

Cape Flattery Settlement Restoration Project: Restoring Reefs in Kāneʻohe Bay



PROGRESS REPORT

DIVISION OF AQUATIC RESOURCES

AQUATIC INVASIVE SPECIES PROGRAM

PROJECT PERIOD: JANUARY 2021 – DECEMBER 2021



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Restoration plan actions implemented

The Division of Aquatic Resources (DAR) continued Cape Flattery Mitigation efforts to combat invasive algae in Kāneʻohe Bay during the January- December 2021 reporting period. These activities included urchin outplanting on target reefs prioritized for treatment, annual SNAP surveys on the secondary reefs, and reef marker maintenance on patch reefs throughout Kāneʻohe Bay. A summary of progress made can be found in the work plan in Table 1. All priority reefs have been stocked with target numbers of urchins (*Tripneustes gratilla*) since 2018. Urchin outplanting has progressed to maintenance stocking of reefs based on annual surveys to maintain <5% cover of invasive algae. Urchin outplanting progress can be seen in Table 2 & 3.

The 2021 annual monitoring of Flattery reefs took place from March 8th to March 15th. SNAP surveys were conducted on ten select reefs with a high cooccurrence of live coral and invasive algae relative to other reefs throughout the bay and Marker 12, the inception site of this project. The remaining treatment reefs were surveyed for presence or absence of invasive algae to generate a general map of algae coverage on those reefs for continued management. The presence absence surveys produce a lower resolution view of the invasive algae coverage compared to the maps generated from the finer scale SNAP surveys which can be used to calculate percent cover of invasive algae. Data from both survey methods can be used to forecast urchin needs on individual reefs.

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	
Outplant native sea urchins to restoration area	Project Technicians, DAR Urchin Hatchery	April 2016 - end of project	In progress	Since the last reporting period, 173,720 urchins have been released on treatment reefs	Initial targets reached for all reefs. Targets updated annually based on survey data.
Annual reporting to the Cape Flattery trustee council	Monitoring Coordinator, DAR Aquatic Biologist	Annual through end of project	In progress	Tenth progress report submitted	Reporting frequency changed from biannual to annual at 2020 Flattery Trustees meeting.
Follow-up monitoring of coral and algae conducted annually	Monitoring Coordinator, Project Technicians	March through end of project	In progress	Annual monitoring for restoration reefs completed in March 2021	Updated monitoring plan approved at 2020 Flattery Trustees meeting.
Maintenance of outplanted urchins	Monitoring Coordinator, Project Technicians	August 2018-end of project	In progress	Urchins added to previously stocked reefs as needed and 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	Reefs are re-prioritized based on annual algae surveys

Approach

Restore and protect coral reef habitat through urchin bioremediation

Ānuenue Fisheries Research Center (AFRC) Urchin Hatchery production

During the 2021 reporting period, Flattery staff conducted 3 urchin spawning events, resulting in 80 wild urchins being spawned with additional urchins spawned from resident AFRC broodstock. 16,850 liters of phytoplankton were produced to feed urchin larvae, and 1,569 kg of macroalgae were produced to feed juvenile urchins. In total, 7,405,000 larvae were produced and moved into tanks for the settlement and grow-out phases during this reporting period. Of those, 173,720 grew to transplantation size (~10mm) and were released onto priority reefs (Table 2).

Table 2. Monthly larval food, larvae, and total urchins outplanted.

DATE		FOOD		URCHINS		
		Phytoplankton produced (l) for urchin larvae	Macroalgae produced (kg) for urchin juveniles	Urchins collected for spawn	Number of larvae moved into settlement/grow-out phase (x1000)	Number of hatchery urchins outplanted
2021	Jan	77	112	0	0	2,000
	Feb	72	179	0	0	8,820
	Mar	480	182	0	0	32,000
	Apr	4,440	142	30	2,695	4,400
	May	448	87	0	0	0
	Jun	450	83	0	0	0
	Jul	4422	158	25	0	0
	Aug	765	101	0	2125	25,200
	Sep	560	152	0	0	40,400
	Oct	3313	163	25	0	21,800
	Nov	1758	110	0	2585	18,800
	Dec	65	100	0	0	15,100
Totals		16,850	1,569	80	7,405	168,520

Deploying hatchery-raised urchins

In total, 168,520 urchins were outplanted onto priority reefs during this reporting period (Table 3). Urchin outplant targets for all priority reefs was reached on November 18, 2018. Additional maintenance outplanting occurred on priority reefs that had algae present at greater than 5% coverage. Refer to Table 3 for urchin release data over the course of the project, including the number and destination of the urchins and the hours contributed by Flattery and DAR civil service staff. Target maintenance number of urchins is based on 2 urchins/ m² of *Kappaphycus* /*Eucheuma*.

Table 3. Log of urchin outplants including outplant location, total number of urchins released, area treated, and total work hours by Flattery and DAR civil service staff.

Date	Reef Number	Urchins Released	Area treated (m ²)
1/12/21	R41	2,000	1,000
2/8/21	R41	5,220	2,610
2/11/21	R14	3,600	1,800
3/4/21	R43, R44	7,400	3,700
3/8/21	R44	5,600	2,800
3/15/21	R26, R27, R38, R43, R44	10,600	5,300
3/18/21	R14, R15, R23, R26	4,800	2,400
3/22/21	R38	3,600	1,800
4/8/21	M12, R41	4,400	2,200
8/5/21	R23, R44	7,600	3,800
8/12/21	R41, R43	7,600	3,800
8/26/21	R43, R40	10,000	5,000
9/2/21	P1	10,800	5,400
9/10/21	P1	11,200	5,600
9/16/21	P5, R27	10,800	5,400
9/23/21	P1	7,600	3,800
10/14/21	M12, R41	7,800	3,900
10/21/21	P1	8,200	4,100
10/28/21	R15, R29	5,800	2,900
11/12/21	R14, R26, R28, R30, R31, P1	7,000	3,500
11/18/21	M12, R9, R16, R20, R24, P3	6,000	3,000
11/24/21	M12	5,800	2,900
12/3/21	M12	4,000	2,000
12/16/21	M12	6,600	3,300
12/22/21	M12	4,500	2,250
Totals		168,520	84,260

Annually monitor treatment reefs in Kāneʻohe Bay

Conduct annual monitoring of Flattery treatment reefs

Surveys were focused on treatment reefs shown in *Figure 1*. The annual monitoring of the treatment reefs began on March 8, 2021. The monitoring consisted of SNAP surveys of all ten priority reefs (Table 4). The remaining treatment reefs were surveyed for presence or absence of invasive algae to generate a general map of algae coverage on those reefs. The presence absence surveys produce a lower resolution view of the invasive algae coverage compared to the maps generated from the finer scale SNAP surveys which can be used to calculate percent cover of invasive algae. Data from both survey methods can be used to forecast urchin needs on individual reefs however, only the maps generated from the SNAP surveys can produce an accurate percent cover for the reefs.

