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MEMORANDUM

Date: 25 February 2014

To: Chris Pomfret, Great Lakes Dredge and Dock Company

From: Anne McCarthy, Project Manager/Project Scientist, CSA Ocean Sciences Inc.
Keith Spring, Senior Scientist, CSA Ocean Sciences Inc.

Re: Final Report for the 30-Day Post-Relocation Monitoring Survey for
Acropora cervicornis Associated with the Miami Harbor Construction Dredging
(Phase 3) Project

The following is the 30-day post-relocation monitoring survey report for *Acropora cervicornis* colonies relocated as part of the environmental mitigation activities associated with the Miami Harbor Construction Dredging (Phase 3) Project. A total of 38 colonies (or “clusters”¹) of *A. cervicornis* located within 100 ft of the northern and southern edges of the ship channel on the second reef were moved to two coral relocation sites, situated north and south of the channel approximately 261 m (856 ft) and 413 m (1,354 ft), respectively. The relocation work was performed from 19 to 21 November and on 2 December 2013. The 30-day post-relocation monitoring survey was conducted on 13-14 January 2014.²

BACKGROUND

On 8 September 2011, the National Marine Fisheries Service (NMFS) issued a Biological Opinion (B.O.) based upon their review of the U.S. Army Corps of Engineers (USACE) planned Miami Harbor dredging activities and the project’s effects on *A. cervicornis* and its designated critical habitat. As part of the B.O., several Reasonable and Prudent Measures (RPMs) were specified to minimize the impacts of incidental take of the coral colonies. Relocation of corals outside of the project footprint and preservation of genetic material via the collection of coral fragments from each of the transplanted coral colonies were identified as necessary and appropriate RPMs. NMFS provided terms and conditions for implementing the RPMs and protocols for the fragmentation and transplantation of *A. cervicornis*; these conditions were subsequently incorporated into the Florida Department of Environmental Protection’s permit (0305721-001-B1) and were used as a basis for the USACE’s technical specifications and requirements (Section 01 57 20 - Environmental Protection; Request for Proposals [RFP] No. W912EP-12-R-0013).

¹ In many cases, a “colony” was composed of several coral branches which may or may not have been attached to each other due to natural fragmentation and movement of branches. In these cases, the group of branches was defined as a colony even though they may have been separated.

² The survey schedule was delayed due to high winds and seas making conditions offshore unworkable.

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As part of the RPMs and to help achieve recovery goals of the species, a 5-cm fragment³ was to be collected from a healthy axial tip of each *A. cervicornis* colony, or representative cluster, and transferred to the University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS), a permitted *Acropora* nursery within the subregion.

Prior to construction and extending from 24 September through 2 October 2013, CSA Ocean Sciences Inc. (CSA) conducted a comprehensive coral survey to locate all *A. cervicornis* coral colonies originally documented during the 2010 *A. cervicornis* survey (Dial Cordy & Associates, Inc. [DCA], 2010⁴) and also catalog colonies not previously recorded. The 2010 DCA survey utilized NMFS's "Recommended Survey Protocol for *Acropora* spp. in Support of Section 7 Consultation – Intermediate to Large Project Areas (>~0.1 hectare or ~0.25 acre)."⁵ The NMFS method calls for a two-tiered survey approach; the first tier employs subsampling a large area to document the presence of colonies but is not all-inclusive, providing one sampling site per 10,000 m² within the 2010 survey area. DCA surveyed 86 sites using the first tier approach and located five or more colonies at two sites, triggering the second tier survey methods whereby belt transects were utilized to cover a larger area within the sites. A total of 31 colonies were documented as part of the DCA 2010 survey.

In order to locate the acroporids previously identified by DCA and document any additional colonies, CSA's 2013 survey was conducted along channel-parallel transects plotted at 10-m intervals and extending out approximately 150 m north and south of the channel walls on the second reef, achieving nearly 100% coverage of the entire survey area. Results from the survey indicated the coral abundance was more than 10 times that identified during the 2010 survey, greatly exceeding the anticipated coral colony numbers. The data from the 2013 survey was used to develop a Coral Relocation Plan (Transmittal No. 01 57 20-5) for submittal to the USACE, the primary guiding document for fragmentation, collection, transplantation, and baseline monitoring activities. In consultation with the USACE, up to 40 coral colonies identified within a 100-ft buffer area to the north and south of the channel edges were proposed for relocation to the recommended coral relocation sites as provided in the Coral Relocation Plan.

METHODOLOGIES

Using global position system (GPS) coordinates collected during the 2013 coral survey, CSA located 38 previously documented *A. cervicornis* colonies within the 100-ft buffer in water depths of 20 to 32 ft. **Table 1** provides the coordinates for the locations from which the coral colonies were collected. Using photographs obtained during the preliminary CSA coral survey and printed on underwater paper, a scientist visually compared the current condition of each coral colony to the condition at the time of the original survey. A brief visual health inspection was conducted to discern signs of disease, bleaching, or recent mortality due to invertebrate or fish predation. Any signs of stressors were noted for each candidate colony identified for collection due to the potential for an effect on its survivorship following transplantation.

³ The Biological Opinion states that a 3-cm fragment must be collected; however, consultation with scientists from the University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS) revealed that the threshold for mortality for *Acropora cervicornis* fragments is approximately 3 cm. Due to concerns relative to fragment mortality, NMFS agreed to allow for an increase in fragment size from 3 cm to 5 cm. (Email from Kelly Logan, NMFS to Terri Jordan-Sellers, USACE, dated 31 October 2013.)

⁴ Dial Cordy & Associates, Inc. 2010. Miami Harbor Acropora Survey Report. Final Report May 2010. Prepared for the U.S. Army Corps of Engineers. 13 pp. + app.

⁵ National Marine Fisheries Service. 2007. Recommended Survey Protocol for *Acropora* spp. In Support of Section 7 Consultation. Accessed 20 February 2014 at: <http://sero.nmfs.noaa.gov/pr/pdf/RecommendedSurveyProtocolforAcropora.pdf>.

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Table 1. GPS coordinates for the locations where coral colonies were collected as part of the approved *Acropora cervicornis* relocation efforts.⁶

Number of Colonies Collected	Latitude (DM*)	Longitude (DM)	Latitude (DMS**)	Longitude (DMS)
1	25°45.5656' N	80°06.1081' W	25°45'33.94" N	80°06'06.49" W
3	25°45.7132' N	80°05.9766' W	25°45'42.79" N	80°05'58.60" W
1	25°45.6719' N	80°06.1244' W	25°45'40.31" N	80°06'07.46" W
1	25°45.6699' N	80°06.1216' W	25°45'40.19" N	80°06'07.30" W
1	25°45.6707' N	80°06.1179' W	25°45'40.24" N	80°06'07.07" W
2	25°45.6767' N	80°06.1013' W	25°45'40.60" N	80°06'06.08" W
2	25°45.6889' N	80°06.0738' W	25°45'41.33" N	80°06'04.43" W
5	25°45.6906' N	80°06.0678' W	25°45'41.44" N	80°06'04.07" W
3	25°45.6914' N	80°06.0602' W	25°45'41.48" N	80°06'03.61" W
7	25°45.6920' N	80°06.0582' W	25°45'41.52" N	80°06'03.49" W
6	25°45.6908' N	80°06.0550' W	25°45'41.45" N	80°06'03.30" W
1	25°45.6928' N	80°06.0544' W	25°45'41.57" N	80°06'03.26" W
3	25°45.7135' N	80°05.9986' W	25°45'42.81" N	80°05'59.92" W
2	25°45.6896' N	80°06.0710' W	25°45'41.38" N	80°06'04.26" W

*Degrees, Minutes, Decimal Minutes.

**Degrees, Minutes, Seconds.

Prior to fragmentation or detachment from the seafloor, each coral colony was photographed (**Photo 1**) with the following items within the field of view:

- An underwater slate showing the temporary number assigned during the survey and associated with specific GPS coordinates;
- Permanently assigned tag number to be attached next to the coral colony at the relocation site; and
- A ruler/scale bar (in cm).

Coral colony lengths were measured *in situ* along the longest perpendicular axis⁷ to sort them by size class (in cm) as defined in RFP No. W912EP-12-R-0013, Section 01 57 20 - Environmental Protection, Subsection 3.2.9, and listed in **Table 2**. Details on each coral colony including tag number, date of collection, name of the qualified individual conducting the fragmentation/collection, maximum linear dimension, size class, number of distinct clusters forming the colony, and water depth are provided in **Table 3**.



Photo 1. Representative *Acropora cervicornis* colony (Tag no. 14) prior to collection of the 5-cm fragment and detachment. The arrow points at the branch selected for fragment collection.

⁶ Coordinates were collected using the diver-operated Shark Marine Navigator (www.sharkmarine.com) underwater position system using Doppler Navigation System (DNS) technology.

⁷ Maximum linear dimension is the length (in cm) that the colony (or "cluster" of branches) extend across the substrate, including any gaps between the individual clusters.

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Table 2. Size class information for *Acropora cervicornis* colonies (Reference Subsection 3.2.9 of Section 01 57 20 - Environmental Protection; RFP No. W912EP-12-R-0013).

Size Class	Size Range (cm)
I	5 - 10
II	11 - 50
III	51 - 100
IV	101 - 200
V	>201

Table 3. Details on the *Acropora cervicornis* colonies prior to fragmentation and collection.

Tag Number	Date Collected	Collector	Maximum Length (cm)	Size Class	Approximate Number of Clusters	Water Depth (ft)
1	11/19/2013	AM	9	I	1	25
2	11/19/2013	AM	21	II	1	25
3	11/19/2013	AM	22	II	1	25
4	11/19/2013	AM	100	III	15	25
5	11/19/2013	AM	18	II	1	27
6	11/19/2013	AM	30	II	1	27
7	11/19/2013	AM	33	II	2	25
8	11/19/2013	AM	15	II	2	25
9	11/20/2013	AM	9	I	1	29
10	11/20/2013	AM	60	III	3	29
11	11/20/2013	AM	28	II	1	29
12	11/20/2013	AM	27	II	1	29
13	11/20/2013	AM	16	II	1	29
14	11/20/2013	AM	40	II	2	30
15	11/20/2013	AM	36	II	4	30
16	11/20/2013	AM	83	III	3	30
17	11/20/2013	AM	10	II	10	28
18	11/21/2013	KS	58	III	1	28
19	11/21/2013	KS	28	II	1	28
20	11/21/2013	KS	40	II	2	28
21	11/21/2013	KS	36	II	1	28
22	11/21/2013	KS	37	II	1	27
23	11/21/2013	KS	31	II	1	27
24	11/21/2013	KS	10	I	1	27
25	11/21/2013	KS	22	II	1	27
26	11/21/2013	KS	23	II	2	27
27	11/21/2013	KS	51	III	2	27
28	11/21/2013	KS	53	III	1	27
29	11/21/2013	KS	52	III	1	27
30	11/21/2013	KS	43	II	8	27

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Table 3. (Continued).

Tag Number	Date Collected	Collector	Maximum Length (cm)	Size Class	Approximate Number of Clusters	Water Depth (ft)
31	12/2/2013	KS	14	II	4	27
32	12/2/2013	KS	23	II	3	27
33	12/2/2013	KS	25	II	5	27
34	12/2/2013	KS	40	II	7	27
35	12/2/2013	KS	25	II	2	29
36	12/2/2013	KS	18	II	2	29
37	12/2/2013	KS	36	II	6	30
38	12/2/2013	KS	42	II	5	32

AM = Anne McCarthy; KS = Keith Spring.

FRAGMENT COLLECTION

After the colony was evaluated for health, photographed, and measured, a small fragment (approximately 5 cm) from a distal end of a healthy branch with white tips (a sign of new growth) was carefully cut using Taam Rio stainless steel coral clippers (Model 316). A waterproof sample label was used to identify each fragment's parent colony with information including the tag number, date, and name of the collector. The label was carefully attached to the base of the 5-cm fragment using a small nylon cable tie as part of the chain of custody process. The tagged coral fragment was then gently placed into a small plastic bag, suspended in seawater, and temporarily held in a collection basket alongside the detached coral colonies on the seafloor until the coral colonies were ready for transport to the relocation sites. Once the coral colonies were raised from the bottom to be transported to the relocation sites, the fragments were brought on board the survey vessel and placed in a cooler with re-circulating seawater until they were delivered to the coral nursery. Delivery to the coral nursery was completed within one hour of the fragments being brought to the surface.

Following fragment removal, the colony was photographed again to document the change prior to detachment and removal. **Photo 2** shows the same coral from **Photo 1** (Tag no. 14) following collection of the coral fragment.

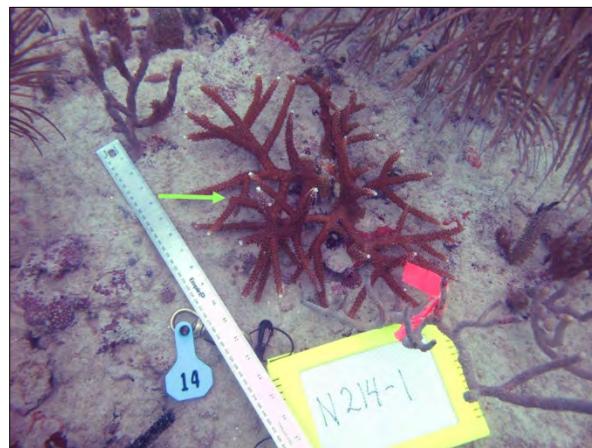


Photo 2. Representative *Acropora cervicornis* colony (Tag no. 14) after collection of the 5-cm fragment. The arrow shows the location where the fragment was collected.

CORAL COLONY DETACHMENT AND TRANSPORT

Each coral colony within the defined harvest areas north and south of the channel was carefully collected using small hand tools, such as a narrow-bladed chisel or chipping hammer, to gently pry the colony from the seafloor. Many of the coral colonies were not attached to the bottom

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and were removed by gently pulling upward from the base of the colony to free the skeletal structure from the seafloor and any overgrowth from sponges, algae, or other biota. *A. cervicornis* colonies fracture easily, so extra care was given to mitigate for breakage during collection. If a colony fragmented during collection, the pieces were delicately attached to each other using a large, releasable cable tie to ensure all the pieces from the parent colony were kept together. Each colony, or cluster, was placed in a large plastic crate with its assigned tag number (attached to a dead section of a branch) for transport to the relocation site. Extreme care was used to minimize direct contact with the coral tissue and to avoid further fragmentation when detaching and placing the coral colonies in the baskets.

Approximately 8 to 12 coral colonies, depending on size, were collected prior to transport to the relocation sites.

Only colonies that could be reattached the same day (or within an estimated 24-hour period) were collected.

