

100 Yards of Hope Reef Restoration Project

Final Report



Florida Department of Environmental Protection
Office of Resilience and Coastal Protection



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Completed Project Milestones

Aug-September 2020

- Developed and Finalized Project and Monitoring Plan
- Obtained collection (urchins) and outplanting permits from FWC
- Scouted and established the three 100YOH restoration plots
- Completed benthic monitoring transects
- Completed pre-outplanting coral disease monitoring (none observed)
- Completed pre-outplanting high resolution photomosaic surveys
- Deployed HOBO temperature loggers at each of the restoration plots
- Collected and fertilized *Orbicella faveolata* (OFAV) gametes from colonies at Rainbow Reef
- Settled and reared OFAV larvae in SECORE's "CRIBs" located at Frost Science
- Propagated *Acropora cervicornis* (ACER) and *Acropora palmata* (APAL) within UM nurseries for outplanting

October 2020

- Conducted spawning observations over 3 nights at Rainbow Reef
- Collected and fertilized *Montastraea cavernosa* (MCAV) gametes from parent colonies at Rainbow Reef >> Only 5 colonies spawned and fertilization was not successful.
- Trained all partners (i.e., Force Blue, Frost Science) on the reef restoration techniques used in this project. Training took place in person over two days at the Frost Museum
- Outplanted 1,000 ACER colonies (15-30 cm max diam) of 20+ genotypes from the UM nurseries
- Outplanted 100 ACER colonies (5-15 cm max diam) grown from 2018-2019 larvae provided by FLAQ
- Outplanted 75 OFAV juvenile corals (5 cm diam) grown from 2018-2019 larvae by FLAQ
- Outplanted 120 SECORE substrates with OFAV coral recruits
- Started water quality collections in collaboration with NOAA AOML
- Supported the filming of Force Blue's "100 Yards of Hope" documentary
- Started the propagation of massive corals from nursery stocks

December 2020

- Completed 1 Rescue a Reef expedition with 10 citizen scientists outplanting 80 massive corals
- Continued the propagation of massive corals for outplanting

January 2021

- Completed post-outplanting high resolution photomosaic surveys
- Collected 200+ adult (72 mm mean diam) *Diadema* sea urchins. Urchins were housed at Frost Science until deployment
- Hosted Super Bowl LV coral restoration expedition and “4HOPE” virtual event that produced media reaching 75+ million viewers
- Continued the propagation of massive corals for outplanting
- Monitored massive coral outplants

February 2021

- Completed 3-month coral disease monitoring (none observed)
- Scouted, established, and surveyed experimental (n=3) and control (n=4) urchin plots
- Transplanted 200+ *Diadema* urchins onto restoration plots (in collaboration with UF)
- Completed 1-day and 1-week monitoring of translocated urchins
- Outplanted 155 APAL colonies (5-15 cm diam) from 10+ genotypes from the UM nursery
- Continued the propagation of massive corals for outplanting
- Continued the outplanting of massive corals
- Monitored massive coral outplants

March 2021

- Completed 1 Rescue a Reef expedition with 8 citizen scientists outplanting 140 ACER corals
- Completed 1-month monitoring of translocated urchins
- Created a 1-min short video describing the activities of 100 YOH
- Continued the outplanting of massive corals

- Monitored massive coral outplants

April 2021

- Completed 6-month coral disease monitoring
 - o Two wild colonies with SCTLD were observed and treated (in collaboration with NSU Strike Team)
 - o No disease was observed on outplanted massive coral colonies
- “100 Yards of Hope” documentary premiered, reaching 3,000+ viewers from 10+ countries
- Completed the outplanting of 751 massive corals (3-10 cm diam) from 6 species
 - o *Montastraea cavernosa*, *Pseudodiploria clivosa*, *Pseudodiploria strigosa*, *Siderastrea siderea*, *Diploria labyrinthiformis*, and *Orbicella faveolata*
- Monitored massive coral outplants

May 2021

- Completed 3-month urchin surveys
- Completed 3-month UM APAL coral condition surveys
- Completed 6-month UM ACER coral condition surveys
- Completed 6-month FLAQ ACER coral condition surveys
- Completed 6-month FLAQ OFAV coral condition surveys
- Completed visual surveys of SECORE substrates
- Completed UM massive coral condition surveys
- Completed temperature and water quality collections
- Completed 6-month high resolution photomosaic surveys
- Prepared Final Report Draft and PowerPoint presentation (scheduled for June 2)