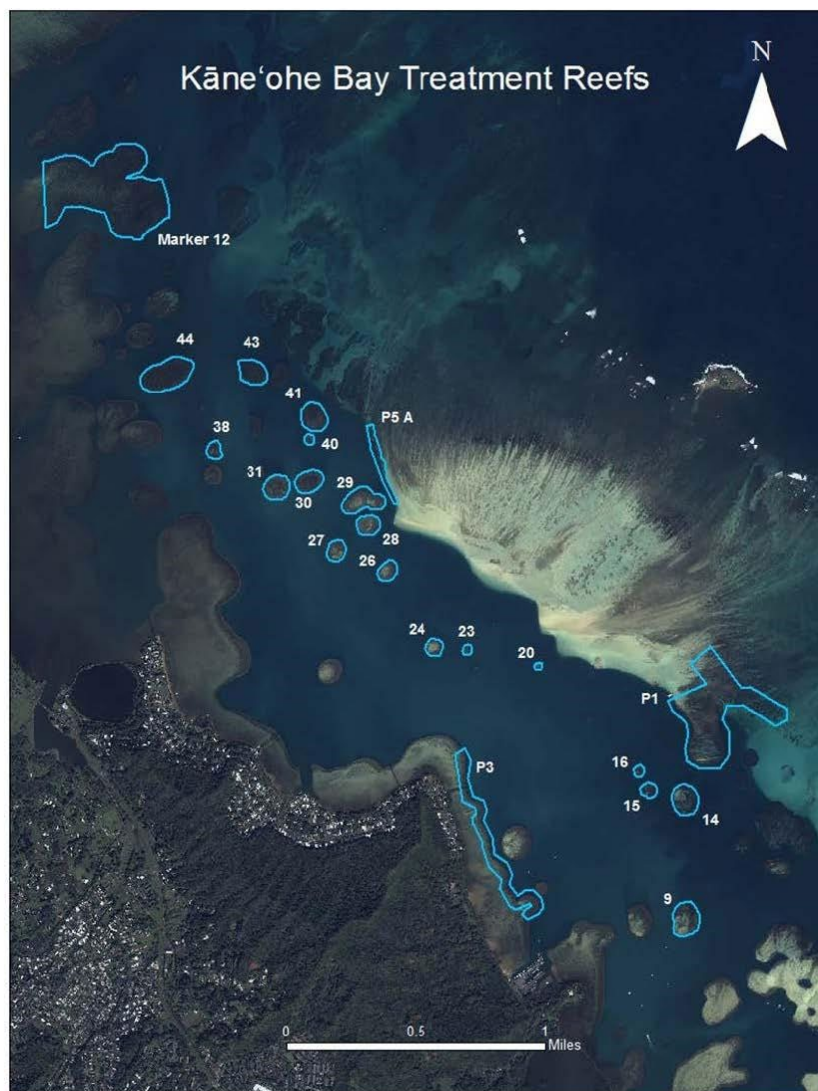


Figure 1. Treatment reefs for the Flattery project in Kāneʻohe Bay

Map survey data

Maps showing coral and invasive algae coverage were created using SNAP data and ArcGIS to create inverse distance weighted (IDW) interpolations for priority reefs. These mapped interpolations estimate cover for coral and invasive algae between GPS data points by calculating weighted average cover values based on nearby data points. For corals, *Kappaphycus/Eucheuma*, and *Gracilaria/Acanthophora* median cover was calculated to quantify percent cover. Due to the large size bins used in mapping cover, the middle value was assumed for each bin resulting in median percent cover estimates. IDW maps for each SNAP reef can be found in Appendix A.

Absence/ presence reef maps created using the aggregate points cartography tool in ArcGIS can be found in Appendix B. The algae presence areas are being used to plan maintenance stocking of urchins and can be found in Table 5. These values are where algae are present, density data was not collected, so we cannot infer the median percent coverage on these reefs. In the coming 2022 monitoring season we plan to do SNAPs for all treatment reefs so we can re-prioritize our monitoring efforts in coming years.

Table 4. Reef characteristics and SNAP survey progress for 2020 and 2021 priority reefs.

Reef Marker	2020 SNAP Survey				2021 SNAP Survey				Target number of urchins needed for ongoing maintenance stocking	Total number of urchins outplanted from Jan – Dec 2021
	Area Surveyed (m ²)	Total Coral area (m ²)	Total <i>Kappaphycus</i> / <i>Eucheuma</i> area (m ²)	Total <i>Gracilaria</i> / <i>Acanthophora</i> area (m ²)	Area Surveyed (m ²)	Total Coral area (m ²)	Total <i>Kappaphycus</i> / <i>Eucheuma</i> area (m ²)	Total <i>Gracilaria</i> / <i>Acanthophora</i> area (m ²)		
M12	278,942	163,407	3,788	50,564	282,025	206,326	3,482	83,583	6,964	33,316
9	29,198	26,257	1,135	1,166	28,772	25,825	155	1,699	310	310
14	24,835	18,465	3,486	3,286	24,822	21,507	2,069	4,623	4,138	6,320
15	7,778	7,773	841	0	7,788	7,758	2,069	0	4,138	1,400
16	3,789	3,371	328	8	3,802	3,780	165	0	330	330
20	2,440	2,432	12	0	2,439	2,408	66	21	132	132
23	3,709	3,680	1,729	0	3,709	3,647	1,658	0	3,316	4,200
30	19,398	18,419	444	0	19,384	18,991	246	0	492	500
40	3,313	3,208	661	0	3,307	3,178	1,032	0	2,064	5,000
41	24,832	19,970	5,194	188	24,824	21,510	7,687	386	15,374	15,920
TOTALS	398,234	266,982	17,618	55,212	400,872	314,930	18,629	90,312	37,258	67,428

Table 5. Area of *Kappaphycus* /*Eucheuma* mapped in Presence / Absence Surveys in Kāneʻohe Bay.