Baskets containing the coral colonies were secured together and carefully raised through the water column and suspended just below the surface using a harness and lift bags (**Photo 3**). Distal fragments were brought on board the survey vessel and were placed in a cooler with recirculating ambient seawater. The baskets of corals remained in the water, suspended just below the surface by the lift bags, and were slowly towed from the collection area to the relocation site using a bridle system attached to the survey vessel. Leaving the corals in the baskets reduced potential tissue damage and unnecessary breakage of the colonies from shifting on board the vessel. The coral colonies were never exposed to the air or direct UV radiation and had a continuous flow of fresh seawater, reducing the potential for overheating or desiccation.

Upon arrival at the relocation site(s) (**Figure 1**), divers carefully lowered the baskets to a central location within the relocation site and detached them from one another to reduce the possibility of the stacked baskets tipping over.

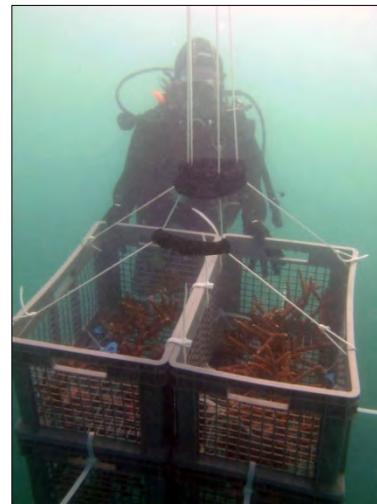


Photo 3. *Acropora cervicornis* colonies being transported to the relocation site.

CORAL COLONY REATTACHMENT

At the relocation site, divers carefully selected suitable surfaces for the reattachment of the colonies. The substrate was cleared of loose sediment and algae using a wire brush and chipping hammer. Each coral colony was inspected for additional damage that may have occurred during transport, and the base of the colony was prepared for reattachment by gently scraping small sections of the underside of the colony (coral skeleton) to maximize the bonding capacity of the adhesive. Once the coral and substrate were cleared of debris, underwater epoxy⁸ was placed at points of contact on the cleaned surface. The unique numbered plastic identification tag for each parent colony was secured to the substrate adjacent to the reattached colony. A minimum 0.75-m buffer was established between adjacent relocated coral colonies. Immediately following completion of the reattachment activities, coral colonies were photographed again with a scale bar and the tag within the field of view to document their condition follow transplantation. **Photo 4** shows a coral colony immediately after reattachment. All coral colonies were reattached at the relocation site within 24 hours of collection.

⁸ All-Fix Epoxy (www.allfixepoxy.com) and Leakmaster™ Quick Set Putty epoxy were used to reattach the coral colonies.

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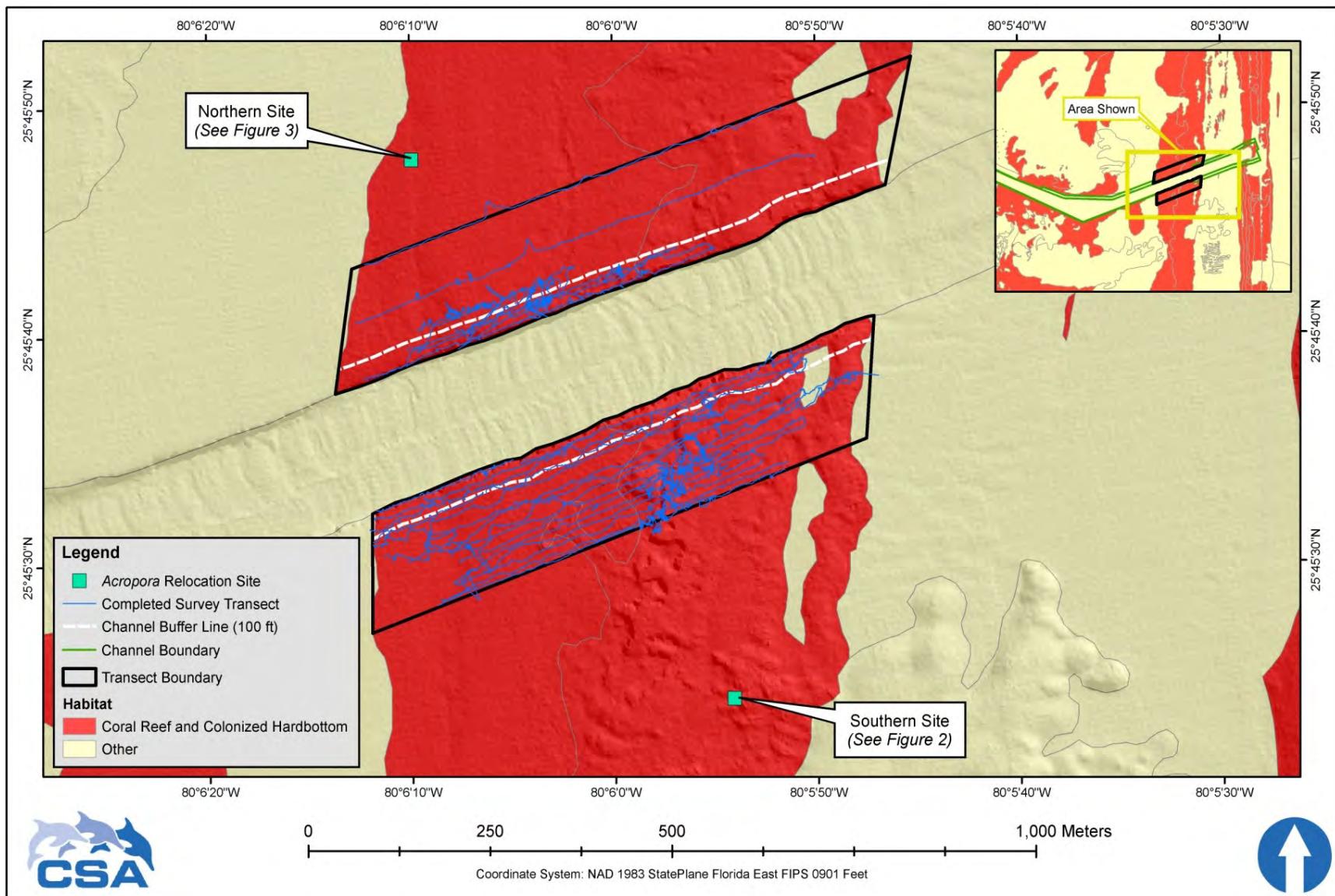


Figure 1. Coral relocation sites to the north and south of the Miami Harbor ship channel.

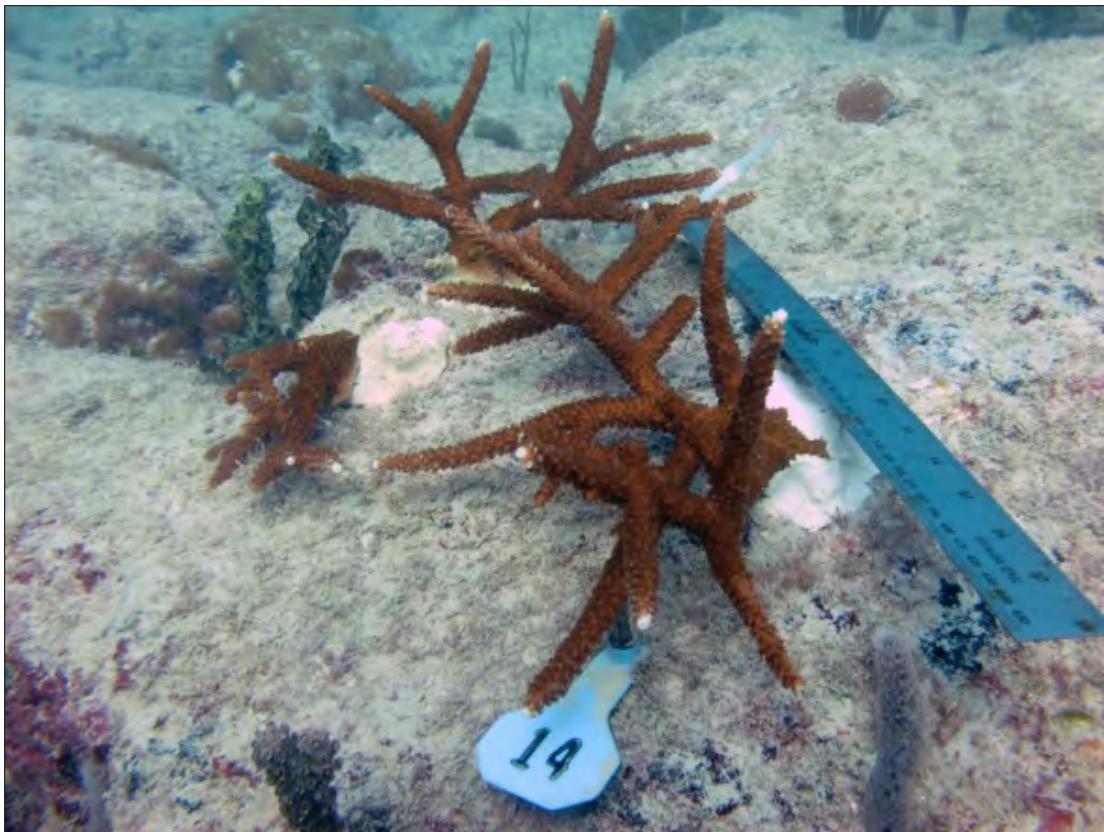


Photo 4. *Acropora cervicornis* colony (Tag no. 14) immediately following reattachment at the southern relocation site.

At the end of each day during the relocation process, the coral distal fragments were transported to Dr. Diego Lirman's laboratory at RSMAS. Dr. Lirman's laboratory manages and maintains a permitted coral nursery and was selected by the USACE as the designated recipient nursery for the fragments collected as part of this project (see **Appendix A**).

MAPPING AND SELECTION OF REFERENCE CORALS

To support monitoring efforts, each relocated colony was mapped relative to a centrally installed reference monument (a fiberglass rod embedded in the seafloor and extending approximately 2 ft above the bottom). A GPS position was collected for the reference monument and the distance and bearings of each colony from that position were recorded. Seventeen colonies were reattached at the northern relocation site and 21 were reattached at the southern site.

The approved relocation and monitoring plan called for five naturally occurring coral colonies to be tagged for monitoring as reference colonies to compare with the health and survivorship of transplants. CSA scientists surveyed the area adjacent to the northern relocation site and located only four reference colonies of *A. cervicornis* due to poor visibility at the time of the monitoring. Each colony was tagged and the GPS coordinates were collected for each of the reference colonies. No naturally occurring *A. cervicornis* colonies were located in the immediate vicinity of the southern relocation site. **Figures 2 and 3** show the locations of the reattached (and reference) coral colonies relative to the reference monuments. **Table 4** provides the coordinates for the reference monuments and reference coral colonies at the northern and southern sites.

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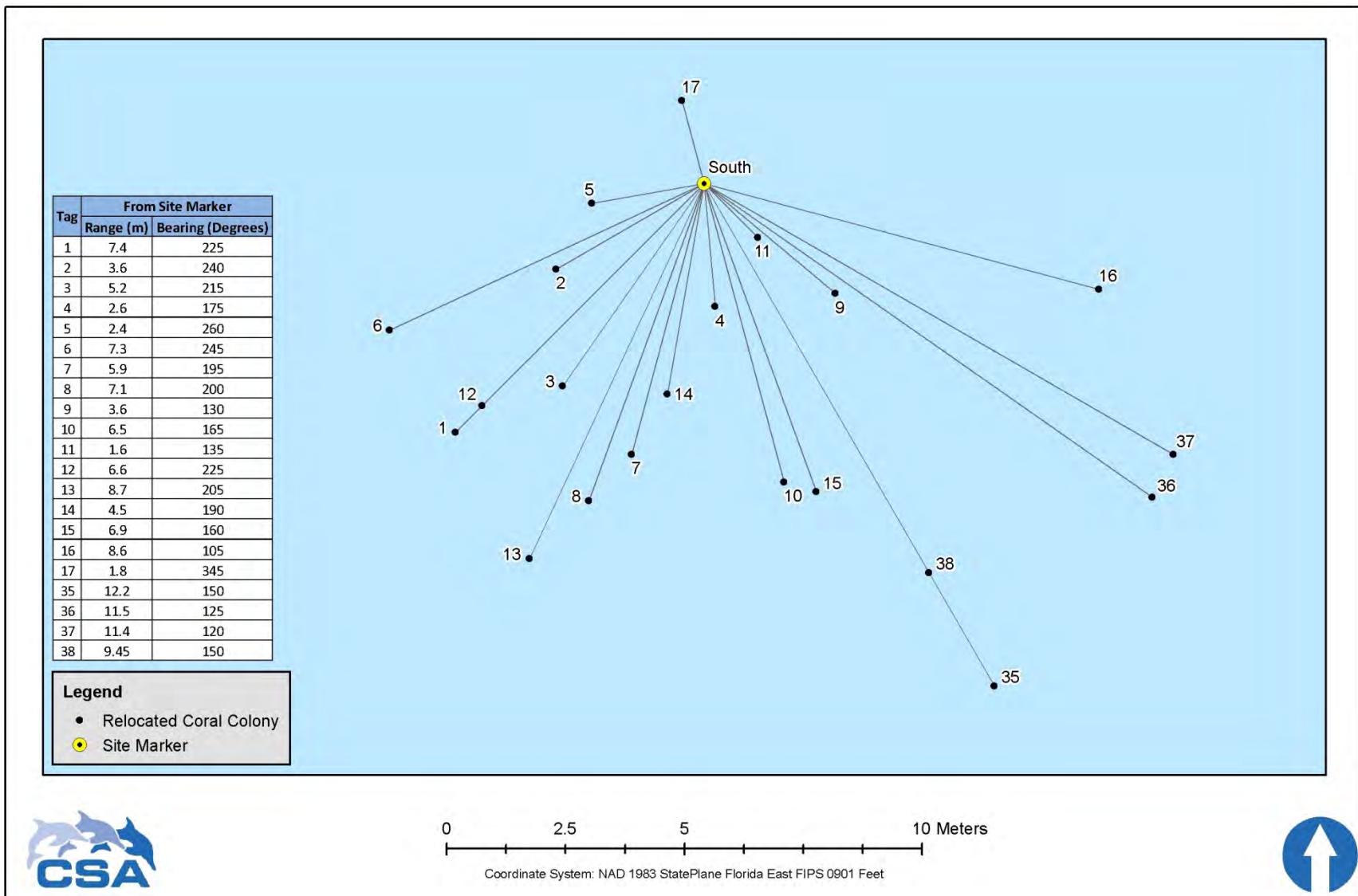


Figure 2. Map of the reattached coral colonies at the southern relocation site. No reference colonies were located in the immediate vicinity.

