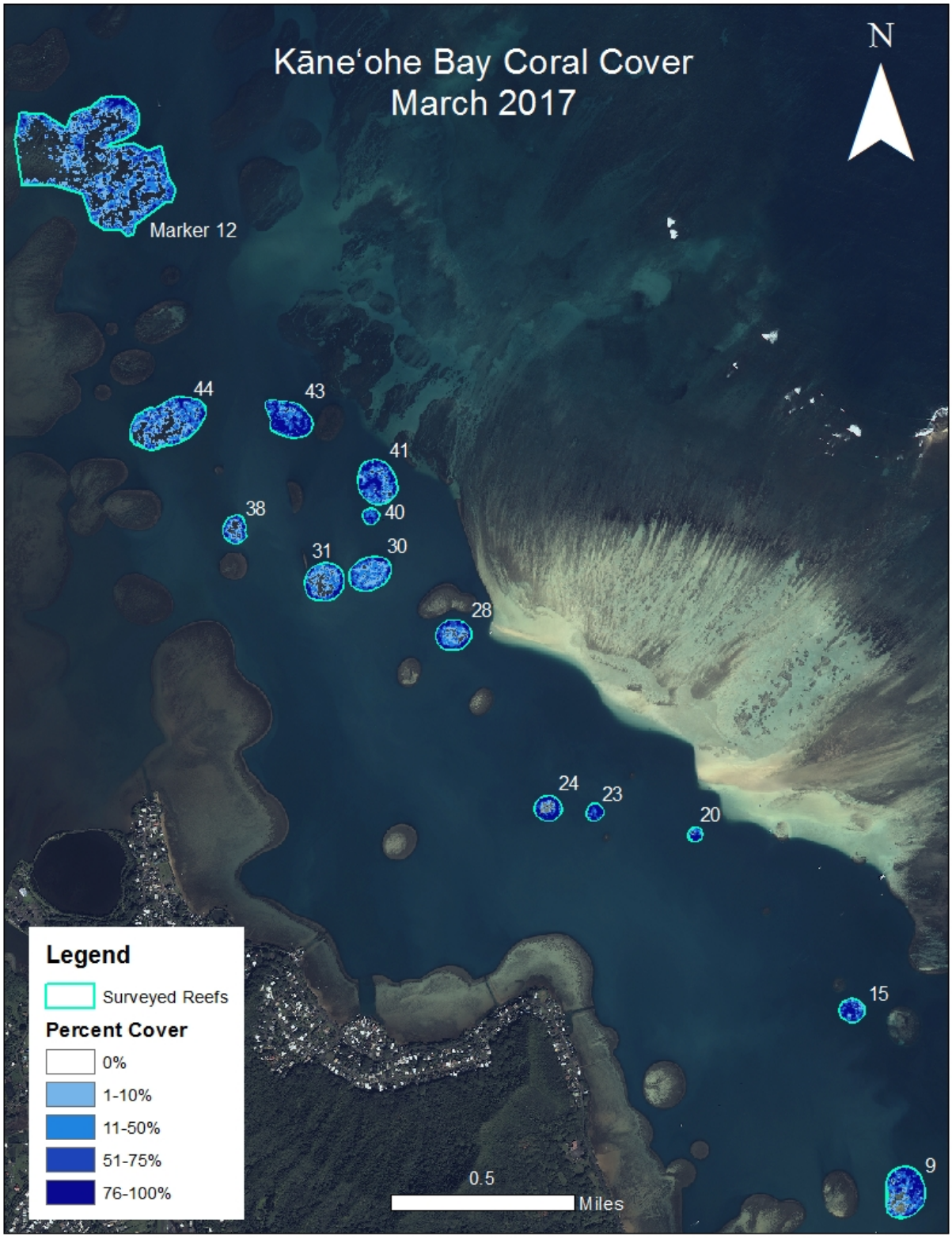


Figure 4: Map of coral distribution and percent cover on Flattery reefs, May 2017.

Kappaphycus/Eucheuma

The area of *Kappaphycus/Eucheuma* decreased on all but three reefs between 2016 and 2017 (Figure 5). Reefs 41, 43, 44 and Marker 12 showed the most dramatic changes, all with decreases > 1000 m^2. Reefs 20, 24 and 31 showed an increase in algae cover, although these increases were very small (<30 m^2). However, it is important to note that the reefs that showed increases were treated with urchins very soon before the monitoring surveys began (treated in January-February 2017, surveyed in March 2017), so the effect of the biocontrol may not have been noticeable at the time of survey. Finally, it is interesting to note that all three of the control reefs (Reefs 9, 15, and 23) showed a decrease in invasive algae, indicating that perhaps the natural decline observed beginning in 2015 is still progressing. The distribution of *Kappaphycus/Eucheuma* across the survey area for the 2017 survey can be seen in Figure 6, with individual maps by reef in the Appendix.