Reef	Area Surveyed (m ²)	Area of <i>Kappaphycus</i> / <i>Eucheuma</i> (m ²)	Target number of urchins needed for ongoing maintenance stocking	Total number of urchins outplanted from Jan – Dec 2021
24	8,258	24	48	48
26	12,338	2,407	4,814	5,708
27	12,345	2,904	5,808	6,000
28	13,974	172	344	350
29	29,773	1,528	3,056	3,060
31	20,742	11	22	22
38	8,658	2,541	5,082	7,200
43	21,852	1,135	2,270	14,300
44	47,068	5,719	11,438	16,700
P1	224,946	18,928	37,856	40,800
P3	93,218	32	64	64
P5	20,061	2,981	5,962	6,000
TOTALS	513,233	38,382	76,764	100,252

Analyze survey data and compare to previous years

Coral

Coral distributions were variable throughout the survey area. Among all surveyed reefs in 2021, total coral area ranged from 2,439 m² to 206,025 m² (Fig. 3). The range of coral area is large because of the large difference in the areal extent of reef M12 vs. all other reefs surveyed (Table 3). The median percent cover of coral was calculated based on the median value of each percent cover bin. Median cover among reefs varied from 21.61% (M12) to 83.79% (R16) in 2021 with the mean of 47.24%. Reefs were assessed for urchin outplant priority based on criteria outlined in the 2020 Flattery Trustee report.

It is important to 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 in 2020 and 2021 (Table 3), therefore the areas of each metric cannot be directly compared across years for this reef without redefining the boundary and reanalyzing the past years' survey data. Additionally, DAR changed the monitoring method of six reefs (24, 28, 31, 38, 43, and 44) from using SNAP surveys to presence/absence surveys for 2020 and 2021 due to a low ratio of *Kappaphycus/Eucheuma* cover to coral cover. Therefore, coral cover estimates were not recorded for these years (Fig. 3).

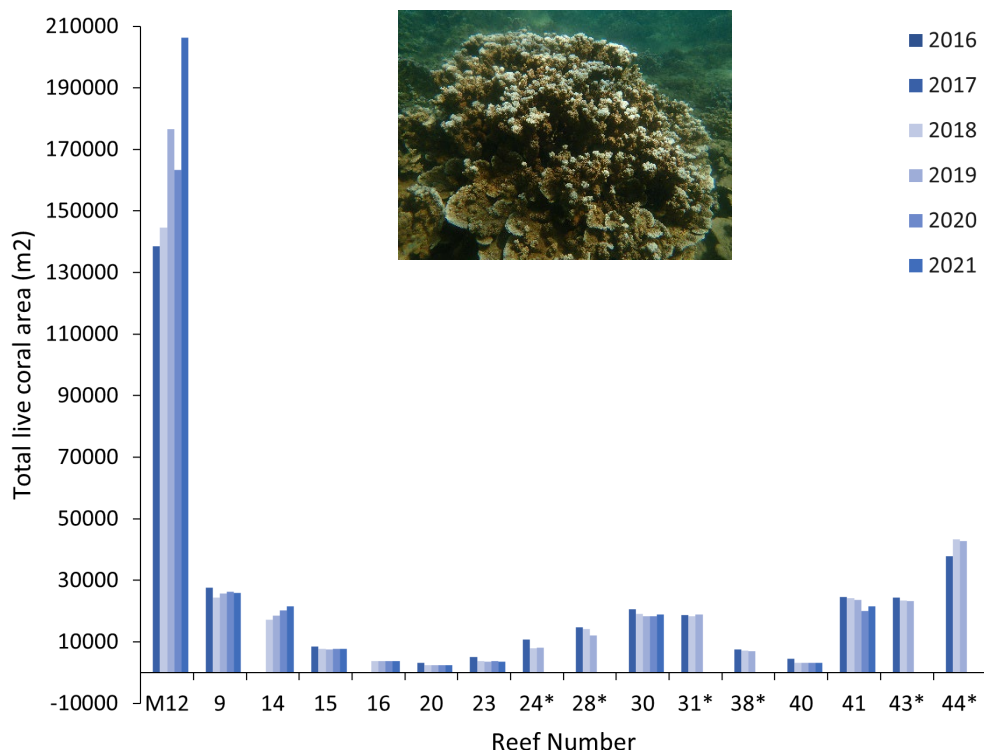


Figure 3. Total coral area (m²) by reef. Starred reefs represent presence/absence reefs where coral area was not quantified from 2020 on.

Kappaphycus/Eucheuma

The area of *Kappaphycus/Eucheuma* decreased on all but four of the priority reefs (Fig. 4: 15, 20, 40, and 41). Reef median algal cover was used to determine if reef algal cover was below the 5% cover management goal. Reef 23 was the only reef with a median *Kappaphycus/Eucheuma* cover value above 5% (9.78%). The target outplanting number for reef 23 was met in August 2021. It should be noted that these 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.