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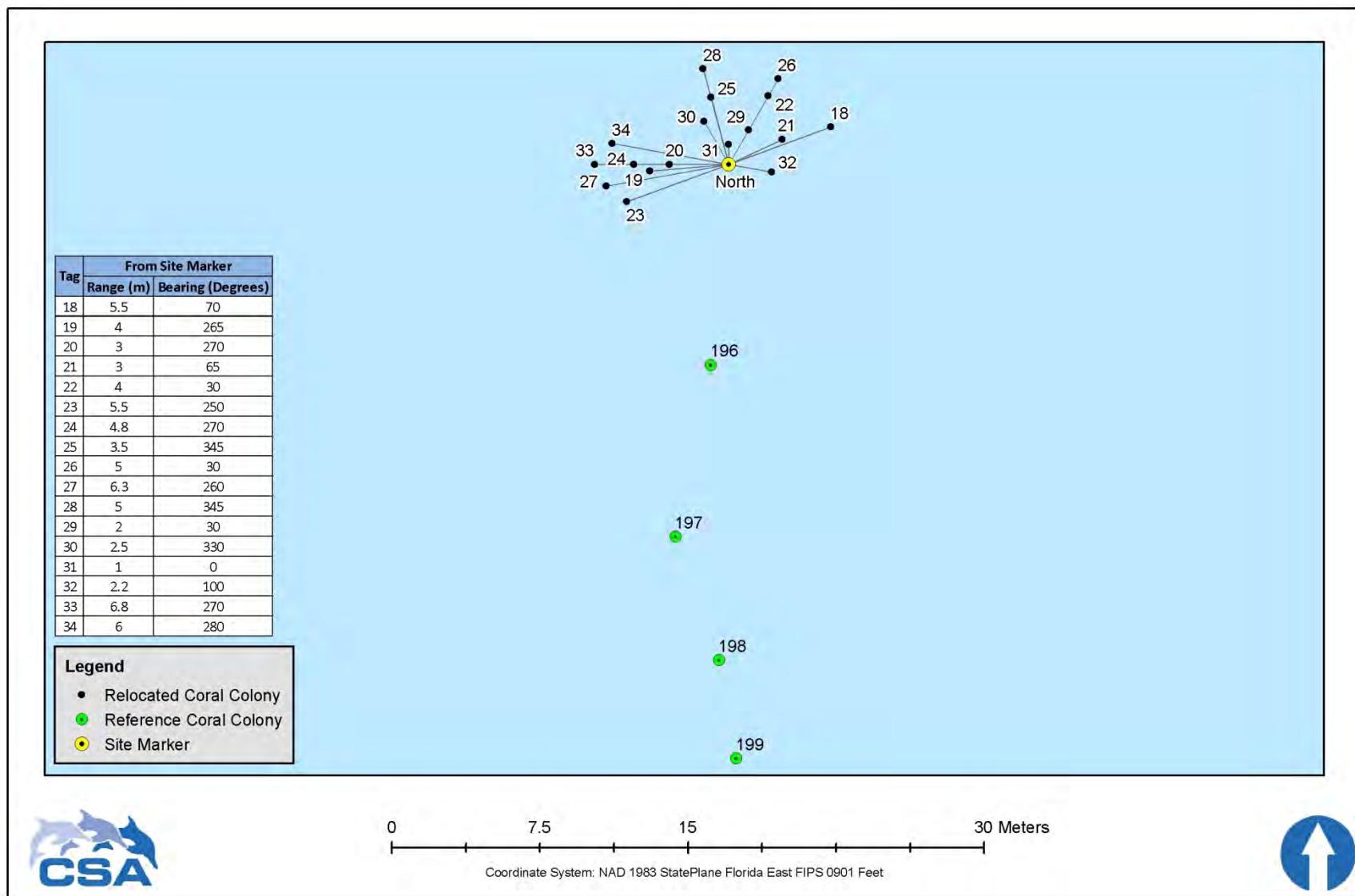


Figure 3. Map of the reattached and reference coral colonies at the northern relocation site.

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Table 4. GPS coordinates for the reference monuments and reference corals at the northern and southern relocation sites.⁹

Site/Reference Coral Colony	Latitude (DM)*	Longitude (DM)	Latitude (DMS)**	Longitude (DMS)
Northern Relocation Site	25°45.7929' N	80°06.1538' W	25°45'47.57" N	80°06'09.23" W
Southern Relocation Site	25°45.4100' N	80°05.8968' W	25°45'24.60" N	80°05'53.81" W
Reference Coral Colony #196	25°45.7874' N	80°06.1544' W	25°45'47.24" N	80°06'09.26" W
Reference Coral Colony #197	25°45.7827' N	80°06.1555' W	25°45'46.96" N	80°06'09.33" W
Reference Coral Colony #198	25°45.7793' N	80°06.1542' W	25°45'46.76" N	80°06'09.25" W
Reference Coral Colony #199	25°45.7766' N	80°06.1537' W	25°45'46.60" N	80°06'09.22" W

XY Coordinate System: WGS84 UTM Zone 17N; Units: meters; Latitude/Longitude: WGS84.

*Degrees, Minutes, Decimal Minutes.

**Degrees, Minutes, Seconds.

30-DAY POST-RELOCATION MONITORING

CSA conducted the post-relocation monitoring survey on 13-14 January 2014, approximately 40 days following the completion of the reattachment activities on 2 December 2013. Poor weather conditions prevented the monitoring survey from being conducted during the desired 30-day post-relocation time period. Underwater visibility was relatively good during the morning at the southern relocation site but deteriorated rapidly in the afternoon, limiting underwater visibility at the northern relocation site.

A health assessment was performed on each relocated and reference *A. cervicornis* colony. Gross morphological changes associated with external, visual cues such as bleaching, tissue mortality, predation, and disease were recorded and assigned a condition index score for tissue color and the extent of partial mortality using notes from the field and photographs. Tissue color was assessed by percent cover of the entire colony and scored using the index provided in **Table 5**. The extent of partial mortality (measured as a percentage) was estimated for each colony and the age of the mortality was ranked according to **Table 6**, which is modified from the Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program protocol (Lang et al., 2010¹⁰). In addition to the tissue color and partial mortality evaluation, notations were made of any disease, predation, or breakage that was observed during the post-relocation condition assessment.

Table 5. Tissue color index developed to score *Acropora cervicornis* colonies' level of tissue paling or bleaching.

Tissue Color Index	
0	Normal coloration
1	Paling
2	Bleached tissue 0% - 25%
3	Bleached tissue 26% - 50%
4	Bleached tissue 51% - 75%
5	Bleached tissue 76% - 100%

⁹ GPS coordinates were collected using a Furuno GPS Model GP37 and stored in Hypack® hydrographic survey software.

¹⁰ Lang, J.C., K.W. Marks, P.A. Kramer, P.R. Kramer, and R.N. Ginsburg. 2010. AGGRA Protocols Version 5.4. 31 pp. Accessed 11 February 2014 at: http://www.agrra.org/method/AGRRA-V5.4_2010.pdf.

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Table 6. Partial mortality index modified from the Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program protocol to score the period of time in which tissue mortality occurred.

Partial Mortality Index		
0	No Mortality	Living tissue covers nearly the entire colony
1	Recent Mortality	Non-living parts where the corallites are still intact but white skeleton is exposed and free of sediment and biofilm
2	Old Mortality	Non-living parts are covered by organisms that are not easily removed such as thick turf algae or sponges

Colonies/clusters were measured in the following two ways during the 30-day post-relocation monitoring survey:

- For each colony/cluster, measurements were collected across the maximum length (longest axis), width (perpendicular to longest axis), and vertical height of living tissue for the entire colony (where only a single branch) or across the aggregation of branches composing the entire tagged colony (**Photo 5(A)**); and
- For colonies composed of an aggregation of branches where individual branches were somewhat separated, measurements were collected for each separately attached branch of a tagged colony (**Photo 5(B)**), across the maximum length (longest axis), width (perpendicular to longest axis), and vertical height of living tissue. The separate branches of several tagged colonies were attached too closely together and intertwined to allow individual measurements.

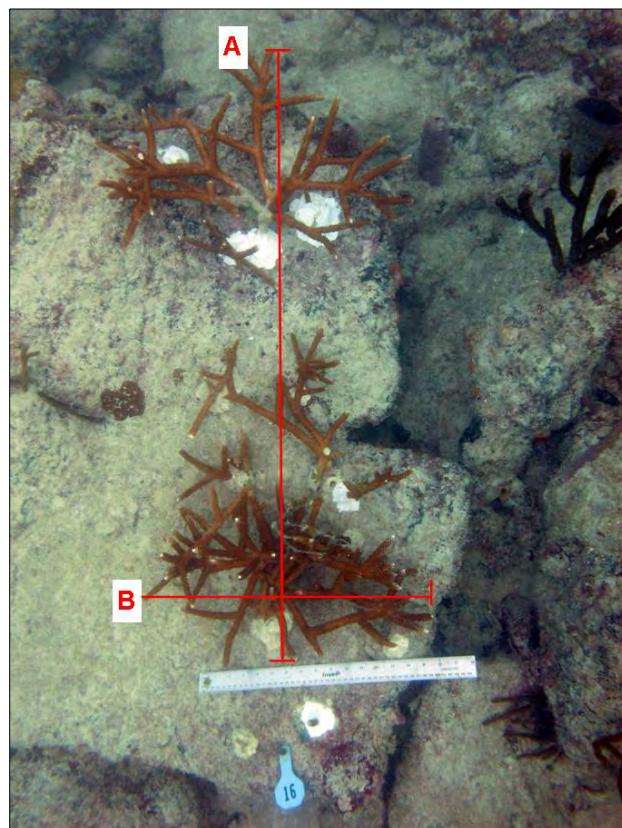


Photo 5. Example photograph demonstrating measurement methods for colonies/clusters (A) and branches (B).

Table 7 summarizes the baseline 30-day post-relocation monitoring data, showing the maximum length, number of branches per colony, water depth, tissue color scores, and the percentage of recent or old mortality. **Appendix B** provides greater detail on the size measurements for the total colony, size measurements of each individual branch composing the colony/cluster, and observations relative to mortality per branch. No signs of disease or predation were observed on any of the reattached or reference colonies.

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Table 7. Summarized baseline data for reattached and reference *Acropora cervicornis* colonies collected during the 30-day post-relocation monitoring survey.

Reattached <i>Acropora cervicornis</i> Colonies						
Tag Number	Maximum Length (cm)	Number of Branches	Water Depth (ft)	Tissue Color Score	Partial Mortality	
					Index	Percentage
1	8	1	25	0	0	--
2	23	1	25	0	0	--
3	23	1	25	0	0	--
4	46	1	26	0	0	--
5	16	1	26	0	0	--
6	34	4	25	0	2	10
7	43	5	26	0	1	20
8	23	3	25	2	1	5
9	7	1	24	0	0	--
10	47	7	26	0	0	--
11	47	3	25	0	0	--
12	52	4	24	2	0	--
13	19	1	24	0	0	--
14	54	4	25	2	0	--
15	38	3	25	0	2	20
16	90	7	23	0	0	--
17	50	4	24	0	0	--
18	45	2	24	0	2	5
19	39	2	25	0	0	--
20	33	1	25	0	2	5
21	38	1	24	0	0	--
22	9	1	24	0	2	5
23	36	1	25	2	1	5
24	34	1	25	0	0	--
25	49	1	24	0	0	--
26	35	1	24	0	0	--
27	26	1	25	0	0	--
28	57	1	24	0	0	--
29	61	3	24	0	0	--
30	82	1	24	0	0	--
31	33	5	25	0	0	--
32	26	1	25	0	0	--
33	32	2	25	0	0	--
34	40	1	25	0	0	--
35	26	2	24	0	2	<5
36	23	1	26	0	0	--
37	42	4	25	0	0	--
38	45	5	24	0	0	--
Reference <i>Acropora cervicornis</i> Colonies						
196	44	1	25	0	0	--
197	21	1	25	0	0	--
198	17	1	25	0	2	10
199	21	1	25	0	2	15

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Each reattached and reference colony was photographed again with the identification tag visible within the field of view. **Appendix C** contains photographs of the reference corals and each relocated coral colony in the following sequence:

- Pre-fragmentation and detachment;
- Post-fragmentation;
- Immediately follow reattachment activities; and
- 30-days post-relocation.

During the 30-day post-relocation monitoring survey, 15 of the 38 colonies/clusters (39%) had one or more fragments broken from the parent colony, likely attributable to heavy seas during December and early January. Continuous wind speed data from 3 December 2013 through 11 January 2014 was downloaded from the National Oceanic and Atmospheric Administration's (NOAA's) National Data Buoy Center to determine the average and maximum wind speeds at Station FWYF1¹¹ (Fowey Rocks), the Coastal-Marine Automated Network (C-MAN) station nearest to the project site. During this time period, average wind speed was 18.6 mph (8.3 m/s) with a maximum recorded speed of 38 mph (17 m/s). Historical wave heights for this station are not available, however it is anticipated that given these winds speeds, wave heights could exceed 6 ft (1.8 m), dependent upon wind direction and tidal period.

Of those colonies where breakage occurred, most of the fragments are believed to have been located within the immediate area of the parent colony and were reattached. Only four colonies (Nos. 5, 11, 26, and 27) may have lost some biomass due to breakage and distribution of several small fragments that were not located. The epoxy bond held securely, with only two colonies/branches (Nos. 11 and 16) detached from their base; these were subsequently reattached.

DISCUSSION

A total of 38 *Acropora cervicornis* colonies were relocated to two sites (one north of the ship channel and one south of the ship channel) and tagged for monitoring as part of the environmental mitigation activities associated with the Miami Harbor Construction Dredging (Phase 3) Project. An additional four reference colonies were tagged in the northern relocation site to compare the health of the reattached and naturally occurring colonies.

Fragmentation occurred on 39% of the relocated colonies at what could be considered minor levels (i.e., typically 1 to 3 branches). Fragmentation of this species as a reproductive strategy is well documented and is thought to help sustain growth rates through "pruning" colonies (Lirman, 2002¹²), although some immediate tissue loss can be a concern when not stabilized. The majority of the colonies did not experience fragmentation, while those that did had visible fragments reattached.

All coral colonies were alive and in good health during the 30-day post-relocation monitoring survey; only minor bleaching and partial mortality were observed. Reported partial mortality and bleaching were associated primarily with either previously dead basal areas of colonies or natural fragmentation, and the resultant bleaching or mortality due to temporary burial of the

¹¹National Oceanic and Atmospheric Administration. 2013. National Data Buoy Center. Station FWYF1 – Fowey Rock, FL. Accessed 20 February 2014 at: http://www.ndbc.noaa.gov/station_history.php?station=fwyf1.