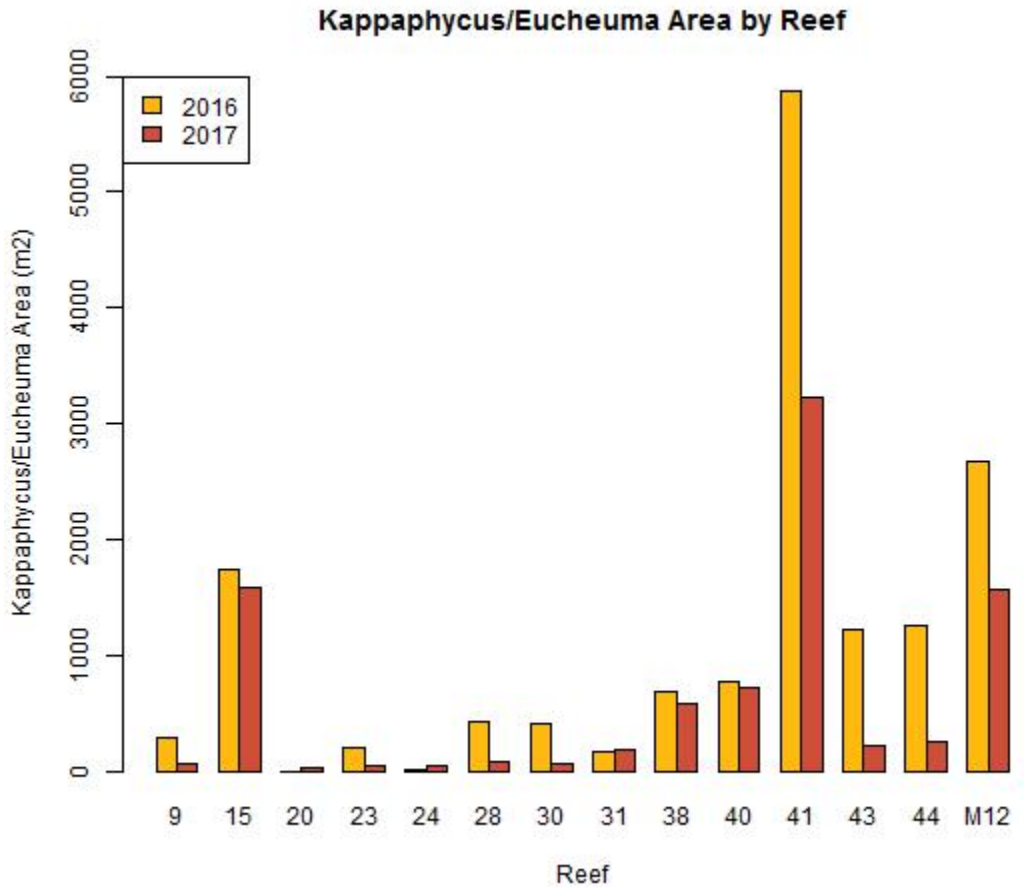


Figure 5: *Kappaphycus/Eucheuma* cover (m^2) by reef from the 2016 and 2017 monitoring surveys.

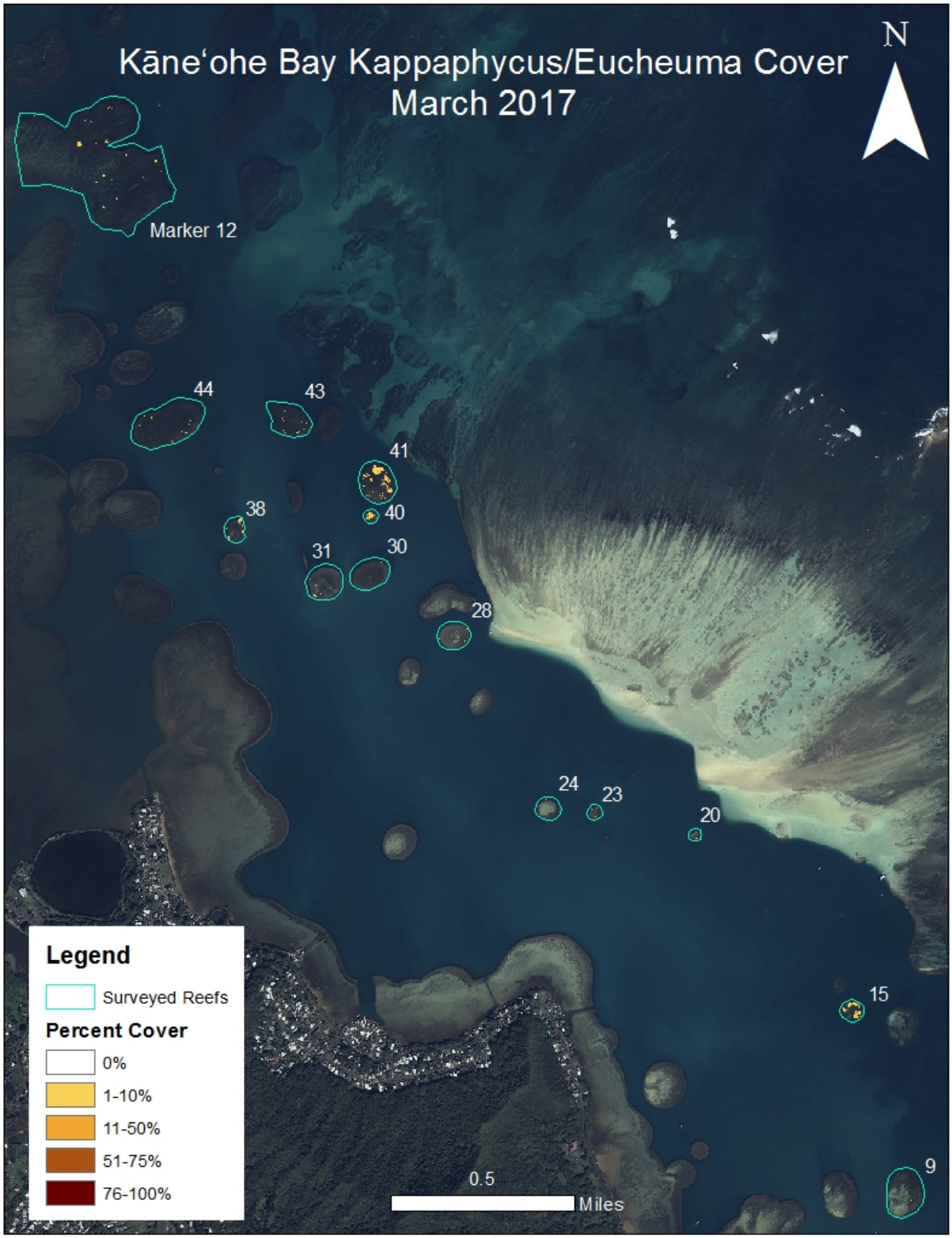


Figure 6: Map of *Kappaphycus/Eucheuma* distribution and percent cover on Flattery reefs, May 2017.