Acropora Restoration (Appendix 6, 7, 9, & 28)

As part of this project, we propagated and planted 1,000 UM staghorn and 150 elkhorn colonies, as well as 100 FLAQ staghorn corals grown from larvae onto the 3 restoration plots at a density of ~ 5 *Acropora* colonies m^{-2} . The nursery outplants included > 20 staghorn and > 10 elkhorn distinct genotypes. All 100 FLAQ staghorn are distinct genotypes, thus representing the outplanting of > 130 *Acropora* genotypes onto Rainbow Reef! The corals provided by FLAQ (ACER) were already housed at the UM in-water nursery and were transferred onto the reef directly. Survivorship, recorded from a subset of tagged outplants (UM and FLAQ corals), exceeded 90% after 1 and 3-6 months, exceeding regional benchmarks of success. All corals were outplanted using cement and showed 100% attachment.

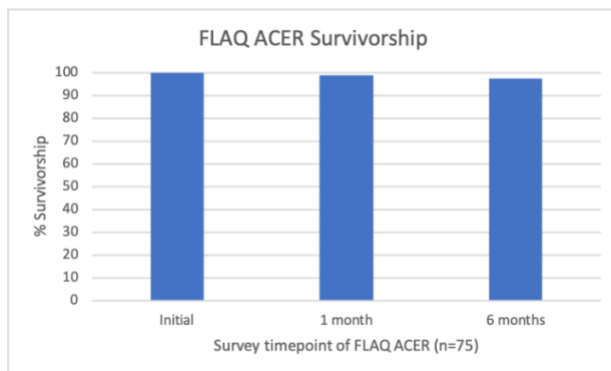


Figure 1. Survivorship of The Florida Aquarium's juvenile *Acropora cervicornis* coral outplants after 6 months.

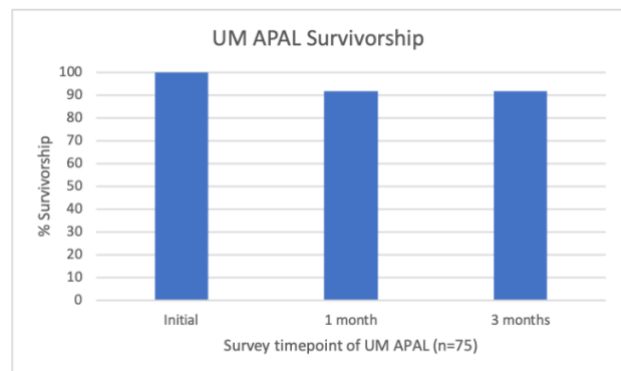


Figure 2. Survivorship of the University of Miami *Acropora palmata* coral outplants after 3 months.



Figure 3. Newly outplanted *Acropora cervicornis* coral outplant initially (left) and again after 6 months (right).

Massive Coral Restoration (Appendix 11, 12, 13, 14, 15, 16, 17, & 28)

A total of 751 colonies from massive coral taxa were outplanted as either clusters of small fragments (3 cm in diam, 5 fragments per cement base) or individual outplants (~ 10 cm). The

species outplanted were *Montastraea cavernosa*, *Pseudodiploria clivosa*, *Pseudodiploria strigosa*, *Siderastrea siderea*, *Diploria labyrinthiformis*, and *Orbicella faveolata*. All corals came from the UM nursery stocks, composed of fragments propagated from 2017-2018 corals of opportunity field collections, or 2019-2020 donations from construction projects (Key Biscayne, Key West, Port of Miami). Colonies were kept on our in-water nursery tables until fragmentation. For propagation, the parent colonies were brought into the lab, fragmented, and mounted onto ceramic plugs. Not all corals were available at the same time, so corals were outplanted in “waves” as they became available to prevent long stays in the UM tanks (fragments created in the lab were outplanted within 2-3 weeks after fragmentation). The corals provided by FLAQ (OFAV) were already housed at the UM in-water nursery and were transferred to the reef directly.