¹²Lirman, D. 2002. Report from the Biology and Ecology Working Group, pp. 18-27. In: A. Bruckner, Proceedings of the Caribbean *Acropora* Workshop: Potential Application of the U.S. Endangered Species Act as a Conservation Strategy. NOAA Technical Memorandum NMFS-OPR-24. Silver Spring, MD. 199 pp.

ATTACHMENT 1

loose fragments in sediments. Neither was a direct result of the transplantation process. Although it appears four colonies lost some biomass due to natural fragmentation, survivorship of the tagged colonies/clusters is higher than NMFS anticipated with respect to the potential for post-transplantation mortality (2011 Biological Opinion). Several colonies were observed growing over the epoxy base (**Photos 6, 7, and 8**), evidencing *Acropora cervicornis*' rapid growth rate and providing a positive sign that the colonies have the potential for further growth and expansion at these sites.



Photo 6. *Acropora cervicornis* branch growing over the epoxy base approximately 40 days after transplantation.



Photo 7. Two *Acropora cervicornis* branches growing over the epoxy base approximately 40 days after transplantation.



Photo 8. *Acropora cervicornis* colony showing tissue extension and skeletal accretion over the epoxy base.

ATTACHMENT 1

Appendices

Appendix A

U.S. Army Corps of Engineer's Confirmation of Permitted
Acropora cervicornis Coral Nursery

ATTACHMENT 1

McCarthy, Anne

From: Jordan-Sellers, Terri SAJ [Terri.Jordan-Sellers@usace.army.mil]
Sent: Wednesday, October 30, 2013 12:41 PM
To: McCarthy, Anne
Cc: Kruempel, Craig; dlirman@rsmas.miami.edu; Kel Logan - NOAA Federal; Bowell, Shealy C
Subject: Acropora fragment relocation to nursery (UNCLASSIFIED)

Classification: UNCLASSIFIED

Caveats: NONE

Anne - per our conversation today - GLDD/CSA should coordinate with Dr. Lirman's lab regarding the relocation of Acropora fragments from the Port of Miami project. This satisfies the requirements of Term and Condition #5 that states "COE will coordinate with NMFS to determine the appropriate nursery to receive the fragments. (RPM 2)". USACE has previously coordinated with NMFS and Dr. Lirman at RSMAS in May 2013 to designate the RMSAS lab as the proper recipient nursery for the fragments.

Please let me know if you have any questions.

Terri Jordan-Sellers
Biologist/Regional Technical Specialist
Coastal Section
Environmental Branch-Planning Division
Jacksonville District-US Army Corps of Engineers

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Classification: UNCLASSIFIED
Caveats: NONE

Appendix B

30-Day Monitoring Data of Reattached and Reference *Acropora cervicornis* Colonies

ATTACHMENT 1

Table B-1. Size measurements and coral health observations of reattached *Acropora cervicornis* colonies/clusters.

Tag Number	Total Colony or Branch Number		Length (cm)	Width (cm)	Height (cm)	Notes	Water Depth (ft)	Tissue Color Score	Partial Mortality by Total Colony	
									Index	Percentage
1	Total Colony		8	3	6		25	0	0	--
2	Total Colony		23	21	14		25	0	0	--
3	Total Colony		23	12	15		25	0	0	--
4	Total Colony		46	33	10	Multiple small and tightly clustered branches	26	0	0	--
5	Total Colony		16	14	7		26	0	0	--
6	Total Colony		34	30	10	Colony composed of 4 branches	25	0	2	10
	Branch Number	1	13	13	9	Old mortality on the distal tips of 2 branches				
		2	15	11	9	Old mortality in center of branch				
		3	18	15	8					
		4	7	2	9					
7	Total Colony		43	30	13	Colony composed of 5 branches	26	0	1	20
	Branch Number	1	16	18	11					
		2	14	18	8					
		3	18	10	10					
		4	16	7	13	Very recent mortality due to fragmentation and partial burial in sand; 65% of branch recently dead				
		5	10	3	4					
8	Total Colony		23	10	9	Colony composed of 3 branches	25	2	1	5
	Branch Number	1	9	8	9					
		2	7	7	9					
		3	8	5	9	Fragmented branch was sitting in sand causing ~10% bleaching and ~5% recent mortality				
9	Total Colony		7	6	8		24	0	0	--
10	Total Colony		47	34	17	Colony composed of 7 branches	26	0	0	--
	Branch Number	1	16	9	7					
		2	21	16	12					
		3	12	6	15					
		4	4	1	8					

ATTACHMENT 1

Table B-1. (Continued).

Tag Number	Total Colony or Branch Number	Length (cm)	Width (cm)	Height (cm)	Notes	Water Depth (ft)	Tissue Color Score	Partial Mortality by Total Colony	
								Index	Percentage
11	Branch Number	5	14	16	13	25	0	0	--
		6	7	7	7				
		7	18	14	12				
12	Total Colony	47	14	13	Colony composed of 3 branches	24	2	0	--
	Branch Number	1	23	18	12				
		2	15	8	13				
		3	7	6	9				
13	Total Colony	52	30	16	Colony composed of 4 branches	24	0	0	--
	Branch Number	1	7	8	4				
		2	8	5	13				
		3	29	27	20				
		4	2	2	8				
14	Total Colony	19	14	21		25	2	0	--
	Branch Number	54	48	18	Colony composed of 4 branches				
		1	30	28	18				
		2	14	8	9				
		3	30	20	9				
15	Total Colony	40	21	10	Colony composed of 3 branches	25	0	2	20
	Branch Number	1	38	21	9				
		2	10	6	10				
		3	9	7	6				
16	Total Colony	90	47	25	Colony composed of 7 branches	23	0	0	--
	Branch Number	1	1	1	5				
		2	46	33	25				
		3	25	10	15				
		4	12	10	10				
		5	28	20	9				
		6	40	30	21				
		7	25	29	13				

ATTACHMENT 1

Table B-1. (Continued).

Tag Number	Total Colony or Branch Number		Length (cm)	Width (cm)	Height (cm)	Notes	Water Depth (ft)	Tissue Color Score	Partial Mortality by Total Colony	
									Index	Percentage
17	Total Colony		50	24	12	Colony composed of 4 branches	24	0	0	--
	Branch Number	1	15	15	16					
		2	16	16	5					
		3	13	10	7					
		4	2	1	2					
18	Total Colony		45	22	16	Colony composed of 2 branches	24	0	2	5
	Branch Number	1	25	22	16	Old mortality on tip of branch				
		2	18	12	45					
19	Total Colony		39	25	11		25	0	0	--
	Branch Number	1	39	14	11					
		2	17	35	50					
20	Total Colony		33	30	13	Old mortality on tip of branch	25	0	2	5
21	Total Colony		38	17	13		24	0	0	--
22	Total Colony		9	4	12	Two tips with old mortality and sponge growth	24	0	2	5
23	Total Colony		36	32	13	Two bleached tips and recent partial mortality at base due to detachment; found in sand.	25	2	1	5
24	Total Colony		34	26	10		25	0	0	--
25	Total Colony		49	29	11		24	0	0	--
26	Total Colony		35	15	17		24	0	0	--
27	Total Colony		26	24	13	Sponge on 1 tip (5.5 cm)	25	0	0	--
28	Total Colony		57	32	17		24	0	0	--
29	Total Colony		61	31	12	Colony composed of 3 branches	24	0	0	--
	Branch Number	1	34	25	12					
		2	19	13	10					
		3	8	6	15					
30	Total Colony		82	71	17	Composed of 9 tightly clustered branches	24	0	0	--

ATTACHMENT 1

Table B-1. (Continued).

Tag Number	Total Colony or Branch Number		Length (cm)	Width (cm)	Height (cm)	Notes	Water Depth (ft)	Tissue Color Score	Partial Mortality by Total Colony	
									Index	Percentage
31	Total Colony		33	25	12	Colony composed of 5 branches	25	0	0	--
	Branch Number	1	21	16	12					
		2	10	5	9	Sponge on distal tip				
		3	3	2	1	Single branch				
		4	1	1	1	Data measurements incomplete; estimated from photo				
		5	1	1	1		25	0	0	--
32	Total Colony		26	19	14		25	0	0	--
33	Total Colony		32	29	13	Colony composed of 2 branches				
	Branch Number	1	25	17	13					
		2	11	7	8					
34	Total Colony		40	38	15	Colony composed of 7 tightly clustered branches	25	0	0	--
35	Total Colony		26	24	15	Colony composed of 2 branches	24	0	2	<5
	Branch Number	1	8	8	12	Old mortality on tip of branch				
		2	26	20	15					
36	Total Colony		23	14	11		26	0	0	--
37	Total Colony		42	27	17	Colony composed of 4 branches	25	0	0	--
	Branch Number	1	18	14	15					
		2	13	17	15					
		3	17	17	17					
		4	13	7	9					
38	Total Colony		45	33	18	Colony composed of 5 branches	24	0	0	--
	Branch Number	1	23	4	10					
		2	26	14	11					
		3	16	13	17					
		4	22	15	14					
		5	6	4	8					

ATTACHMENT 1

Table B-1. (Continued).

Tag Number	Total Colony or Branch Number	Length (cm)	Width (cm)	Height (cm)	Notes	Water Depth (ft)	Tissue Color Score	Partial Mortality by Total Colony	
								Index	Percentage
Reference Colonies									
196	Total Colony	44	22	17	Growing on wire cable	25	0	0	--
197	Total Colony	21	19	16	Growing tangled with a sponge, next to <i>Colpophyllia natans</i> ; 6 inches north of wire cable	25	0	0	--
198	Total Colony	17	15	10	Growing on wire cable, 4 tips with old mortality	25	0	2	10
199	Total Colony	21	15	17	Old mortality at base of colony, growing 2 ft north of wire cable.	25	0	2	15

Appendix C

Representative Photographs of Reattached and
Reference *Acropora cervicornis* Colonies

ATTACHMENT 1



Photo C-1a. *Acropora cervicornis* colony #1 pre-fragmentation.



Photo C-1b. *Acropora cervicornis* colony #1 post-fragmentation.



Photo C-1c. *Acropora cervicornis* colony #1 immediately post-reattachment.



Photo C-1d. *Acropora cervicornis* colony #1 30 days post-reattachment.

ATTACHMENT 1



Photo C-2a. *Acropora cervicornis* colony #2 pre-fragmentation.

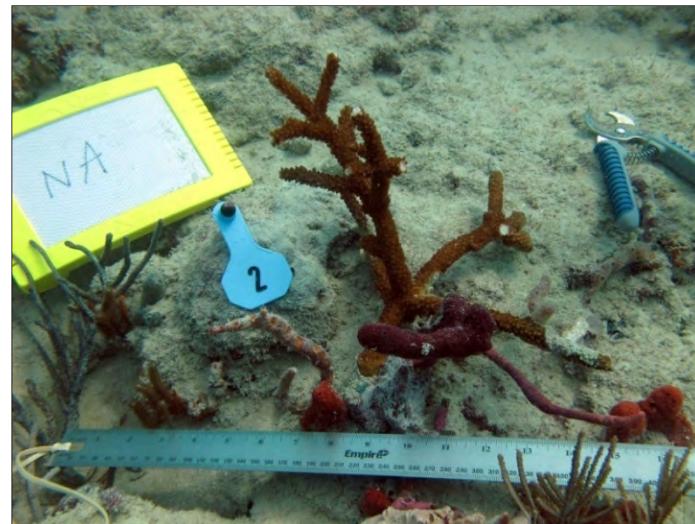


Photo C-2b. *Acropora cervicornis* colony #2 post-fragmentation.



Photo C-2c. *Acropora cervicornis* colony #2 immediately post-reattachment.



Photo C-2d. *Acropora cervicornis* colony #2 30 days post-reattachment. Epoxy was used to reattach a detached fragment during the monitoring survey.

ATTACHMENT 1



Photo C-3a. *Acropora cervicornis* colony #3 pre-fragmentation.

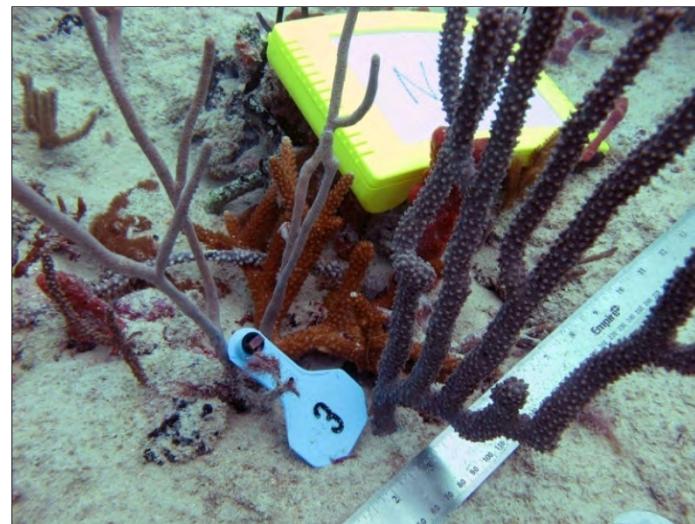


Photo C-3b. *Acropora cervicornis* colony #3 post-fragmentation.



Photo C-3c. *Acropora cervicornis* colony #3 immediately post-reattachment.



Photo C-3d. *Acropora cervicornis* colony #3 30 days post-reattachment.

ATTACHMENT 1

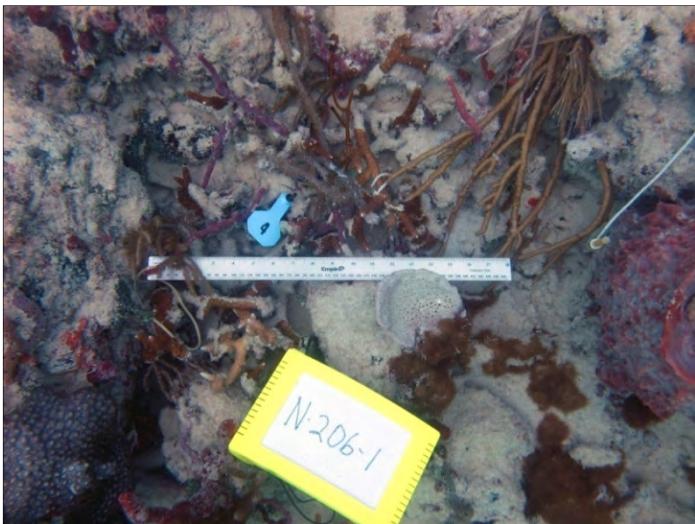


Photo C-4a. *Acropora cervicornis* colony #4 pre-fragmentation.