Gracilaria/Acanthophora

Gracilaria/Acanthophora cover remained low on all reefs previously exhibiting low cover in 2016, and decreased on reefs showing higher cover in 2016 (Figure 7). In 2016, Reefs 28, 41 and Marker 12 were the only reefs with >100 m^2 of *Gracilaria/Acanthophora* cover; all three of these reefs showed declines of > 150 m^2 (Reef 28 and Marker 12 showed decreases of > 1500 m^2). Reefs 20, 23, 38, and 44 were the only reefs to show slight increases (≤ 200 m^2) in 2017; however the total *Gracilaria/Acanthophora* cover on these reefs remains low despite these small increases. Importantly, there were no sightings of *Acanthophora spicifera* during the 2017 surveys, so the numbers reported for 2017 reflect *Gracilaria salicornia* cover only. The distribution of *Gracilaria/Acanthophora* across the survey area for the 2017 survey can be seen in Figure 8, with individual maps by reef in the Appendix.

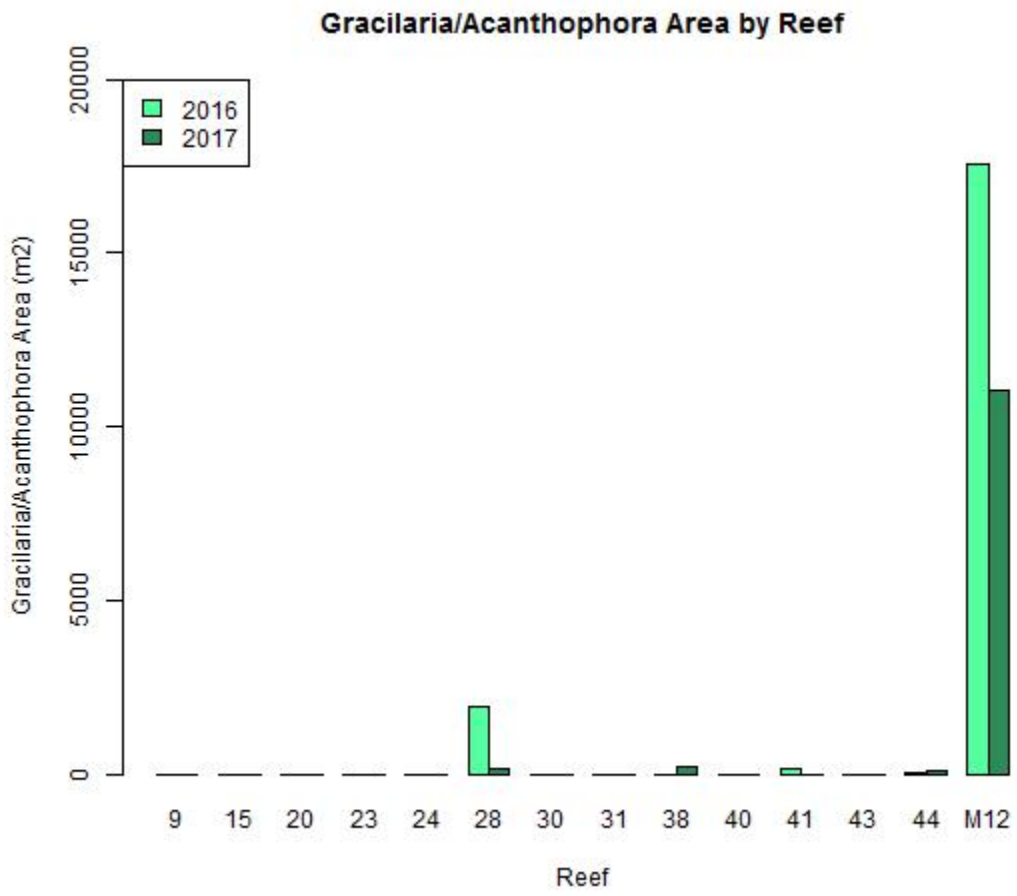


Figure 7: *Gracilaria/Acanthophora* cover (m^2) by reef from the 2016 and 2017 monitoring surveys.