Post-outplanting, whole-colony survivorship (clusters were considered a single colony for this analysis as suggested for the SCTL D Restoration Trial Team outplanting proposal) ranged from 20% (DLAB) to 100% (SSID). Survivorship, recorded at the last survey for each outplanted batch, exceeded 90% for the other 4 species. While predation impacts, evidenced as fish bite scars, were common, no instances of disease were recorded among outplanted corals. All corals were outplanted using cement and showed 100% attachment. Many of the corals deployed within clusters were fusing after 8 weeks. Survivorship was related to colony size. FLAQ OFAV corals > 4 cm in diameter had 100% survivorship compared to smaller corals (~3 cm in diam) that had 65% survivorship.

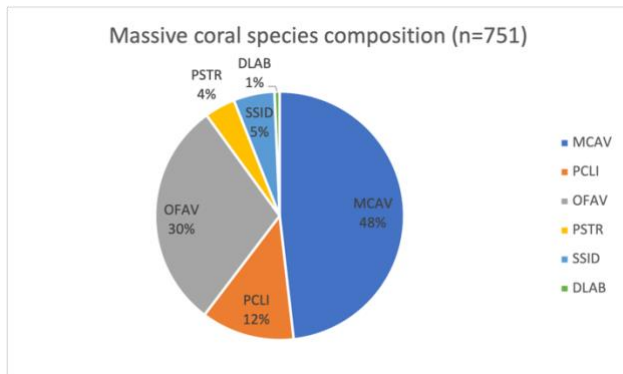


Figure 4. Massive coral outplant species composition between 100 Yards of Hope restoration plots (n=3).

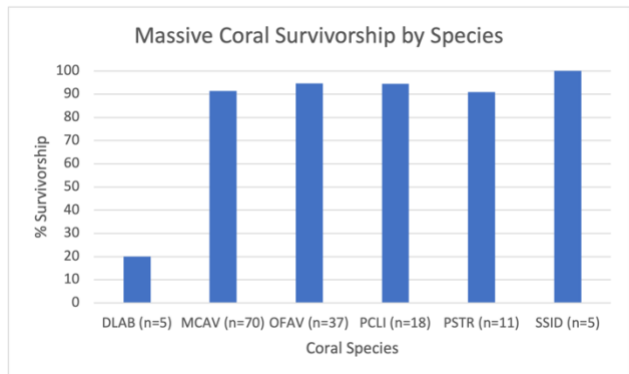


Figure 5. Massive coral outplant survivorship by species at final time-point between restoration plots (n=3).

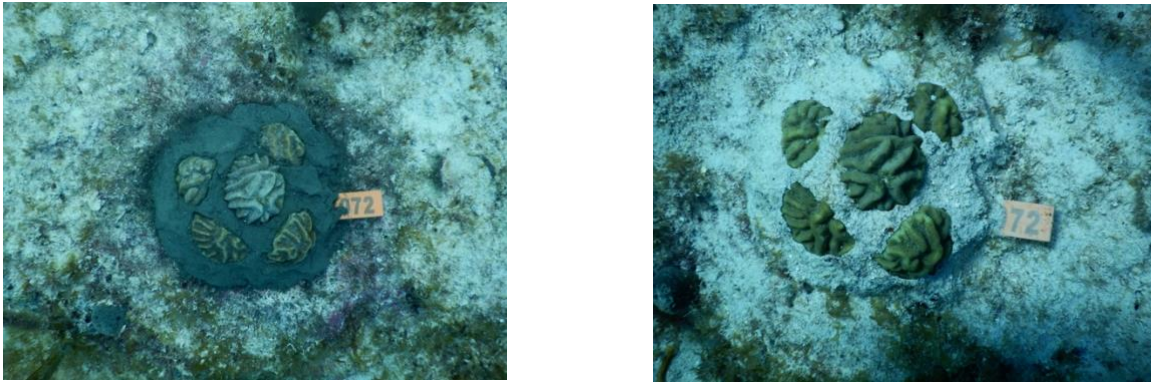


Figure 6. Newly outplanted *Pseudodiploria strigosa* corals initially (left) and again after 12 weeks (right).

Sexual Reproduction (Appendix 18)

Ceramic, gear-shaped substrates were used to settle *Orbicella faveolata* (OFAV) larvae during Sept 2020 and outplanted to the 100YOH site in Oct using cement. The substrates were distributed evenly among the three plots. A subset of the substrates had an individual tag attached and were outplanted to plot 98. During follow-up surveys, two divers searched the area around each plot stake to identify the substrates, cleaned them (plucking macroalgae and fanning sediment) to provide view to the substrate surface, and examined the vertical surfaces (where the settlers were concentrated) with either a hand magnifying glass or an underwater fluorescence dive light.