Photo C-4b. *Acropora cervicornis* colony #4 post-fragmentation.



Photo C-4c. *Acropora cervicornis* colony #4 immediately post-reattachment.



Photo C-4d. *Acropora cervicornis* colony #4 30 days post-reattachment.

ATTACHMENT 1



Photo C-5a. *Acropora cervicornis* colony #5 pre-fragmentation.



Photo C-5b. *Acropora cervicornis* colony #5 post-fragmentation.



Photo C-5c. *Acropora cervicornis* colony #5 immediately post-reattachment.



Photo C-5d. *Acropora cervicornis* colony #5 30 days post-reattachment. Breakage and loss of coral fragments occurred since reattachment.

ATTACHMENT 1



Photo C-6a. *Acropora cervicornis* colony #6 pre-fragmentation.



Photo C-6b. *Acropora cervicornis* colony #6 post-fragmentation.

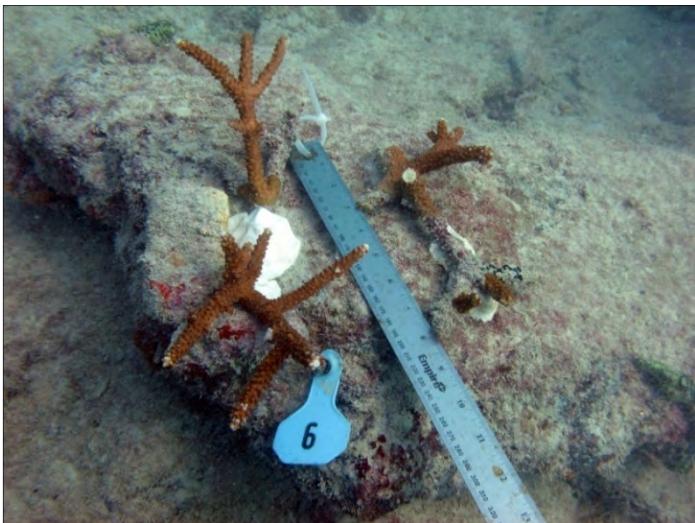


Photo C-6c. *Acropora cervicornis* colony #6 immediately post-reattachment.

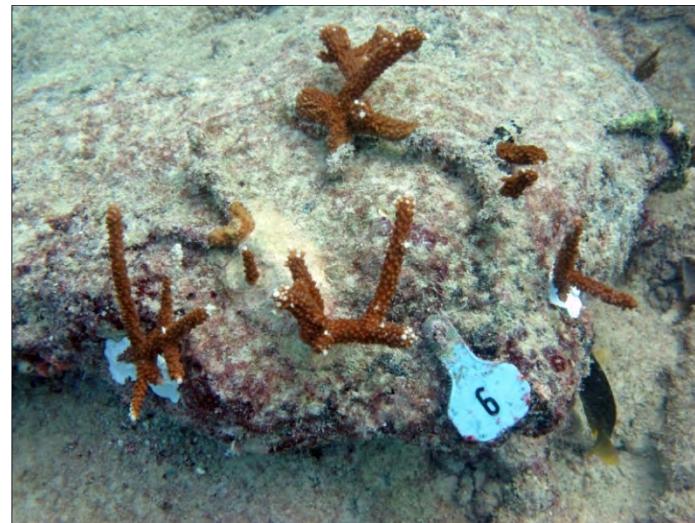


Photo C-6d. *Acropora cervicornis* colony #6 30 days post-reattachment. Epoxy was used to reattach detached fragments during the monitoring survey.

ATTACHMENT 1

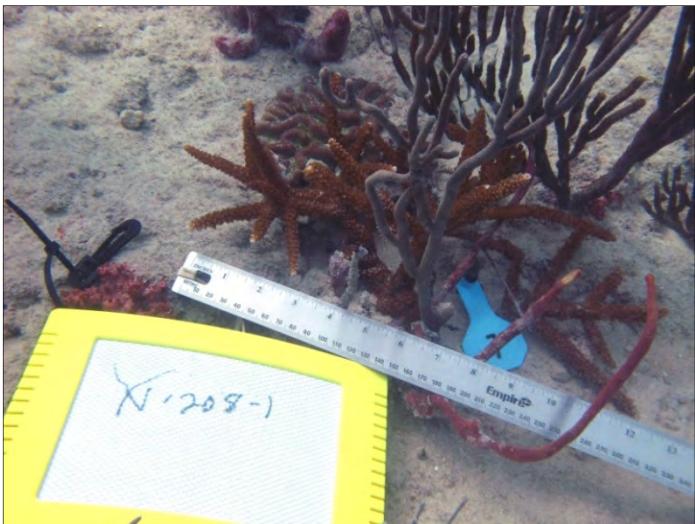


Photo C-7a. *Acropora cervicornis* colony #7 pre-fragmentation.



Photo C-7b. *Acropora cervicornis* colony #7 post-fragmentation.



Photo C-7c. *Acropora cervicornis* colony #7 immediately post-reattachment.



Photo C-7d. *Acropora cervicornis* colony #7 30 days post-reattachment. Epoxy was used to reattach a detached fragment during the monitoring survey.

ATTACHMENT 1



Photo C-8a. *Acropora cervicornis* colony #8 pre-fragmentation.



Photo C-8b. *Acropora cervicornis* colony #8 post-fragmentation.

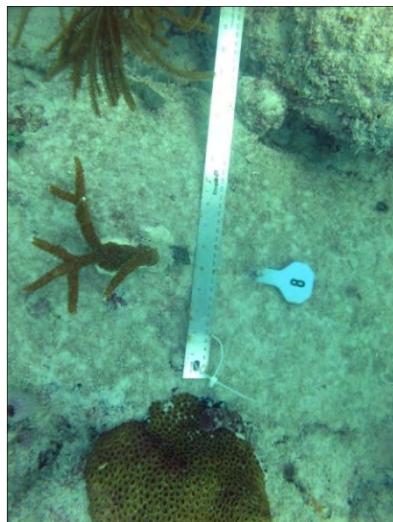


Photo C-8c. *Acropora cervicornis* colony #8 immediately post-reattachment.



Photo C-8d. *Acropora cervicornis* colony #8 30 days post-reattachment. Epoxy was used to reattach detached fragments during the monitoring survey.

ATTACHMENT 1

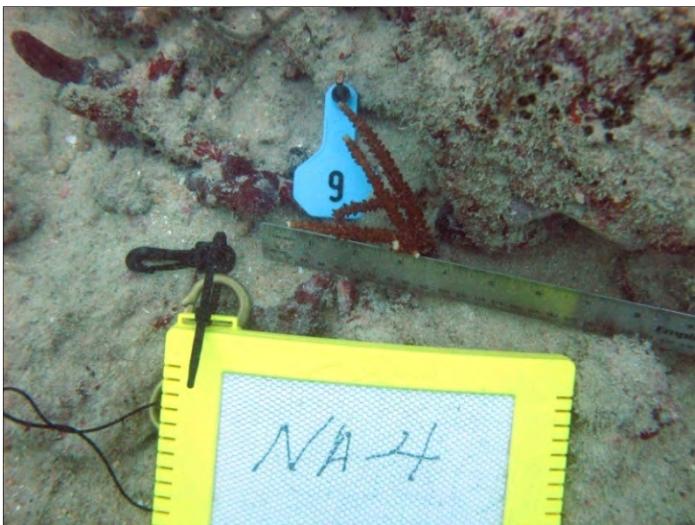


Photo C-9a. *Acropora cervicornis* colony #9 pre-fragmentation.

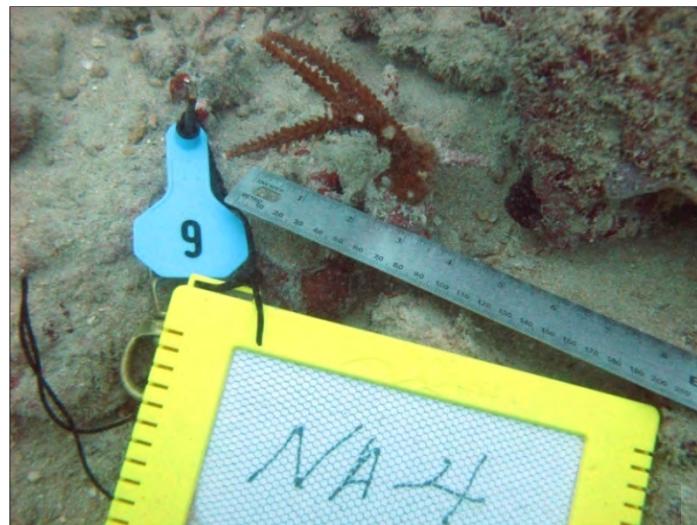


Photo C-9b. *Acropora cervicornis* colony #9 post-fragmentation.

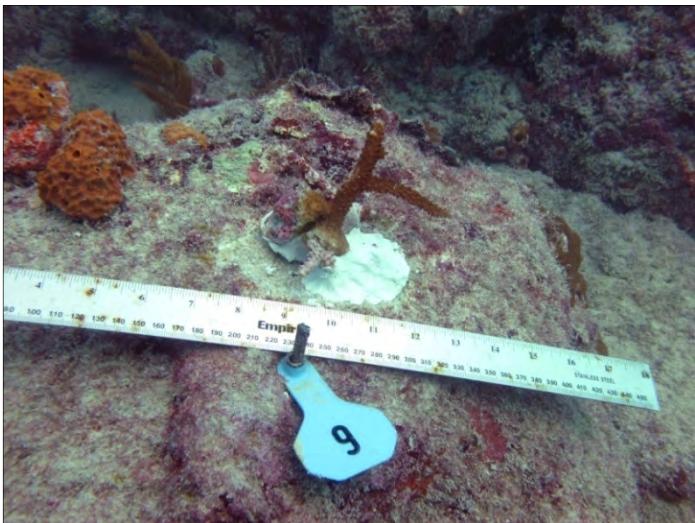


Photo C-9c. *Acropora cervicornis* colony #9 immediately post-reattachment.



Photo C-9d. *Acropora cervicornis* colony #9 30 days post-reattachment. Epoxy was used to reattach a detached fragment during the monitoring survey.

ATTACHMENT 1

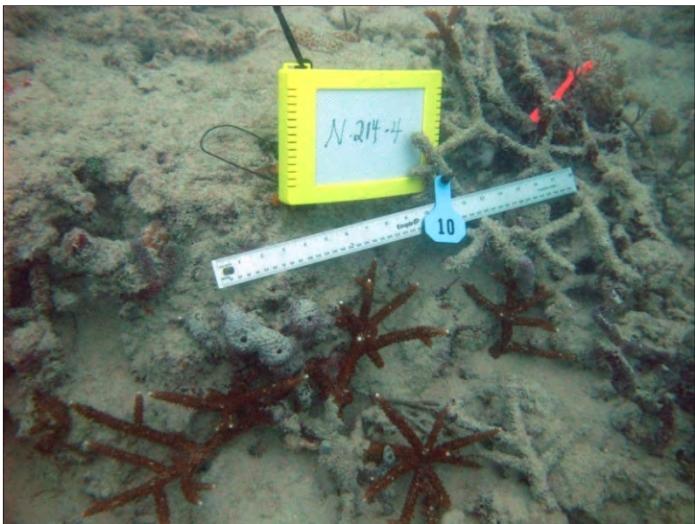


Photo C-10a. *Acropora cervicornis* colony #10 pre-fragmentation.

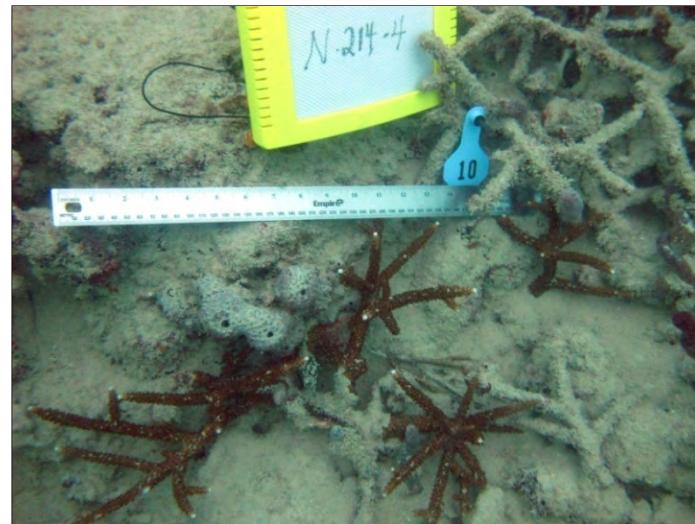


Photo C-10b. *Acropora cervicornis* colony #10 post-fragmentation.



Photo C-10c. *Acropora cervicornis* colony #10 immediately post-reattachment.



Photo C-10d. *Acropora cervicornis* colony #10 30 days post-reattachment.

ATTACHMENT 1

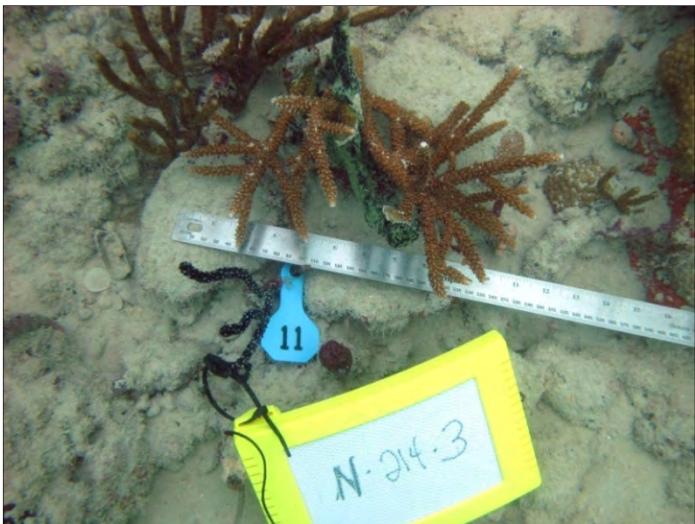


Photo C-11a. *Acropora cervicornis* colony #11 pre-fragmentation.