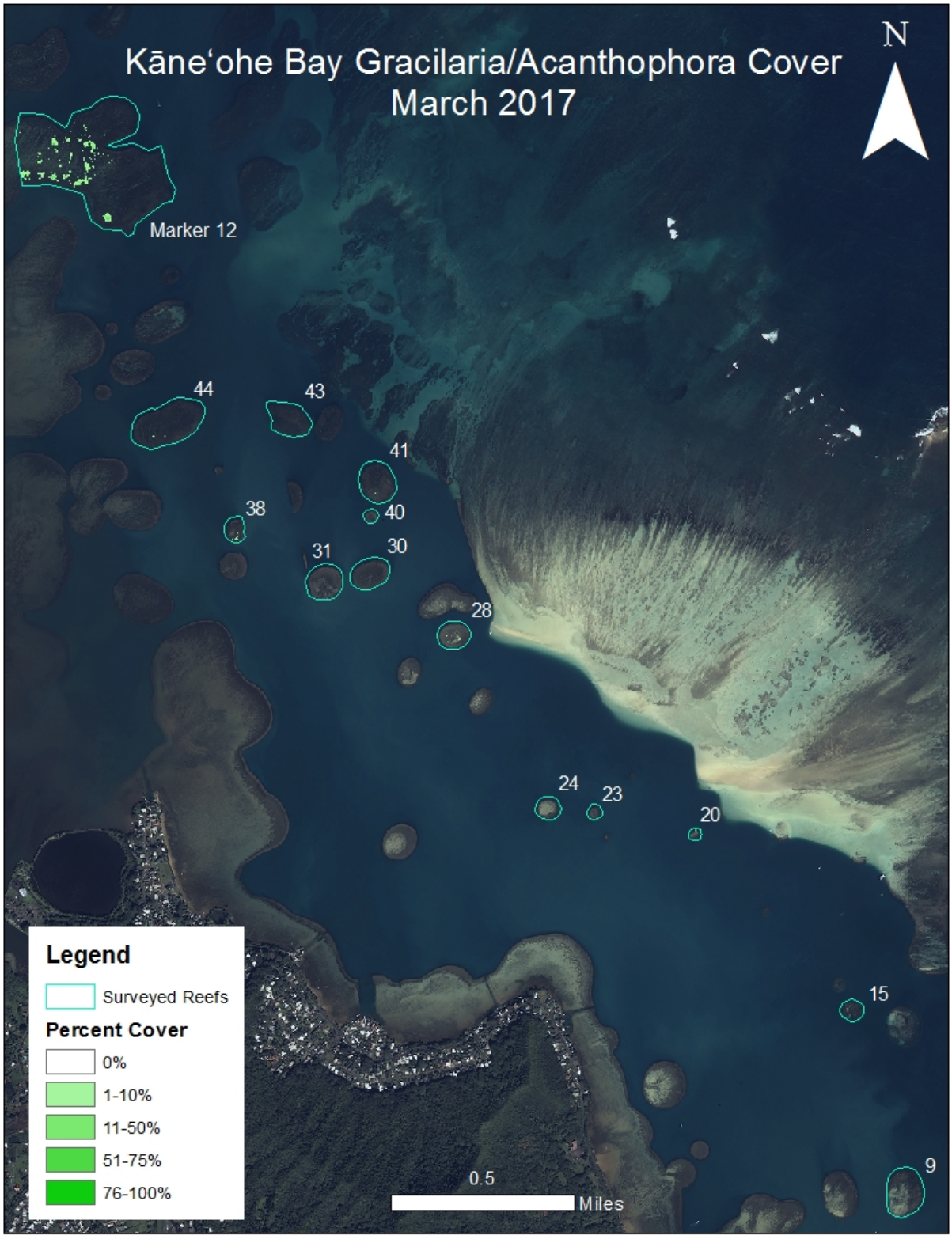


Figure 8: Map of *Gracilaria/Acanthophora* distribution and percent cover on Flattery reefs, May 2017.

CORAL REATTACHMENT PILOT STUDY

In March 2017, the Monitoring Coordinator prepared a proposal for a coral reattachment pilot study, which was submitted to the Division chair 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 Kāneʻohe 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, in order to create a visual representation of coral growth and reef complexity over time, which can be used for data collection, presentations, and outreach.

Both Flattery staff attended a training hosted by the Sandin Lab of the Scripps Institution of Oceanography to learn the 3D photomosaic protocol. The training covered two days on March 6-7, 2017, and was held at the NOAA IRC on Ford Island, Oʻahu. The methods used in this training were incorporated into the coral reattachment protocol, and supplies were purchased using Flattery funds.

The proposal was approved by the chair in April 2017, and two 5 m x 5 m restoration plots were deployed on denuded areas of the P1 fringing reef priority site and Marker 12 on May 10-11, 2017. Initial data were collected May 15-16. The protocol was developed by the Monitoring Coordinator, and the supplies and gear were assembled and purchased by the Technician. In total, approximately 860 fragments of opportunity were reattached, measured, and photo documented for photomosaic analysis. Monitoring of the outplanted fragments will include measurements and photomosaics every month for the first three months (through August 2017) and quarterly thereafter for a minimum of one year.

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. The field team was able to successfully reattach hundreds of small fragments in a relatively short amount of time, indicating that this may be a useful tool for restoring areas degraded by invasive algae, bleaching, boat groundings, etc., if fragment survivorship is high. Methods, such as epoxy type, tagging, and monitoring were tested, and modifications to increase efficiency and success have been noted and will be incorporated into future reattachment studies. Following the current pilot project, the team is looking to begin a second pilot project testing the feasibility of reattaching larger coral fragments.

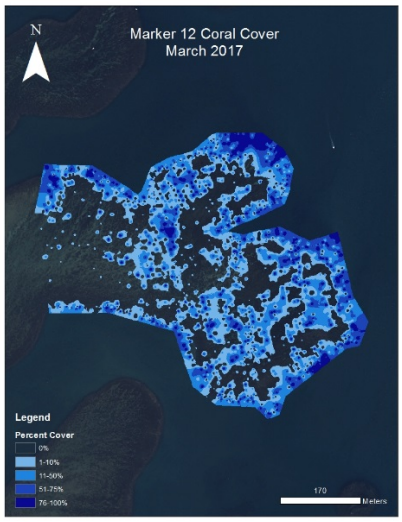
OTHER PROGRESS

The vacant technician position was successfully filled in January 2017, and the technician began work on March 6, 2017.