A vast majority of the outplanted substrates were in place and relocated during our survey. Though the substrates were not all tagged, we estimate we were able to observe a substantial amount of the 120 substrates during this survey (~ 40 at each plot). Unfortunately, the substrates were severely overgrown by turf and macroalgae, along with sediment that binds to the algae. We only observed a single, unequivocal surviving recruit of OFAV at plot 98. As expected, it was yet very small and a single polyp. Thus, it is plausible there are additional surviving recruits that we were not able to detect due to the small size and abundant overgrowth.

It is also quite clear that the benthic habitat, with its extensive biomass of macroalgae, especially *Dictyota* (which is known to have alleopathic effects on small coral recruits), and sediment-

binding turf, represented a sub-optimal habitat for small coral recruits. This highlights the potential improvements that could be made with coordinating restoration with benthic grazers that could help combat this competition on an appropriate spatial scale, such as juvenile urchins and/or gastropods. The co-outplant of these grazers would be fruitful to test in the future.

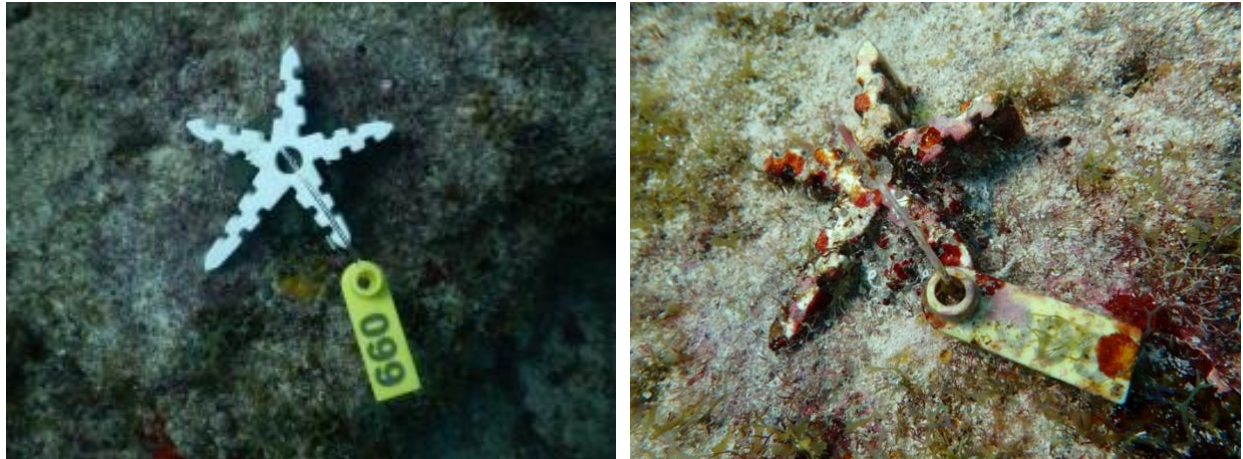


Figure 7. Newly transplanted SECORE settlement substrate with *Orbicella faveolata* coral recruits initially (left) and again after 6 months (right).

Diadema Relocation (Appendix 3 & 29)

Urchins utilized for this effort were collected under FWC permit #SAL-20-2287-R. Sites were identified as potential urchin sites from previous fish collecting efforts for Frost Science. A shallow ledge running south from Graceland Reef was searched by buddy pairs of divers drifting the ledge and surrounding areas. Significant area was covered by divers during each drift. Urchins were collected by divers working in buddy pairs and using special angled aluminum prods to coax urchins from their shelter. Puncture resistant gloves were utilized to minimize puncture wounds. Once coaxed from their shelter, urchins were placed in 10-gallon plastic bins with removable covers. Following each dive, urchins were transferred to coolers or placed in the Frost vessel live well. Collected urchins were transported to and maintained at the Frost Science Bachelor Environmental Center at FIU's Biscayne Bay Campus.