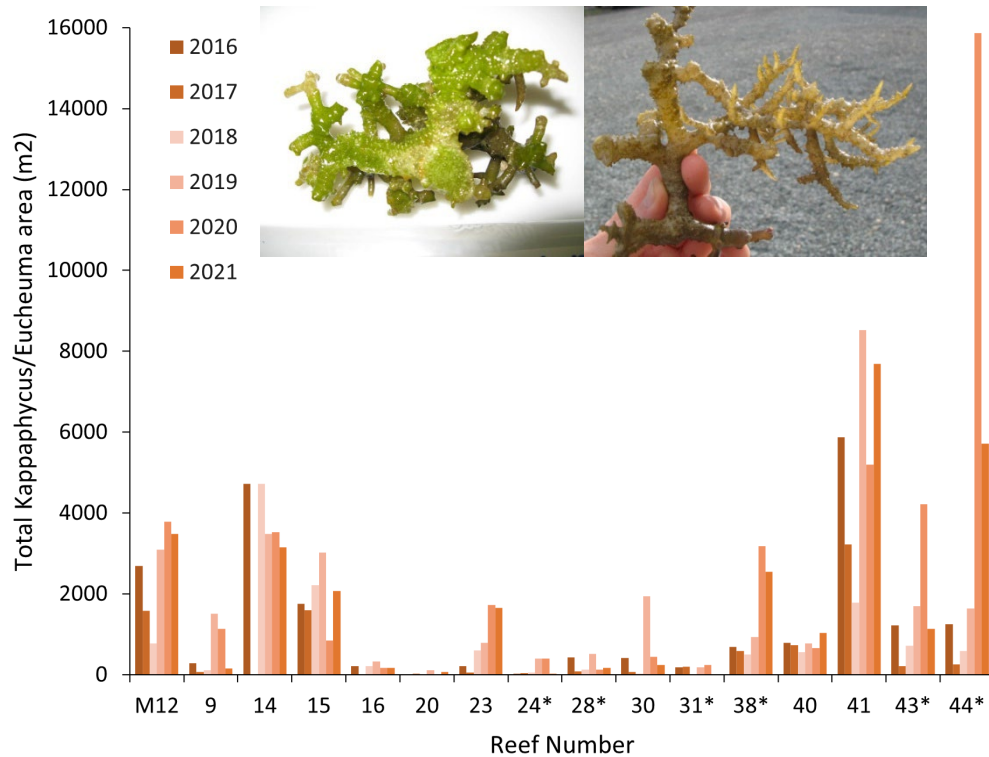


Figure 4. Total *Kappaphycus/Eucheuma* area (m²) by reef. Starred reefs represent presence/absence reefs.

Gracilaria/Acanthophora

Gracilaria salicornia and *Acanthophora spicifera* were specifically targeted for control efforts and are referred to as *Gracilaria/Acanthophora*. An increase in *Gracilaria/Acanthophora* was noted on five of the ten SNAP reefs surveyed in 2021 (Fig. 5: M12, 9, 14, 20, and 41) whereas no *Gracilaria/Acanthophora* was present on the other five reefs. Presence/absence surveys do not quantify *Gracilaria/Acanthophora* cover, as data is only taken for *Kappaphycus/Eucheuma*. Full SNAP surveys will be taken in 2022 to determine *Gracilaria/Acanthophora* cover on these reefs. Current urchin outplanting measures address *Kappaphycus/Eucheuma* cover only because those species are incipient. However, with the increase in *Gracilaria/Acanthophora*, utilizing available urchins to control these species should be discussed.

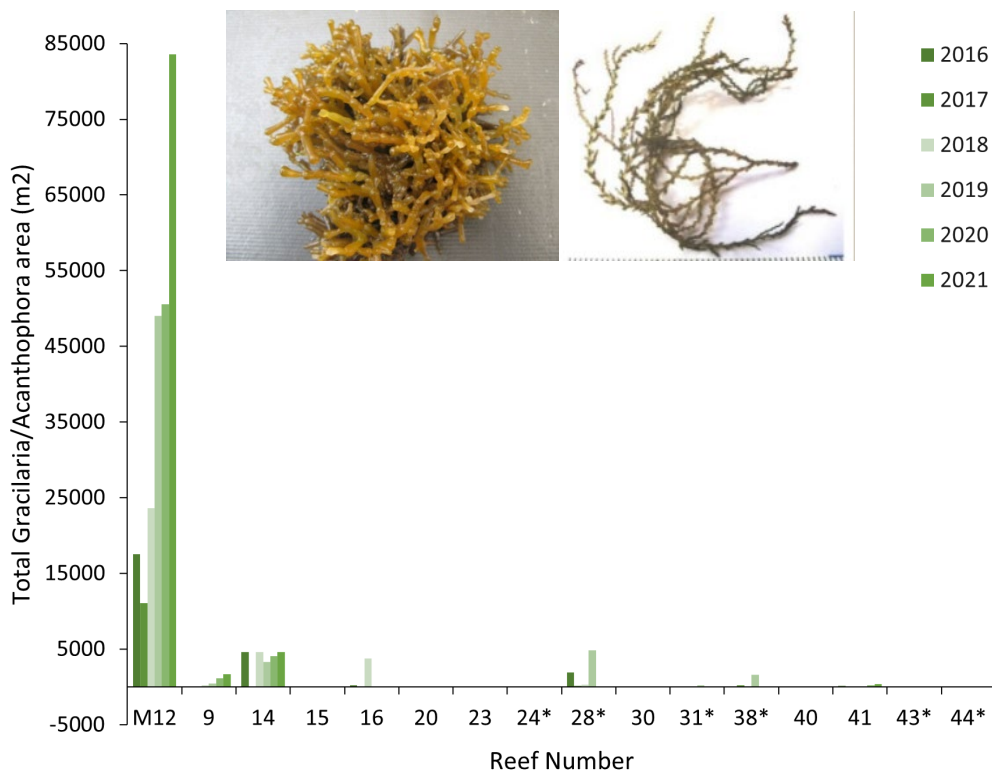


Figure 5. Total *Gracilaria/Acanthophora* area (m²) by reef.