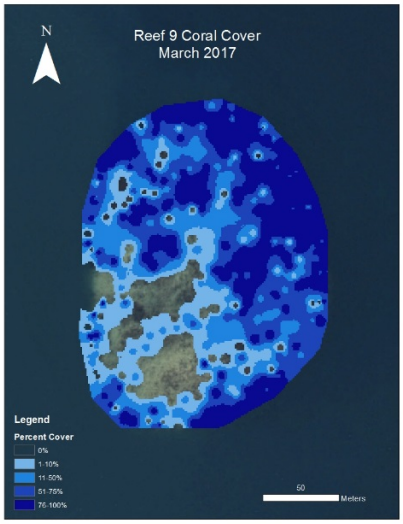
In addition, Flattery funds were used to pay for a transom repair on the boat, a camera and housing for the photomosaics, and other project-related supplies.

APPENDIX

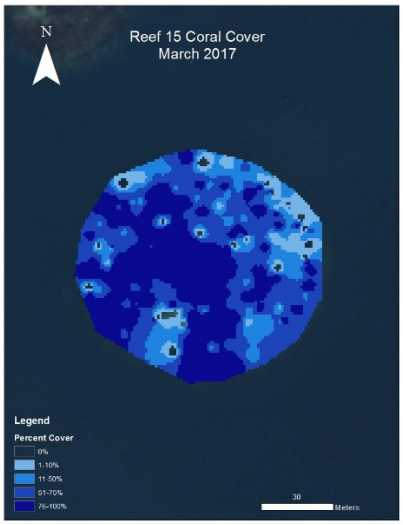
Marker 12

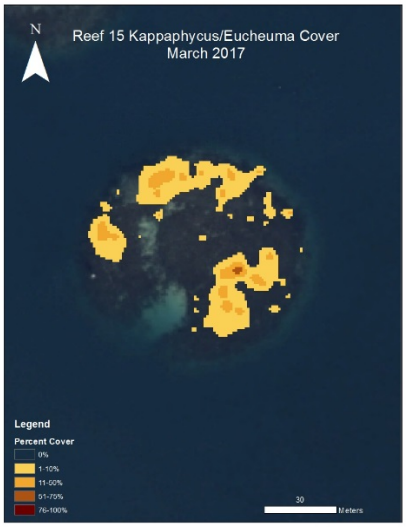


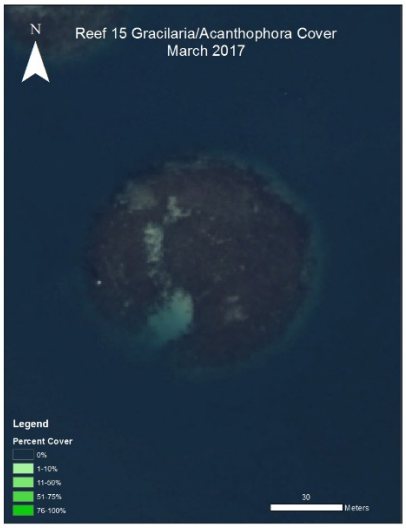
Reef 9



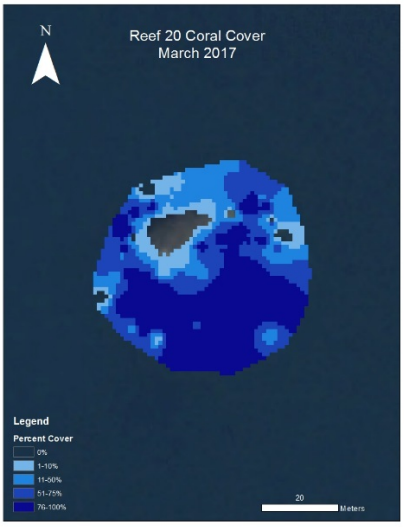
Reef 15