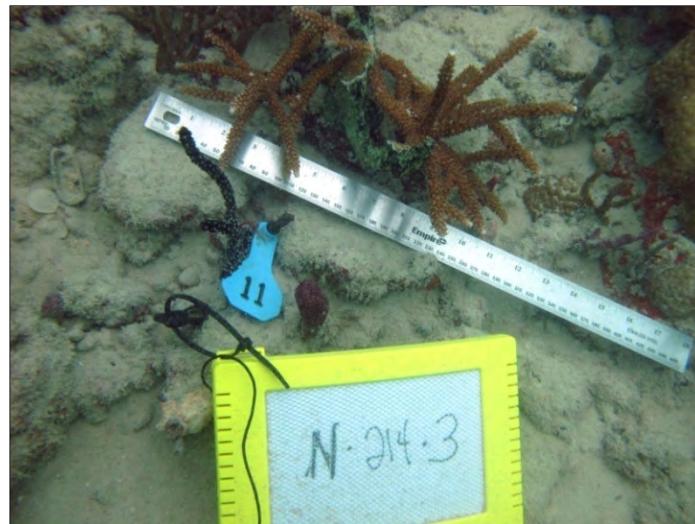


Photo C-11b. *Acropora cervicornis* colony #11 post-fragmentation.



Photo C-11c. *Acropora cervicornis* colony #11 immediately post-reattachment.



Photo C-11d. *Acropora cervicornis* colony #11 30 days post-reattachment. Breakage and loss of coral fragments occurred since reattachment.

ATTACHMENT 1



Photo C-12a. *Acropora cervicornis* colony #12 pre-fragmentation.

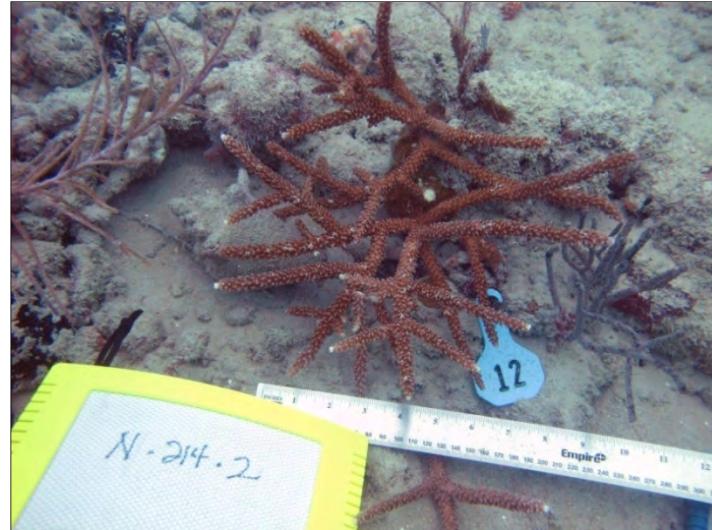


Photo C-12b. *Acropora cervicornis* colony #12 post-fragmentation.



Photo C-12c. *Acropora cervicornis* colony #12 immediately post-reattachment.



Photo C-12d. *Acropora cervicornis* colony #12 30 days post-reattachment.

ATTACHMENT 1

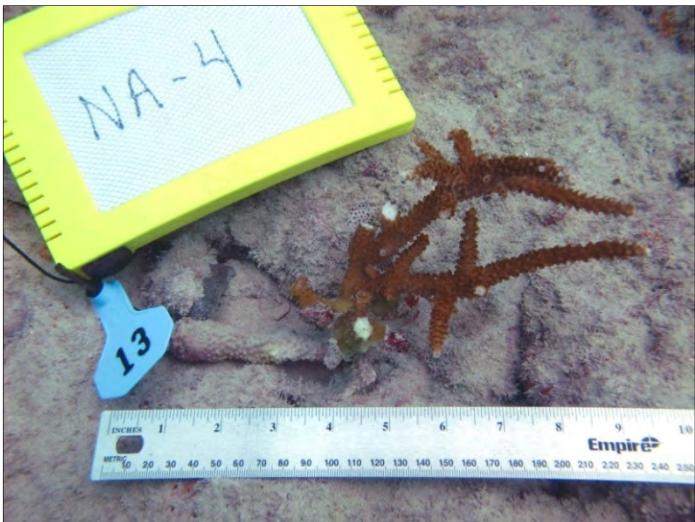


Photo C-13a. *Acropora cervicornis* colony #13 pre-fragmentation.

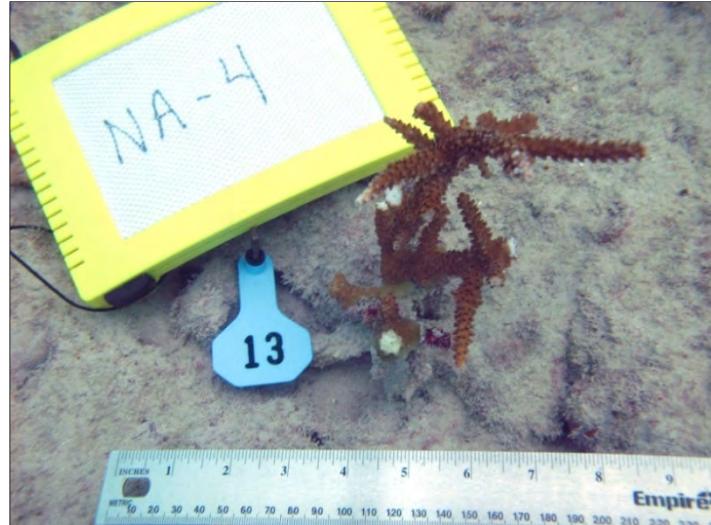


Photo C-13b. *Acropora cervicornis* colony #13 post-fragmentation.



Photo C-13c. *Acropora cervicornis* colony #13 immediately post-reattachment.



Photo C-13d. *Acropora cervicornis* colony #13 30 days post-reattachment.

ATTACHMENT 1



Photo C-14a. *Acropora cervicornis* colony #14 pre-fragmentation.



Photo C-14b. *Acropora cervicornis* colony #14 post-fragmentation.



Photo C-14c. *Acropora cervicornis* colony #14 immediately post-reattachment.



Photo C-14d. *Acropora cervicornis* colony #14 30 days post-reattachment. Epoxy was used to reattach detached fragments during the monitoring survey.

ATTACHMENT 1

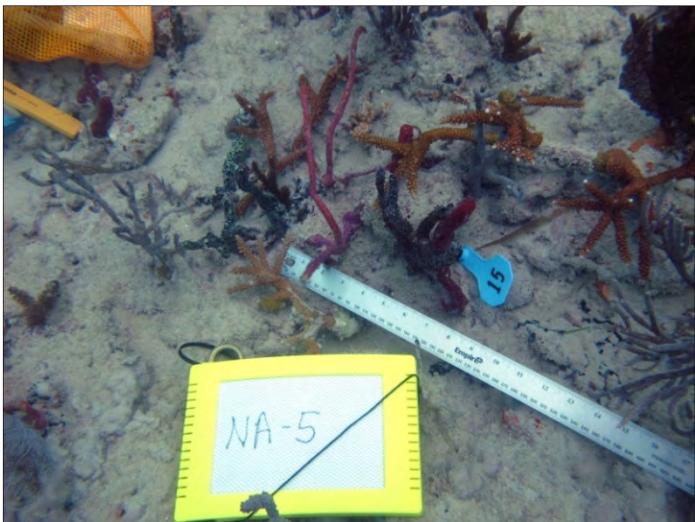


Photo C-15a. *Acropora cervicornis* colony #15 pre-fragmentation.

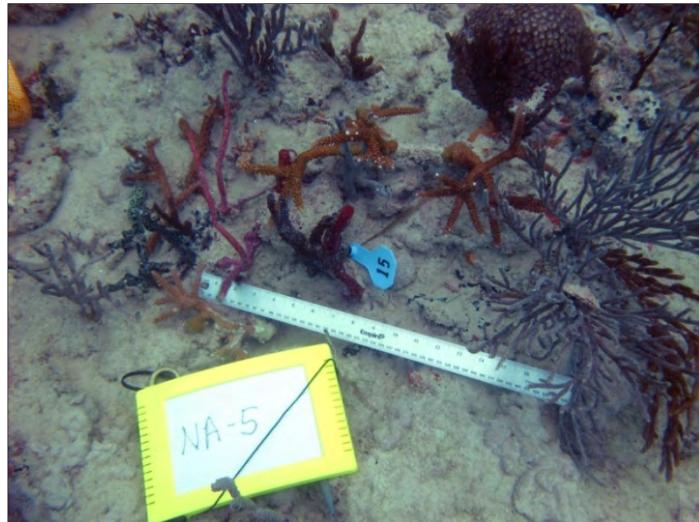


Photo C-15b. *Acropora cervicornis* colony #15 post-fragmentation.

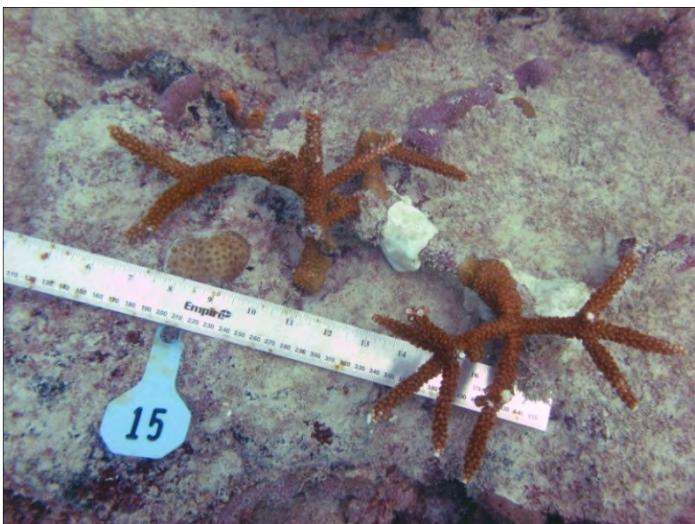


Photo C-15c. *Acropora cervicornis* colony #15 immediately post-reattachment.

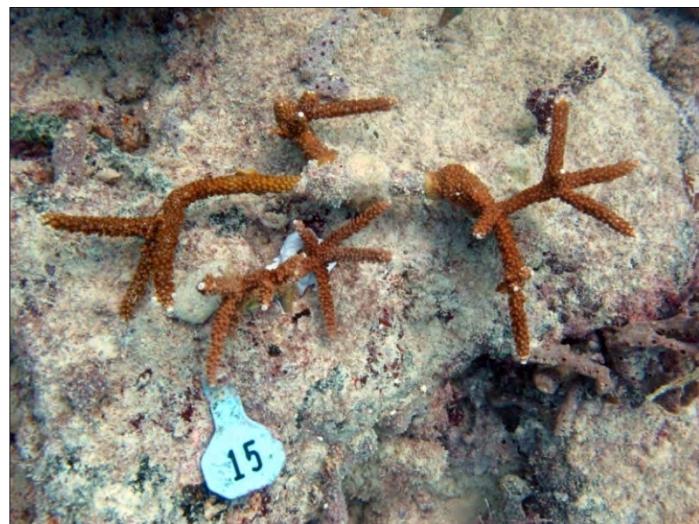


Photo C-15d. *Acropora cervicornis* colony #15 30 days post-reattachment. Epoxy was used to reattach a detached fragment during the monitoring survey.

ATTACHMENT 1



Photo C-16a. *Acropora cervicornis* colony #16 pre-fragmentation.



Photo C-16b. *Acropora cervicornis* colony #16 post-fragmentation.



Photo C-16c. *Acropora cervicornis* colony #16 immediately post-reattachment.



Photo C-16d. *Acropora cervicornis* colony #16 30 days post-reattachment. Epoxy was used to reattach detached fragments during monitoring survey.

ATTACHMENT 1



Photo C-17a. *Acropora cervicornis* colony #17 pre-fragmentation.

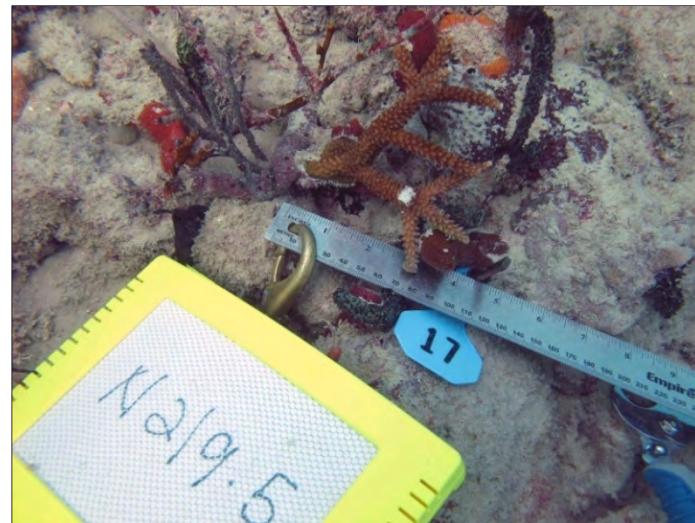


Photo C-17b. *Acropora cervicornis* colony #17 post-fragmentation.

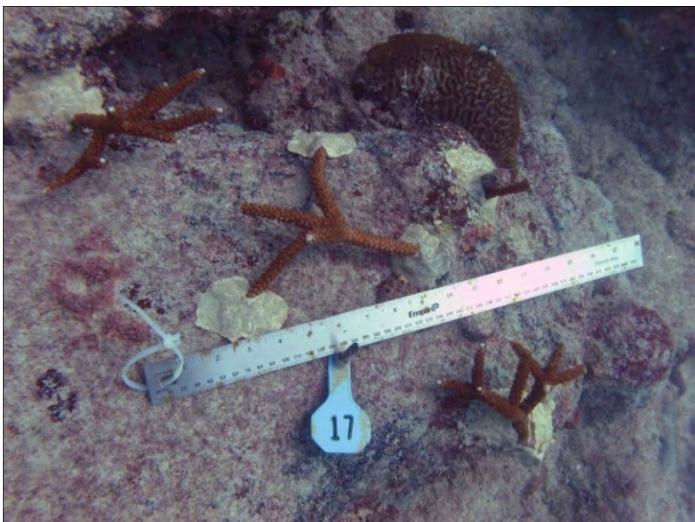


Photo C-17c. *Acropora cervicornis* colony #17 immediately post-reattachment.



Photo C-17d. *Acropora cervicornis* colony #17 30 days post-reattachment.

ATTACHMENT 1



Photo C-18a. *Acropora cervicornis* colony #18 pre-fragmentation.