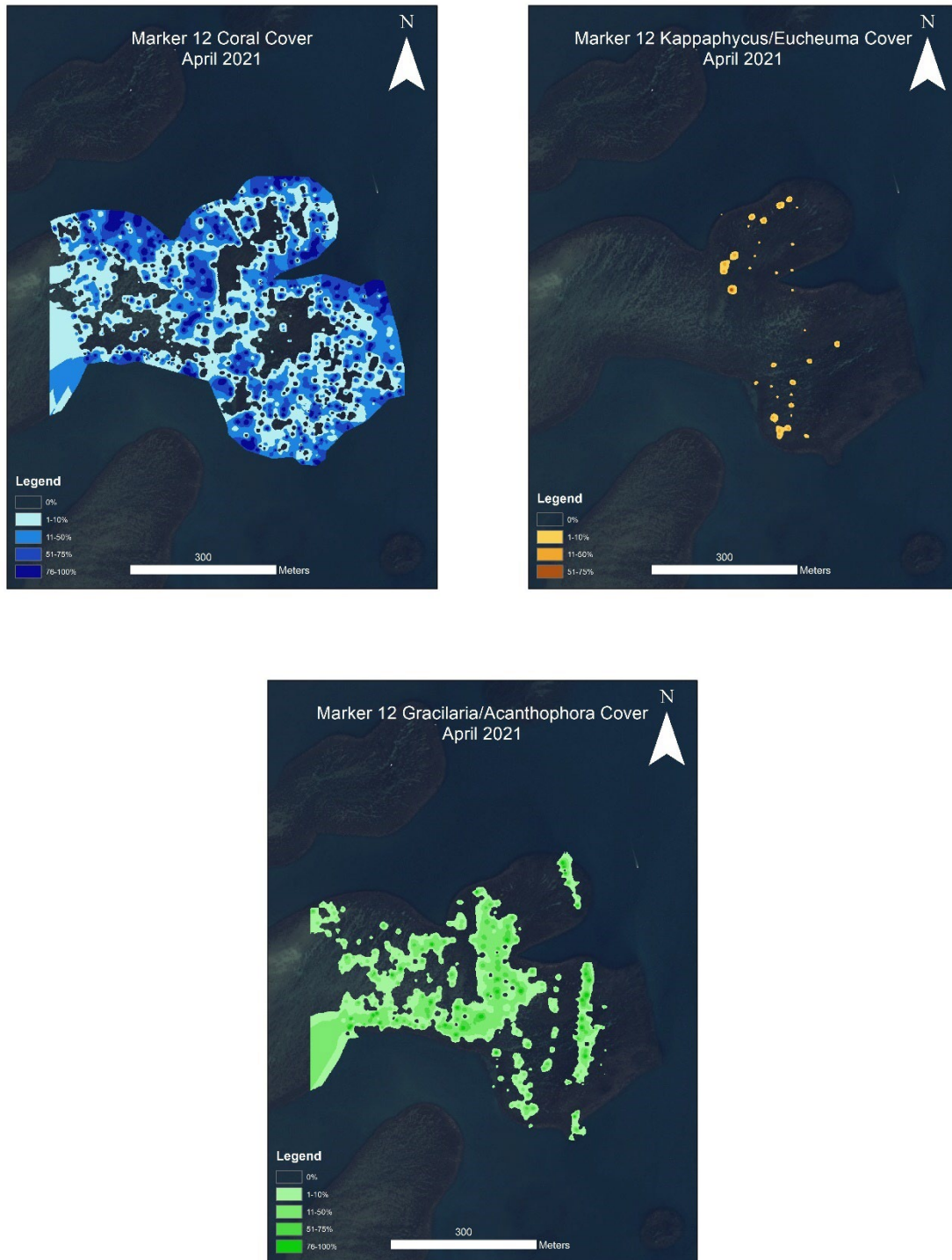
Flattery scar monitoring and other activities

Division of Aquatic Resource (DAR), Aquatic Invasive Species (AIS) Program staff collaborated with staff from the National Oceanic and Atmospheric Administration (NOAA) and the United States Fish and Wildlife Service (USFWS) to monitor the Cape Flattery grounding site in August and September 2021. DAR staff provided logistical and vessel support, as well as performing *in situ* monitoring via SCUBA. Monitoring included coral count transects and orthoimagery that DAR staff entered and provided to USFWS for processing.

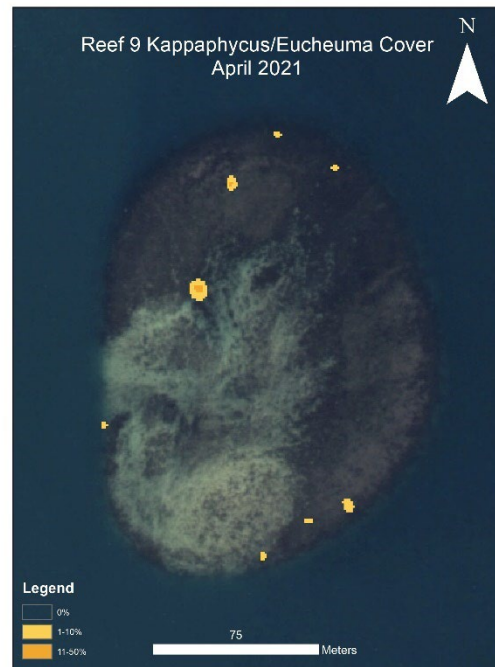
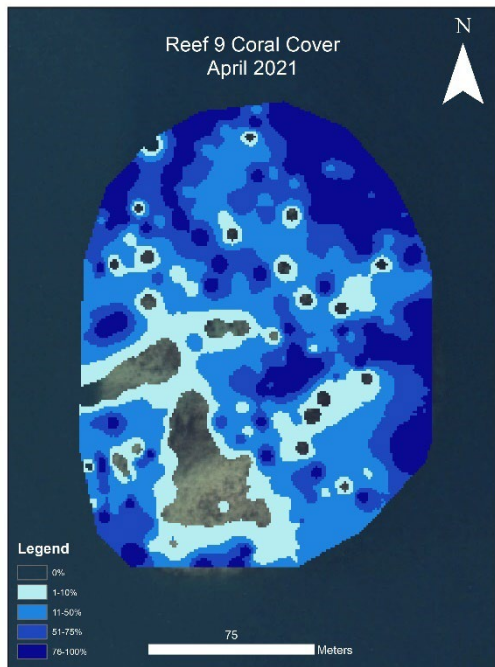
In addition, project staff provided field and vessel support for the Honolulu Harbor channel dredge damage response and a pre-dredge survey for the Ewa side of the channel.