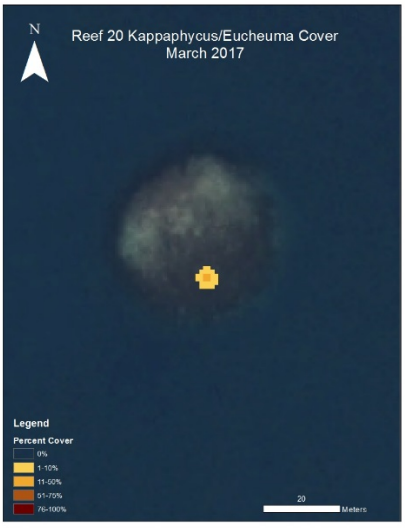


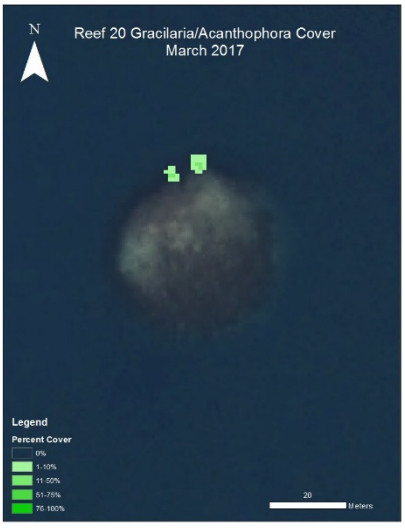




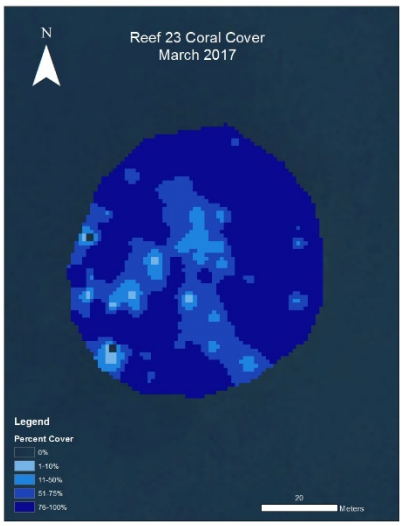
Reef 20

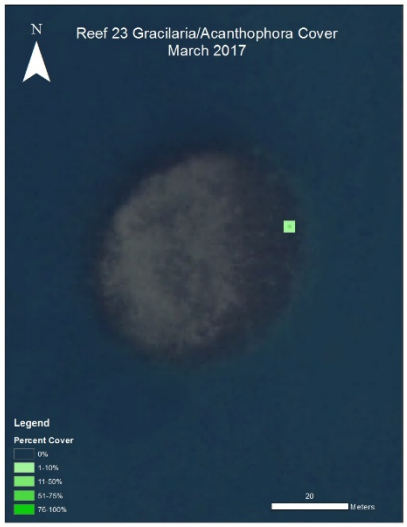




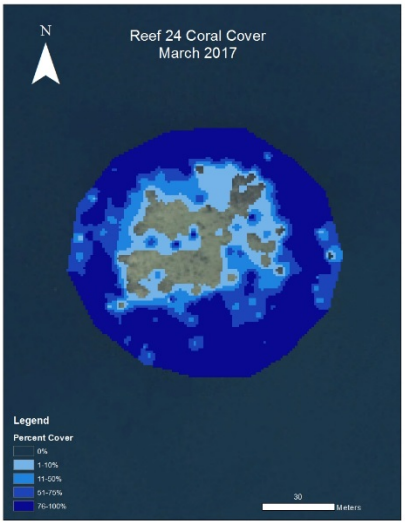


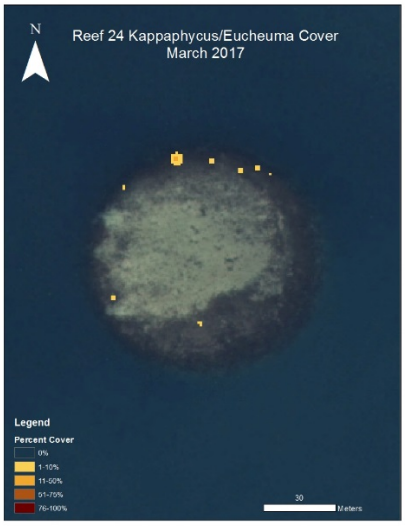
Reef 23

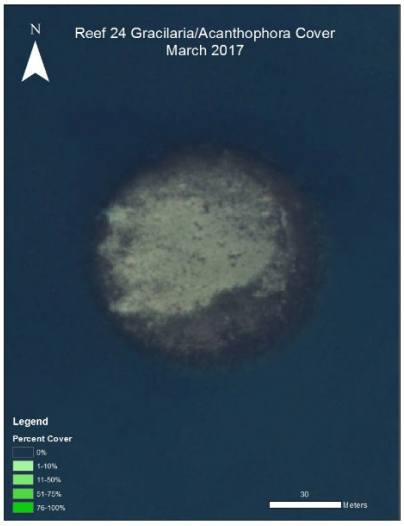




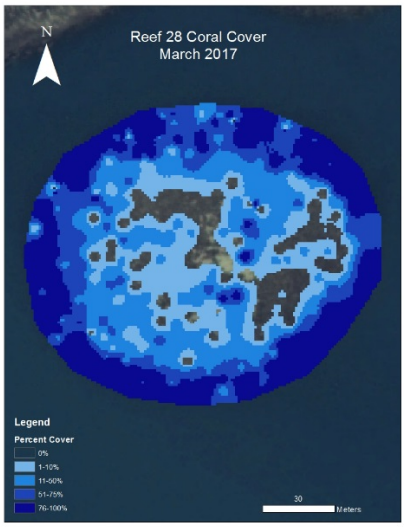
Reef 24

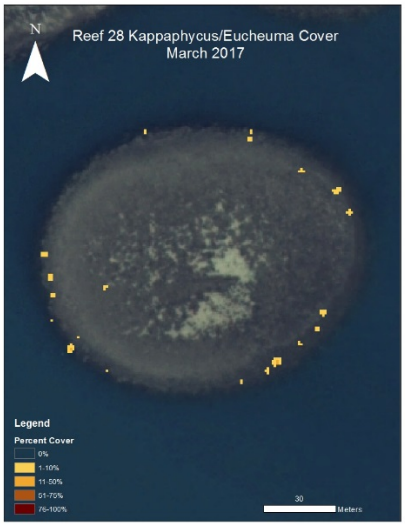