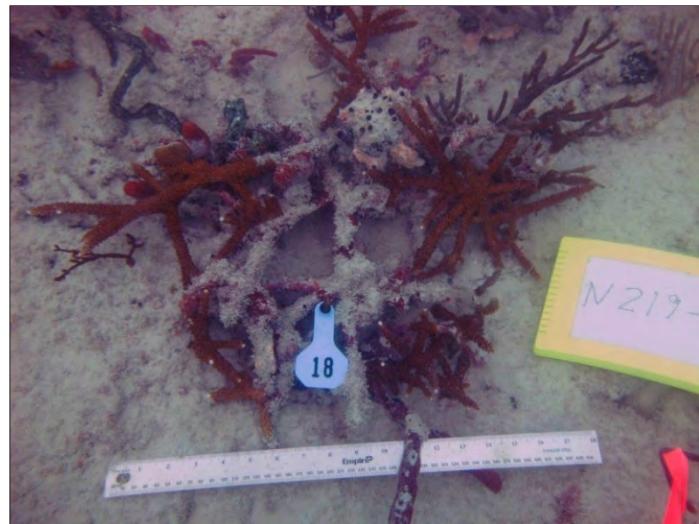


Photo C-18b. *Acropora cervicornis* colony #18 post-fragmentation.



Photo C-18c. *Acropora cervicornis* colony #18 immediately post-reattachment.



Photo C-18d. *Acropora cervicornis* colony #18 30 days post-reattachment.

ATTACHMENT 1

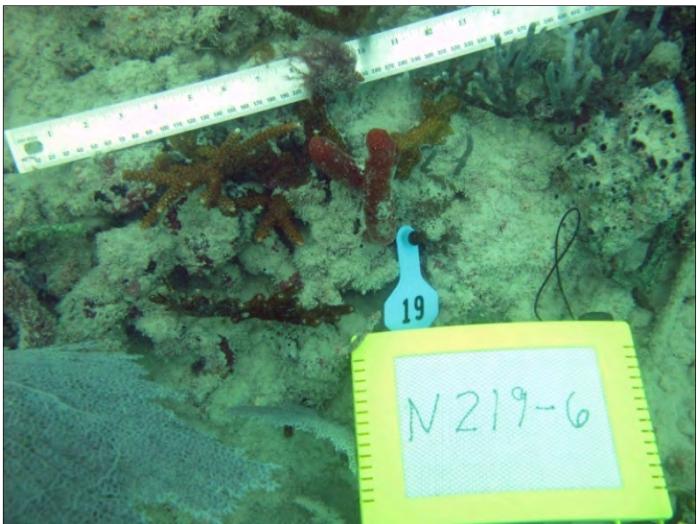


Photo C-19a. *Acropora cervicornis* colony #19 pre-fragmentation.

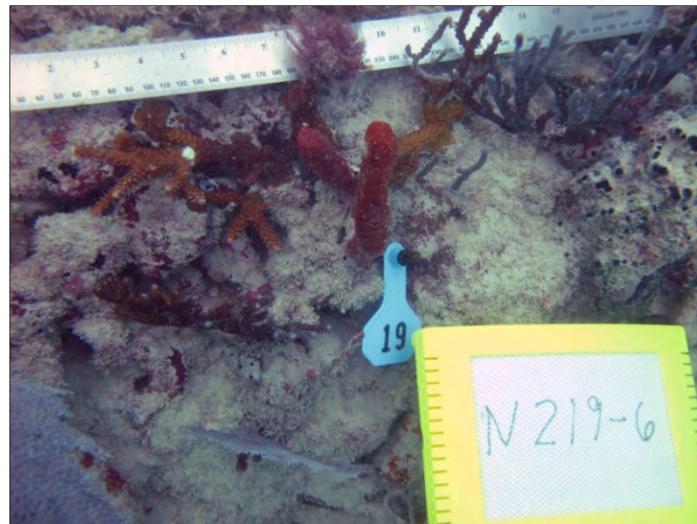


Photo C-19b. *Acropora cervicornis* colony #19 post-fragmentation.



Photo C-19c. *Acropora cervicornis* colony #19 immediately post-reattachment.



Photo C-19d. *Acropora cervicornis* colony #19 30 days post-reattachment.

ATTACHMENT 1



Photo C-20a. *Acropora cervicornis* colony #20 pre-fragmentation.

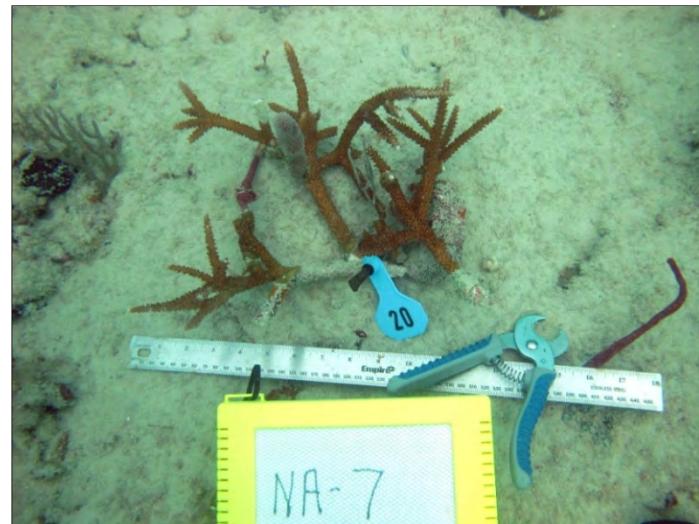


Photo C-20b. *Acropora cervicornis* colony #20 post-fragmentation.



Photo C-20c. *Acropora cervicornis* colony #20 immediately post-reattachment.



Photo C-20d. *Acropora cervicornis* colony #20 30 days post-reattachment.

ATTACHMENT 1



Photo C-21a. *Acropora cervicornis* colony #21 pre-fragmentation.

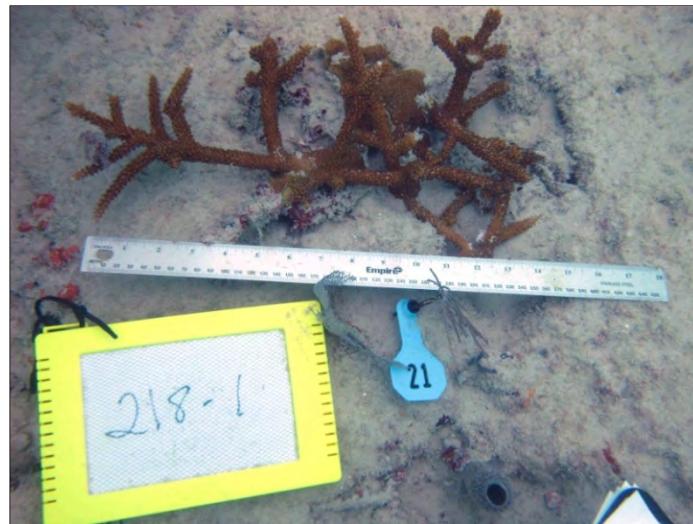


Photo C-21b. *Acropora cervicornis* colony #21 post-fragmentation.



Photo C-21c. *Acropora cervicornis* colony #21 immediately post-reattachment.



Photo C-21d. *Acropora cervicornis* colony #21 30 days post-reattachment.

ATTACHMENT 1

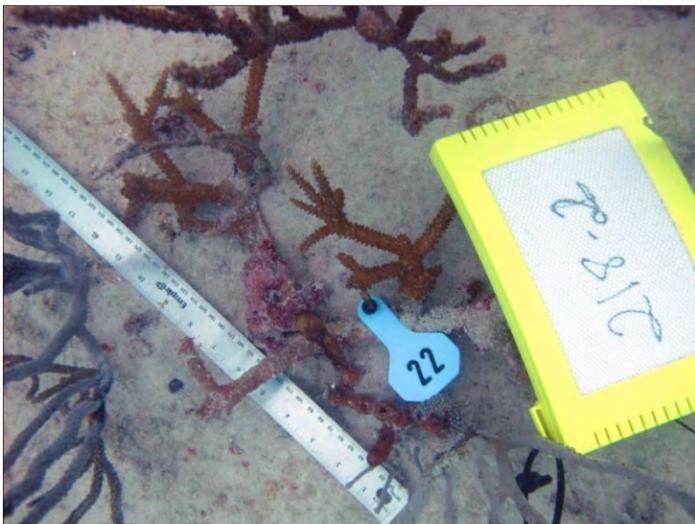


Photo C-22a. *Acropora cervicornis* colony #22 pre-fragmentation.

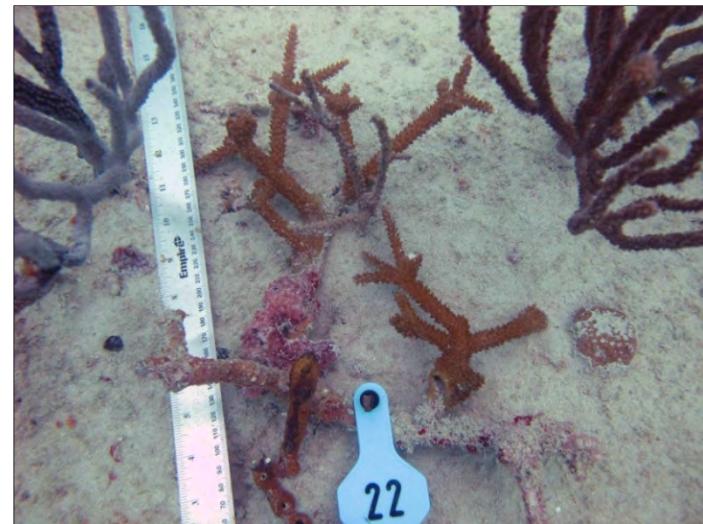


Photo C-22b. *Acropora cervicornis* colony #22 post-fragmentation.

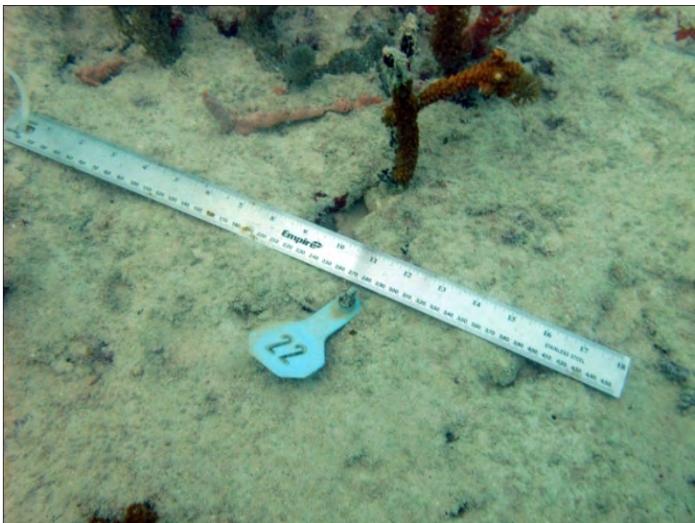


Photo C-22c. *Acropora cervicornis* colony #22 immediately post-reattachment. Several fragments from colony #22 were incidentally reattached to colony #23.



Photo C-22d. *Acropora cervicornis* colony #22 30 days post-reattachment. Several fragments from colony #22 were incidentally reattached to colony #23.

ATTACHMENT 1



Photo C-23a. *Acropora cervicornis* colony #23 pre-fragmentation.



Photo C-23b. *Acropora cervicornis* colony #23 post-fragmentation.



Photo C-23c. *Acropora cervicornis* colony #23 immediately post-reattachment. Several fragments from colony #22 were incidentally reattached to colony #23.



Photo C-23d. *Acropora cervicornis* colony #23 30 days post-reattachment. Several fragments from colony #22 were incidentally reattached to colony #23.

ATTACHMENT 1

Photo not available

Photo C-24a. *Acropora cervicornis* colony #24 pre-fragmentation.



Photo C-24c. *Acropora cervicornis* colony #24 immediately post-reattachment.

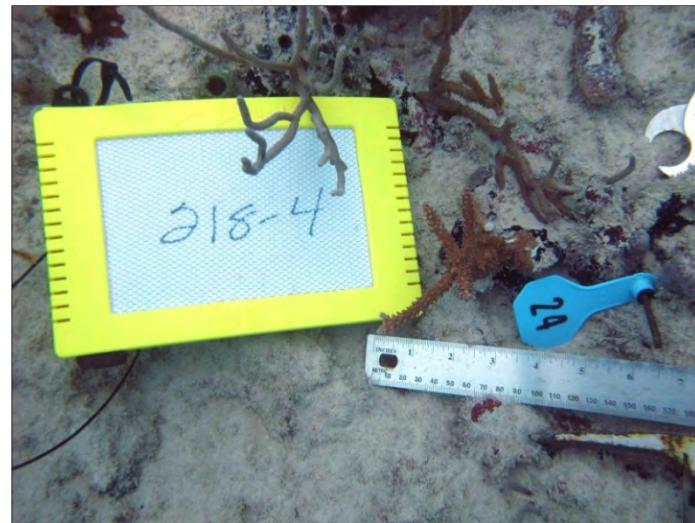


Photo C-24b. *Acropora cervicornis* colony #24 post-fragmentation.



Photo C-24d. *Acropora cervicornis* colony #24 30 days post-reattachment.

ATTACHMENT 1

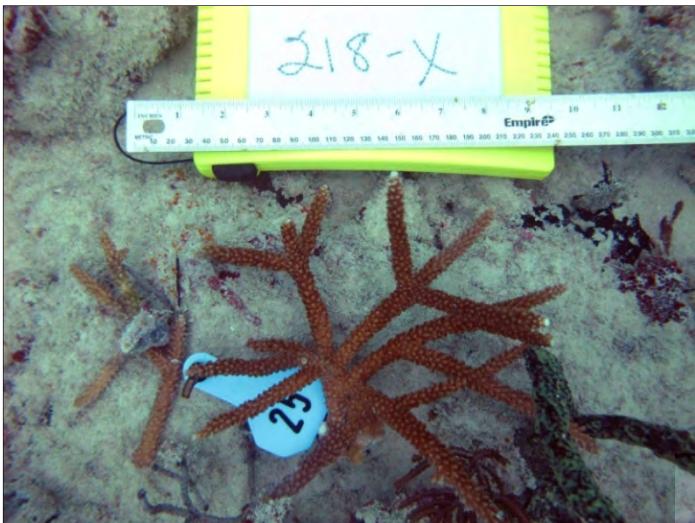


Photo C-25a. *Acropora cervicornis* colony #25 pre-fragmentation.