Appendix A: SNAP Reef Maps

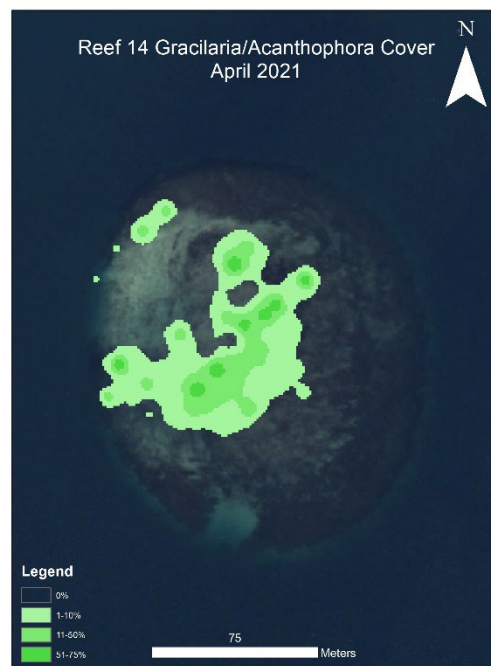
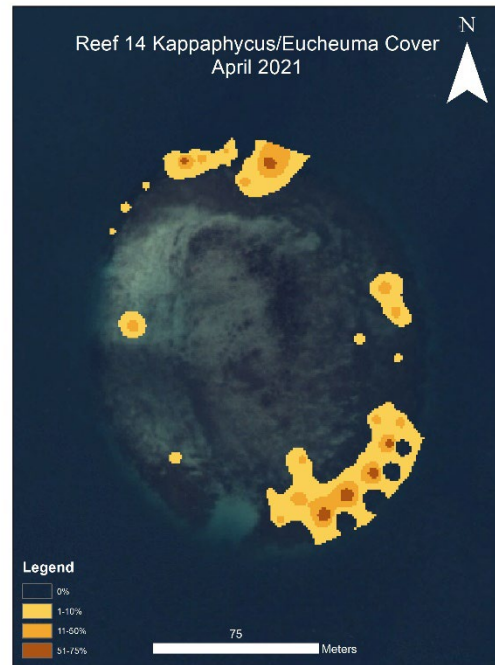
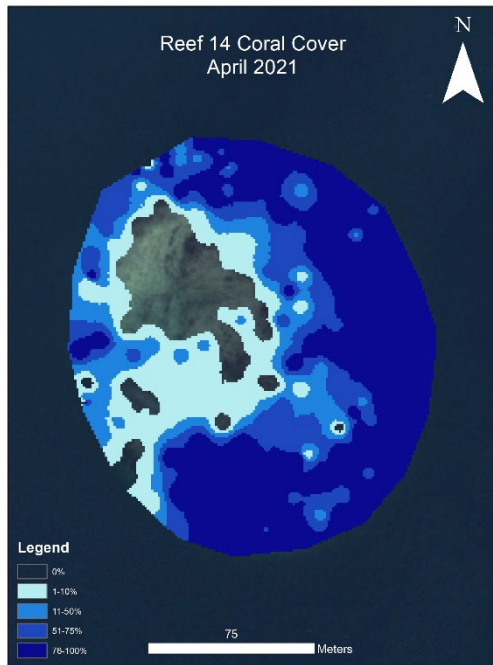
Reef Marker 12



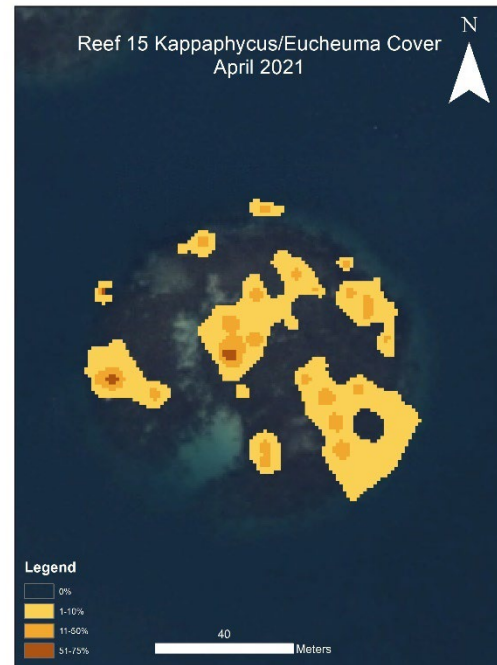
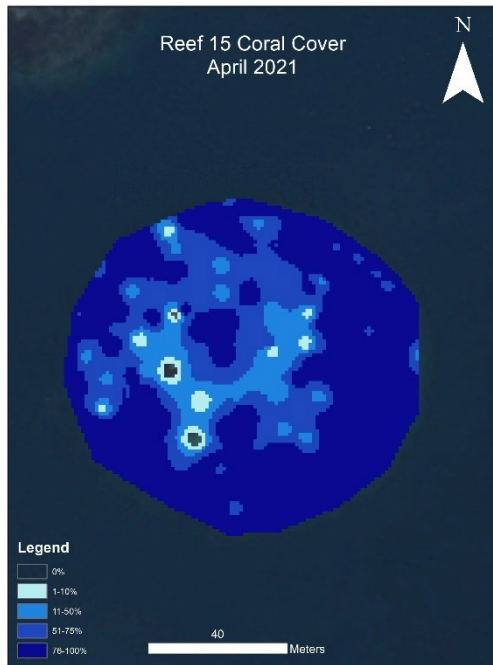
Reef 9