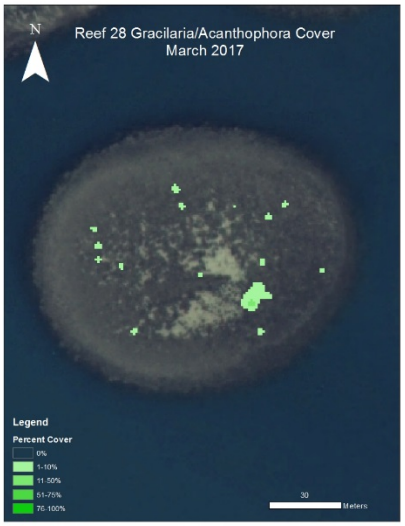




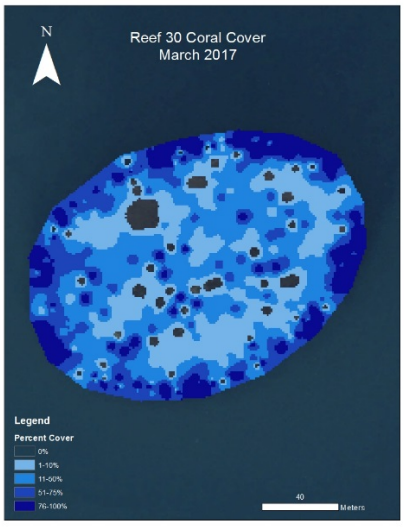
Reef 28

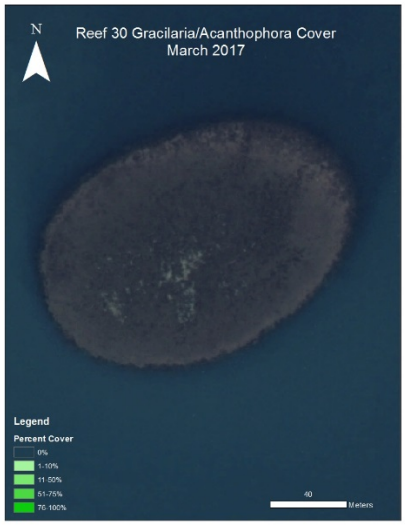




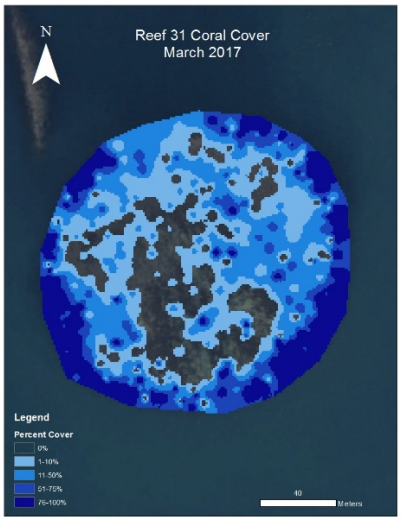


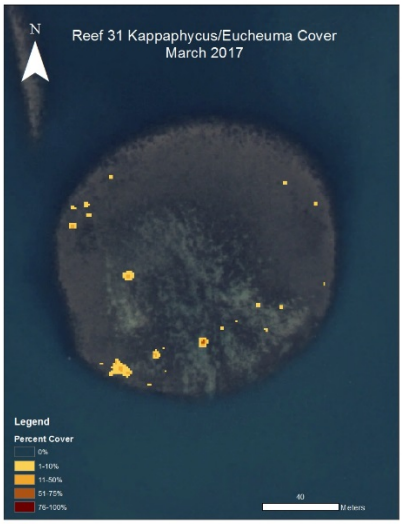
Reef 30

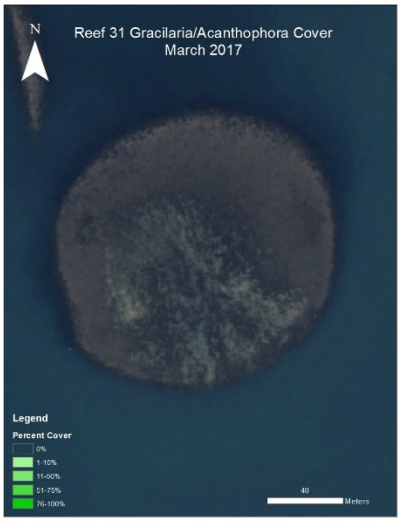




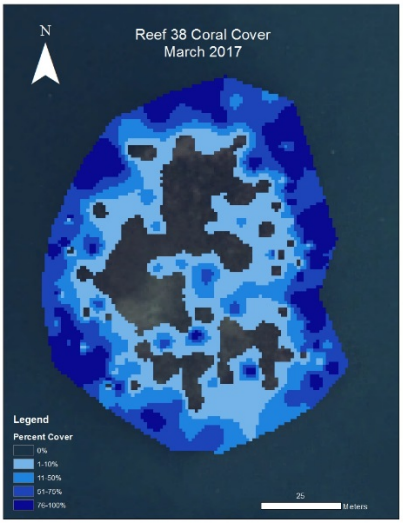
Reef 31

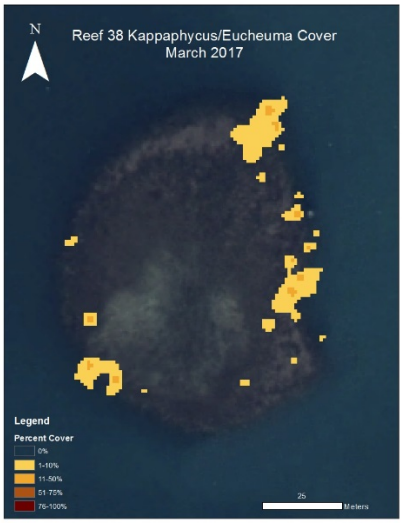


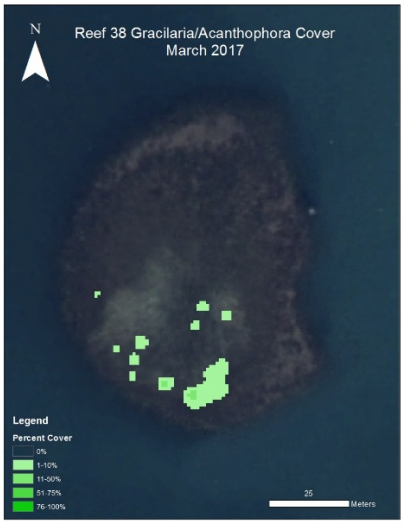