The day preceding relocation, all urchins were measured (50mm -105mm, avg. 72.6mm test dia.) using calipers. Sizes were adjusted to achieve similar average size of urchins in each plot (70.15mm - 75.75mm). On the relocation day (Feb 10, 2021), urchins were loaded into the live

well on the Frost vessel and transported to the 100 Yards of Hope relocation site. Prior to release of urchins, 7 study plots (3 restoration plots, 2 no-coral controls, and 2 no-urchin controls) with a diameter of 10 m were identified and marked using iron rebar stakes and cow tags. Pre-deployment urchin surveys were undertaken in each plot to determine the presence of wild urchins (only 5 wild urchins total were found within 10 m of the 7 plots). Within each plot, ten 25-cm² photoquadrat plots were established, tagged, and photographed to track algal abundance. Forty urchins were deployed at each of the 5 relocation plots.

At day one post-deployment a total of 193 urchins (96.5%) were observed in the 5 plots that received urchins. At 7 days post-deployment 166 urchins (83.0%) were observed. After 1 month 61.5% of urchins were observed, and after 3 months, 62% of urchins remained within the deployment plots. The retention numbers far exceeded our expectations based on prior reports of very low retention of relocated juvenile and adult urchins and bodes well for the use of urchins in future restoration efforts. The data on algal abundance and micro-habitat selectivity are being analyzed and will be incorporated in Fall 2021.

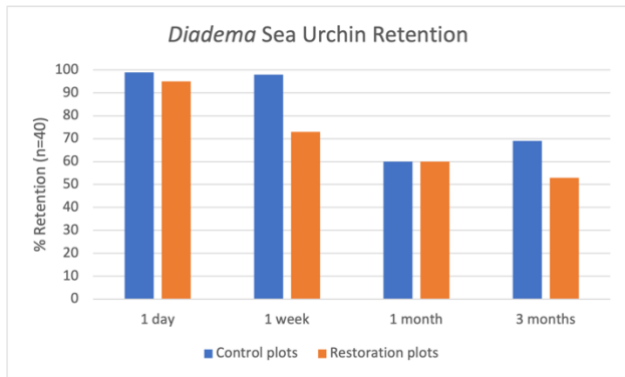


Figure 8. *Diadema* sea urchin retention percentages across plots over time.



Figure 9. *Diadema* sea urchin residing under an *Acropora cervicornis* coral outplant.

Outreach & Citizen Science (Appendix 22, 23, 24, 25, & 30)

From September 2020 – April 2021 our team hosted or participated in 29 education and public outreach activities reaching 6,000+ individuals. These activities included virtual presentations, panel events, and lab tours that sought to raise awareness, support, and action for the conservation and restoration of Florida’s Coral Reef while highlighting the 100 Yards of Hope project. Two significant outreach events were the “4HOPE” virtual event and the premiere of

the official “100 Yards of Hope” documentary. The 4HOPE event and 100YOH expedition in the run-up to Super Bowl LV garnered significant public and media attention, reaching 75+ million through 30+ broadcast stories. The official 100YOH documentary film had its world premiere during NFL Draft Week (4/27/21 – 5/2/21) was a large success with 3,000+ viewers spanning 10+ nations. The 100YOH documentary has been reopened to the public again for a limited time in celebration of World Oceans Day (June 8th) with the long-term goal of being housed on a global streaming platform (i.e. Netflix). The film can be viewed at: [100 Yards of Hope - Florida's Coral Reef](#).

In addition to public outreach activities, the 100YOH project was featured frequently and prominently across all partner platforms (i.e. Facebook, Twitter, and Instagram). These posts included, but were not limited to, project milestones, educational content, and ways to get involved/support the activities. While formal analytics were outside the scope (and budget) of this effort, social media content shared on the Rescue a Reef program pages regularly and consistently reached 1,000s of individuals. Two such examples are the “4HOPE” event teaser video and 100YOH overview video that were each viewed by 1,000+ audience members across platforms.

Lastly, we hosted 2 citizen science coral restoration expeditions through our Rescue a Reef program. While expedition capacity was limited due to COVID-19 protocols, we were still able to have 18 participants join us for coral nursery maintenance, monitoring, and coral outplanting. With the support of our UM researchers, the citizen scientists outplanted 80 massive corals and 140 staghorn corals between the 2 expeditions at the 100YOH restoration site. Perhaps more

importantly, they gained hands-on, educational experience in marine research, conservation, and sustainability all while contributing to an exciting, real-world restoration project.



Figure 10. University of Miami team members providing training to citizen scientists prior to the coral restoration expedition (left) and during offshore activities at the 100 Yards of Hope site (right).