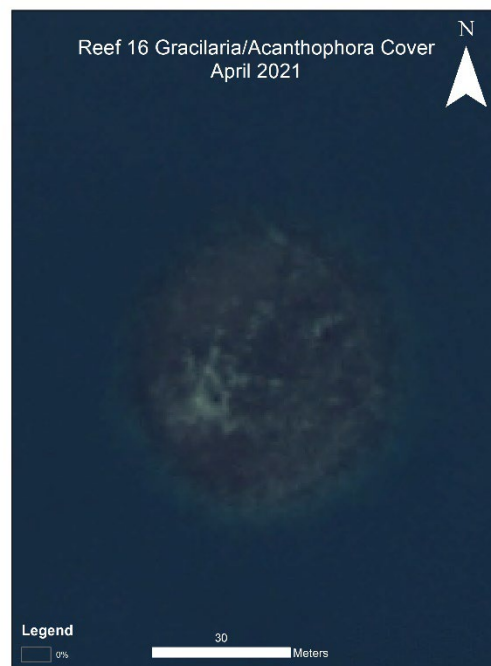
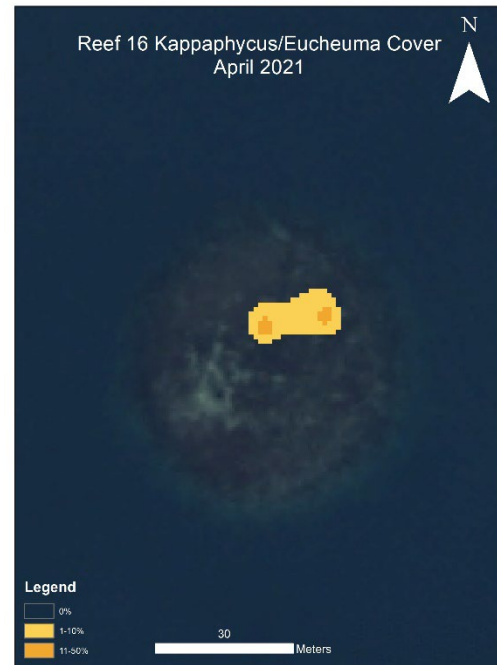
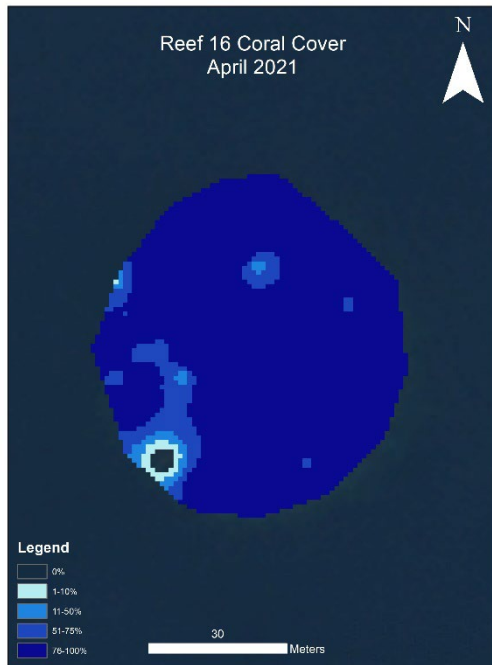
Reef 14



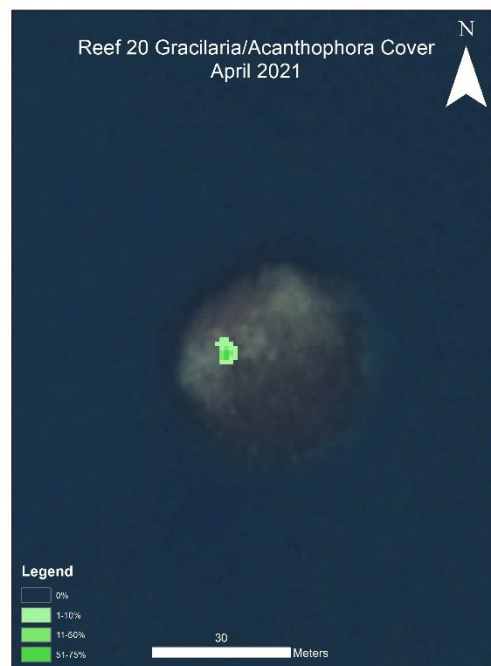
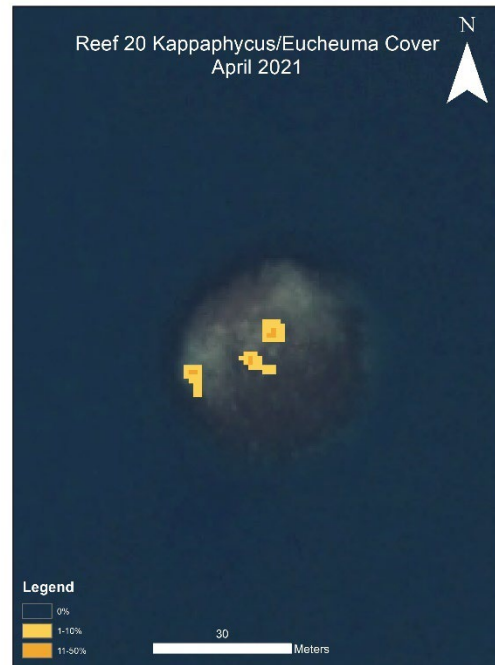
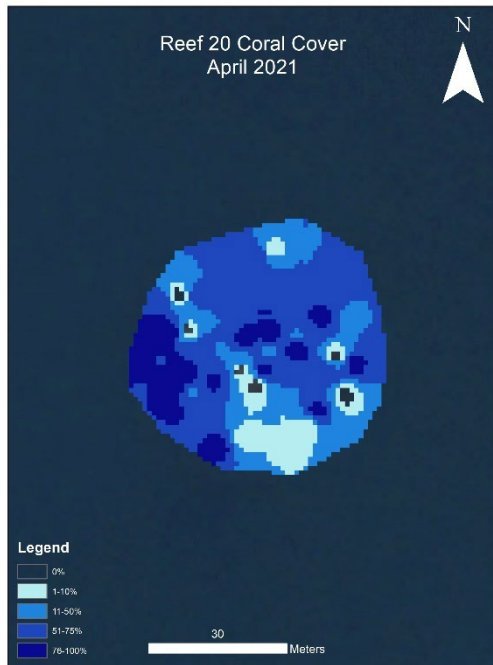
Reef 15