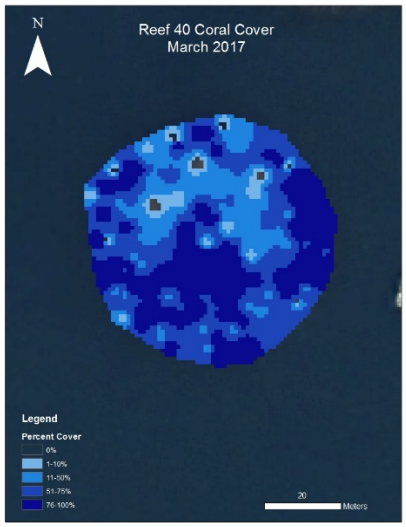
Reef 38

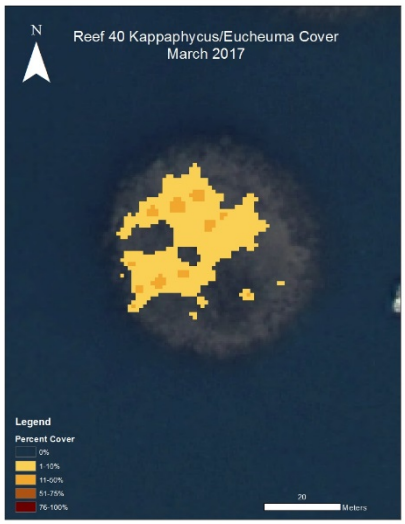


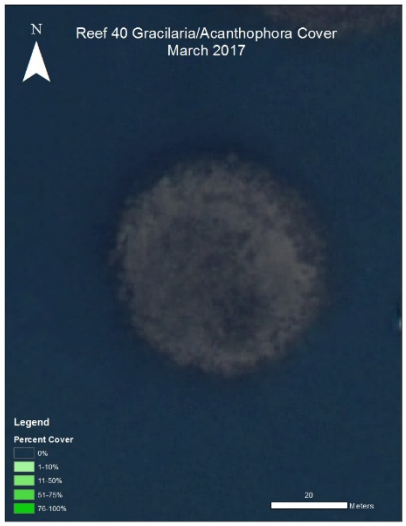




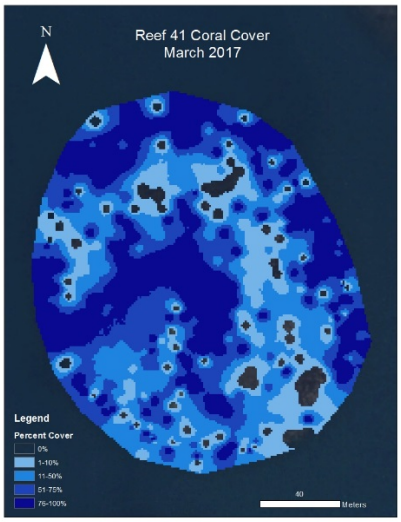
Reef 40

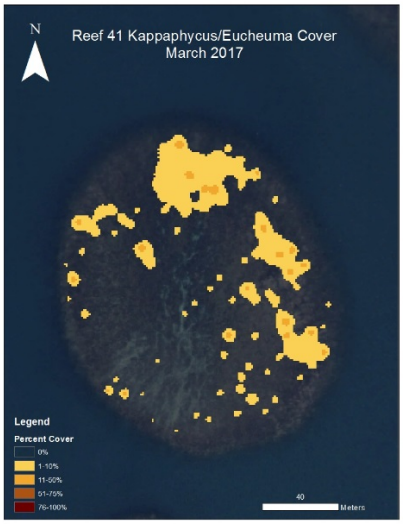


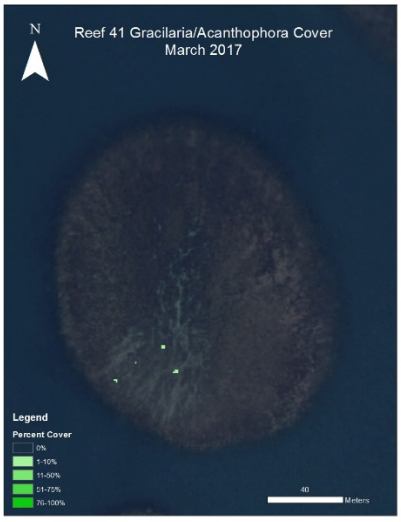




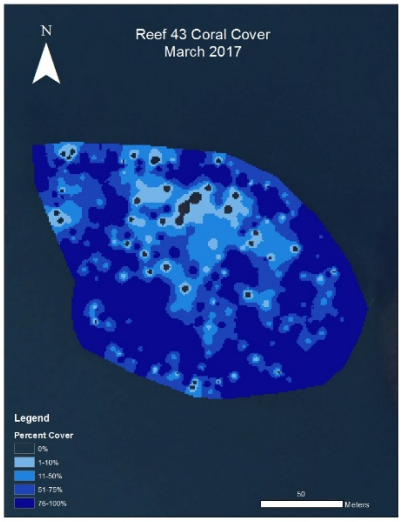
Reef 41

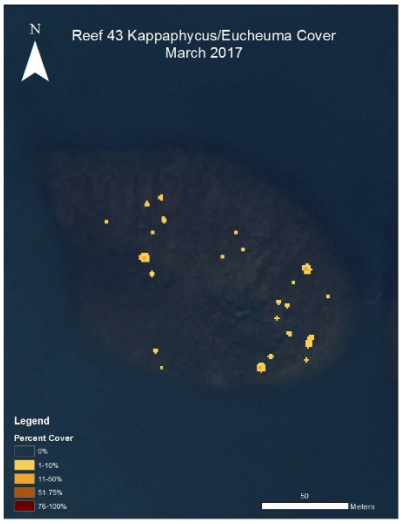






Reef 43





Reef 44