Figure 11. "100 Yards of Hope" documentary film poster (photo by Zach Ransom).

Landscape Mosaics (Appendix 26)

Underwater landscape mosaics were created at each plot in October, January, and May using a pair of DSLR cameras and the Agisoft Metashape software package. A rebar stake marked the center of each plot. Before acquiring imagery, divers used a tape measure to place 50 cm scale bars at a 5 m radius from the center stake thereby demarking the survey area for the plot (~ 80 m²). Two Canon SL-2 DSLR cameras with Canon 18-55mm f/4-5.6 IS STM lenses were used to capture images at these plots. Both cameras were used in Ikelite 200DLM/C underwater TTL housings with dome ports. The lens on one camera was set to 18 mm focal length and the other was set to 55 mm focal length thereby collecting two image sets: one at high spatial resolution and the other with high frame-to-frame overlap.

Approximately 900 images with each camera were acquired at each plot. For each plot, images from both cameras were loaded together into Agisoft Metashape (v. 1.6.5). Images were aligned using the following settings: Accuracy=High, Generic Preselection=Yes, Key Point limit=40,000, Tie Point Limit=4,000. After initial image alignment, the scale bars were used to optimize image alignment, then the dense point cloud was computed using the following settings: Quality=Medium, Filtering Mode=Aggressive. Digital elevation model (DEM) and orthomosaic products were generated following the calculation of the dense point cloud.

The orthomosaics were output from Metashape using maximum resolution, which varied among the plots but was in all cases < 1 mm. The full-resolution orthomosaics, delivered as PNG files, are at: [100 Yards of Hope Restoration Sites](#).