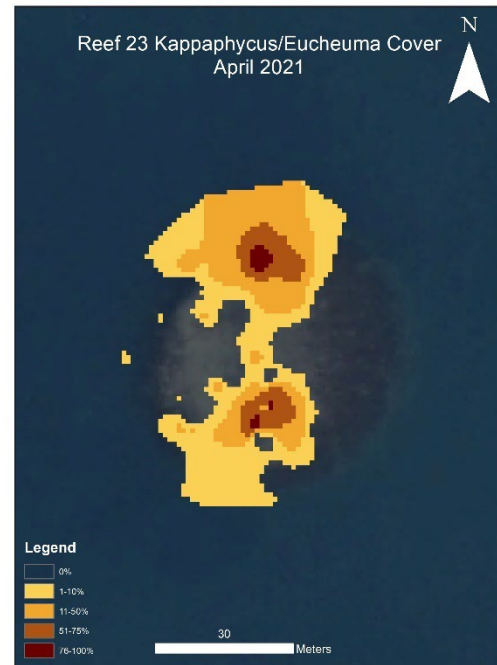
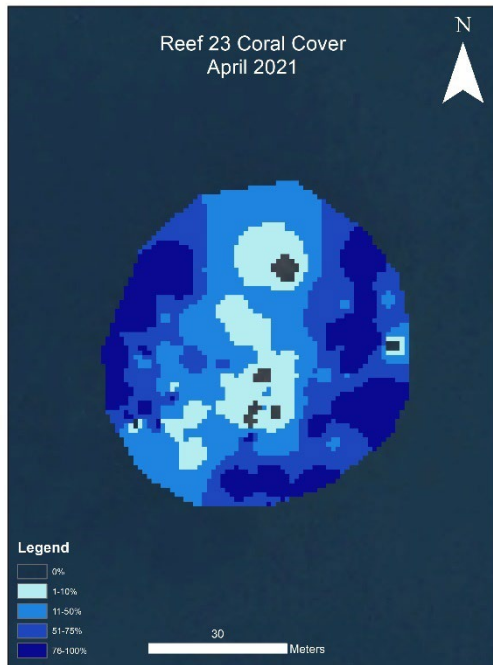
Reef 16



Reef 20



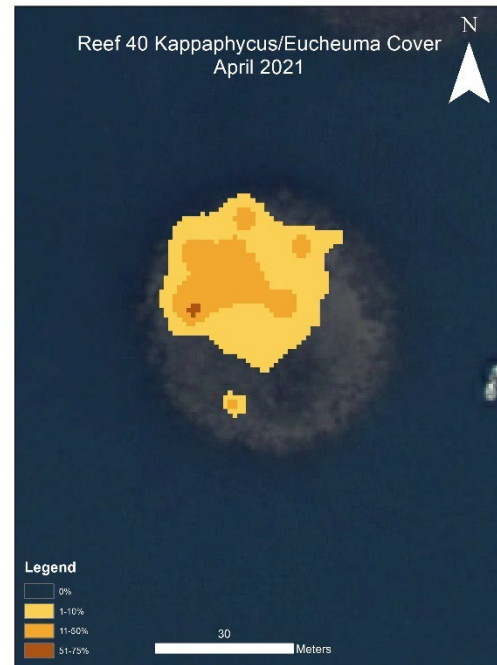
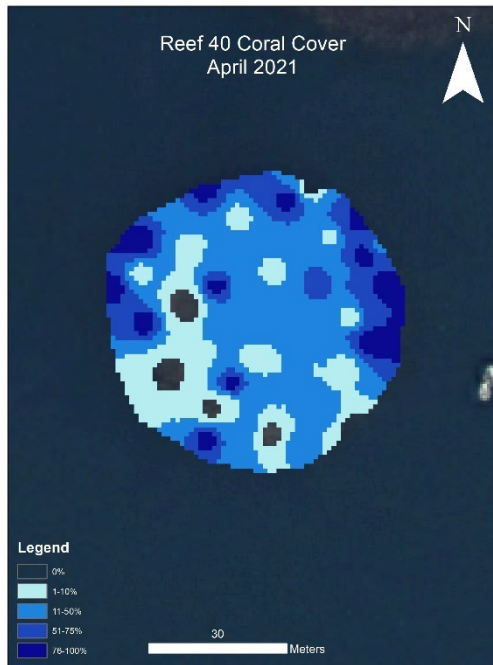
Reef 23



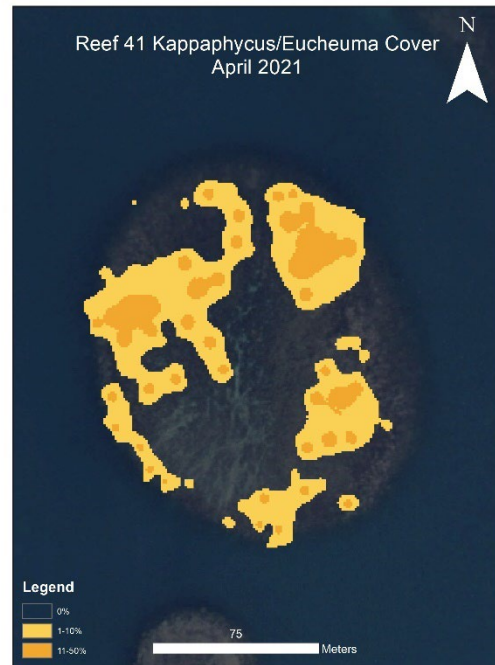
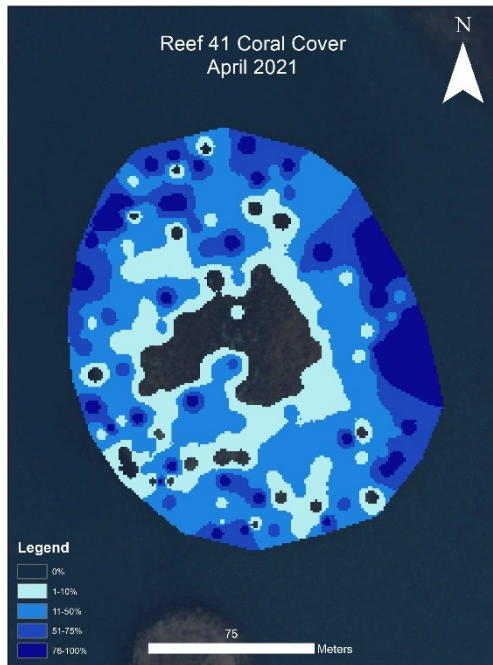
Reef 30



Reef 40



Reef 41



Appendix B: Presence/Absence Reef Maps