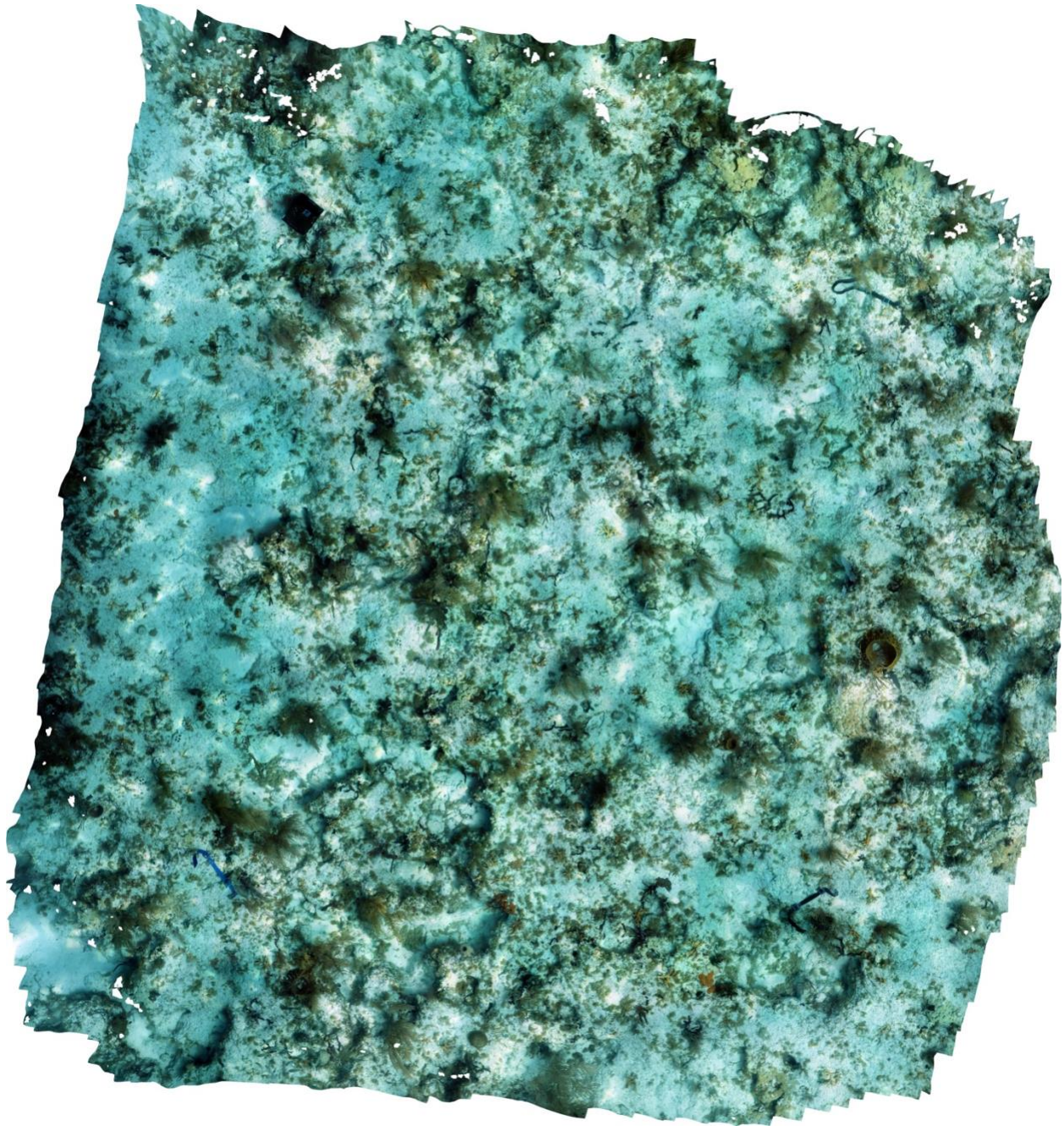


Figure 12. High-resolution landscape mosaic of Plot 97 of the 100 Yards of Hope coral restoration site 6 months post-outplanting.

Water Quality (Appendix 20, 21, 31, & 32)

Temperature data, at hourly intervals, was collected from each plot using a HOBO logger. The loggers were switched once during the project. Final data collection was done in May 2021. A logger was left in place for future data collection. Average (\pm S.D.) temperature between August

2020 and May 2021 was 26.6 ± 2.5 °C. Maximum temperature at the site was 31.9 °C on Aug. 10 (prior to the deployment of the corals). Average deviation in temperature between plots was < 0.2 °C when measurements overlapped in time.

In collaboration with scientists from NOAA's AOML (I. Enochs, C. Kelble, I. Smith) the monthly water samples will be analyzed for carbonate chemistry and nutrients at no cost to this project (sampling protocols appear in Appendix 1). To date, the nutrient data analyzed showed relatively elevated concentrations of 1.72 uM DIN and 0.08 uM PO₄. These values are consistent with an urban environment (Rainbow Reef is in close proximity (5 km) to the city of Key Biscayne and well connected with Biscayne Bay through the Safety Valve and Bear Cut). AOML conducts monthly water quality surveys in South Florida and the closest survey stations are located 5 km South of Rainbow Reef. These sites had slightly lower DIN (1.18 uM) and PO₄ (0.05 uM) values, emphasizing the urban influences on Rainbow Reef.

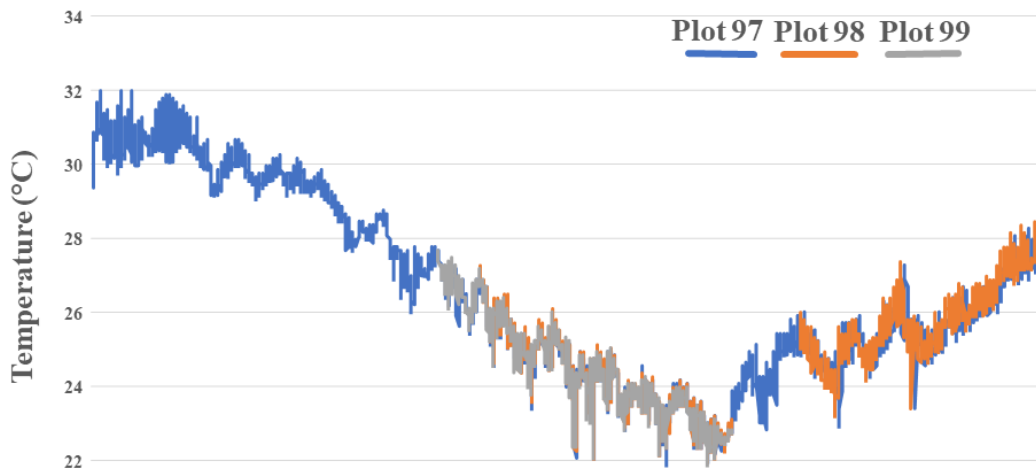


Figure 13. Water temperature (°C) across plots (n=3) over course of 100 Yards of Hope coral restoration project.