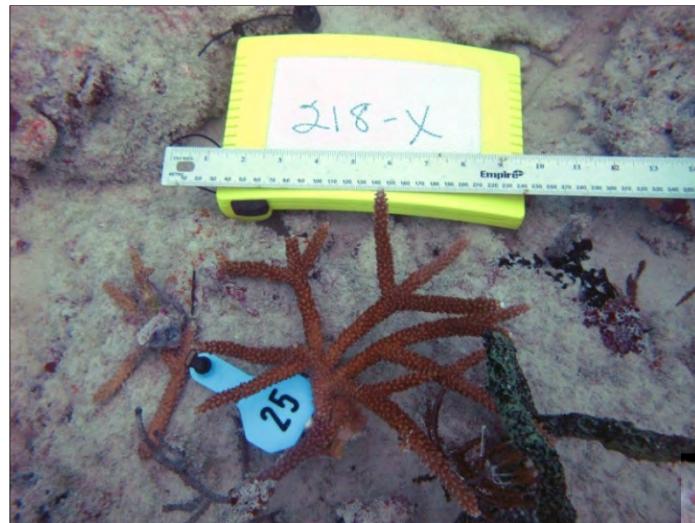


Photo C-25b. *Acropora cervicornis* colony #25 post-fragmentation.



Photo C-25c. *Acropora cervicornis* colony #25 immediately post-reattachment.



Photo C-25d. *Acropora cervicornis* colony #25 30 days post-reattachment.

ATTACHMENT 1

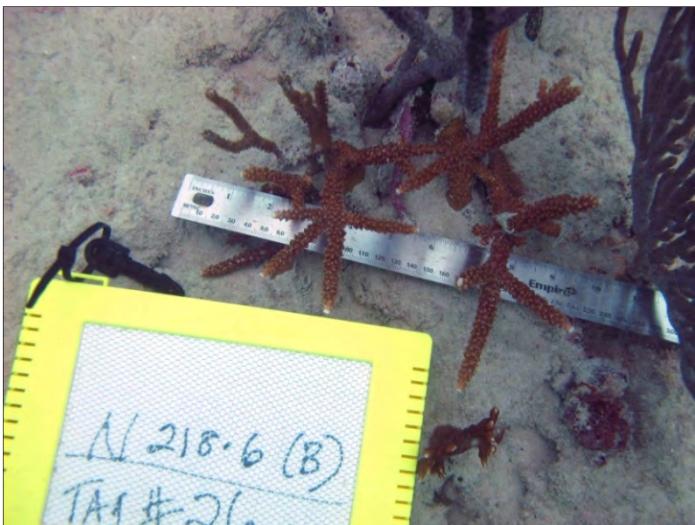


Photo C-26a. *Acropora cervicornis* colony #26 pre-fragmentation.

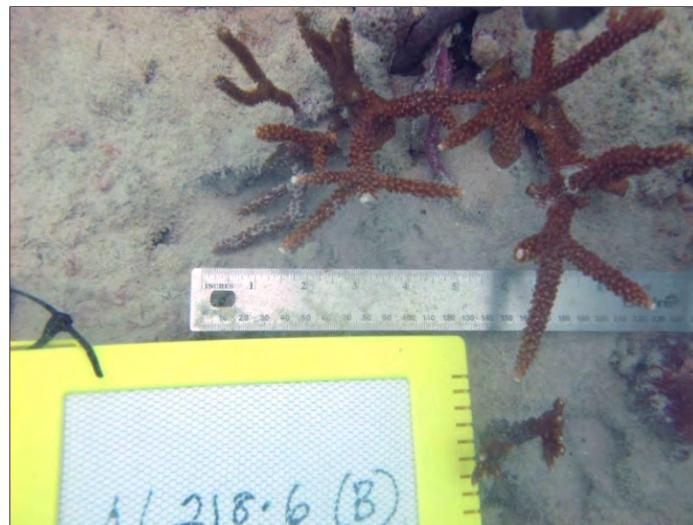


Photo C-26b. *Acropora cervicornis* colony #26 post-fragmentation.



Photo C-26c. *Acropora cervicornis* colony #26 immediately post-reattachment.

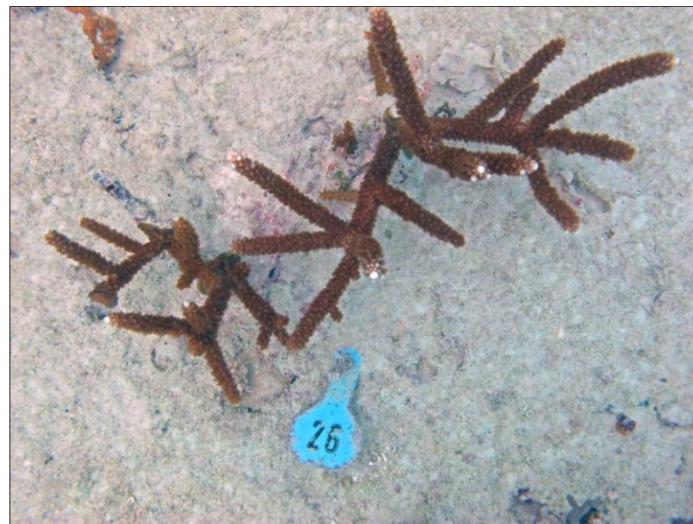


Photo C-26d. *Acropora cervicornis* colony #26 30 days post-reattachment. Breakage and loss of coral fragments occurred since reattachment.

ATTACHMENT 1

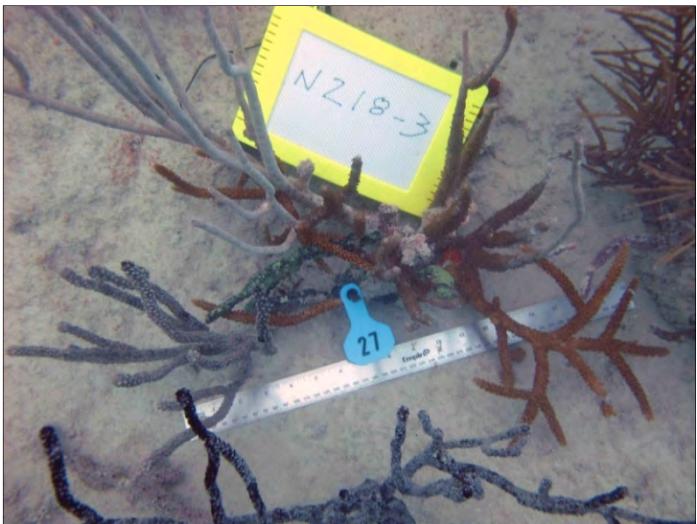


Photo C-27a. *Acropora cervicornis* colony #27 pre-fragmentation.

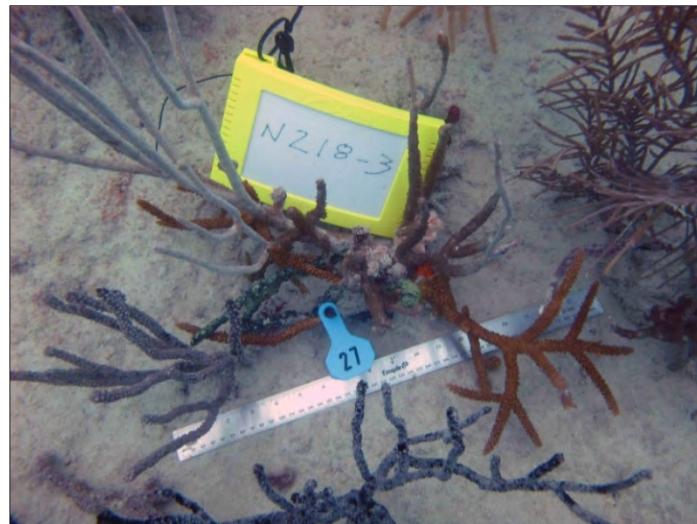


Photo C-27b. *Acropora cervicornis* colony #27 post-fragmentation.



Photo C-27c. *Acropora cervicornis* colony #27 immediately post-reattachment.



Photo C-27d. *Acropora cervicornis* colony #27 30 days post-reattachment. Epoxy was used to reattach detached fragments during monitoring survey. Loss of coral fragments since reattachment also occurred.

ATTACHMENT 1



Photo C-28a. *Acropora cervicornis* colony #28 pre-fragmentation.



Photo C-28b. *Acropora cervicornis* colony #28 post-fragmentation.



Photo C-28c. *Acropora cervicornis* colony #28 immediately post-reattachment.



Photo C-28d. *Acropora cervicornis* colony #28 30 days post-reattachment.

ATTACHMENT 1



Photo C-29a. *Acropora cervicornis* colony #29 pre-fragmentation.



Photo C-29b. *Acropora cervicornis* colony #29 post-fragmentation.



Photo C-29c. *Acropora cervicornis* colony #29 immediately post-reattachment.



Photo C-29d. *Acropora cervicornis* colony #29 30 days post-reattachment.

ATTACHMENT 1



Photo C-30a. *Acropora cervicornis* colony #30 pre-fragmentation.



Photo C-30b. *Acropora cervicornis* colony #30 post-fragmentation.



Photo C-30c. *Acropora cervicornis* colony #30 immediately post-reattachment.



Photo C-30d. *Acropora cervicornis* colony #30 30 days post-reattachment.

ATTACHMENT 1



Photo C-31a. *Acropora cervicornis* colony #31 pre-fragmentation.



Photo C-31b. *Acropora cervicornis* colony #31 post-fragmentation.

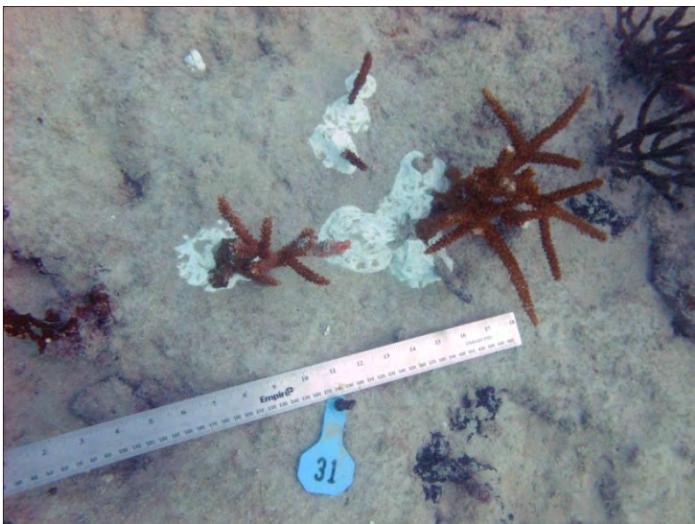


Photo C-31c. *Acropora cervicornis* colony #31 immediately post-reattachment.



Photo C-31d. *Acropora cervicornis* colony #31 30 days post-reattachment.

ATTACHMENT 1



Photo C-32a. *Acropora cervicornis* colony #32 pre-fragmentation.

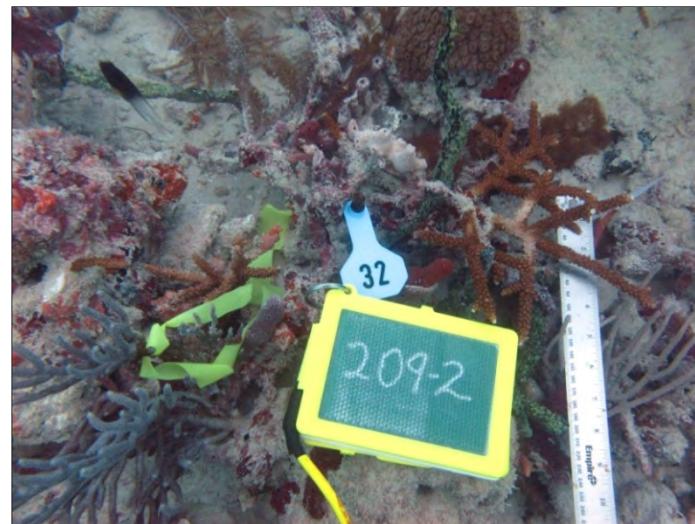


Photo C-32b. *Acropora cervicornis* colony #32 post-fragmentation.

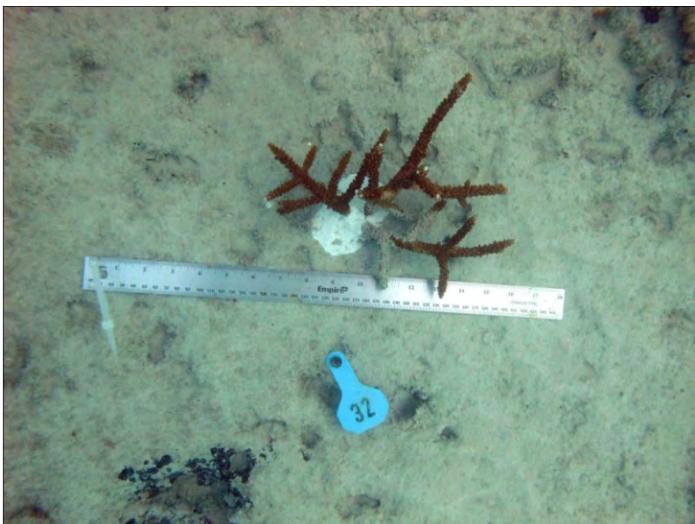


Photo C-32c. *Acropora cervicornis* colony #32 immediately post-reattachment.



Photo C-32d. *Acropora cervicornis* colony #32 30 days post-reattachment.

ATTACHMENT 1



Photo C-33a. *Acropora cervicornis* colony #33 pre-fragmentation.



Photo C-33b. *Acropora cervicornis* colony #33 post-fragmentation.



Photo C-33c. *Acropora cervicornis* colony #33 immediately post-reattachment.



Photo C-33d. *Acropora cervicornis* colony #33 30 days post-reattachment.

ATTACHMENT 1

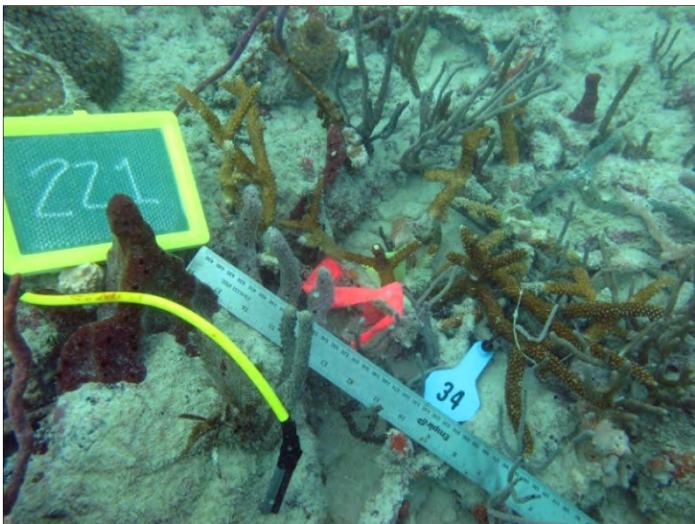


Photo C-34a. *Acropora cervicornis* colony #34 pre-fragmentation.



Photo C-34b. *Acropora cervicornis* colony #34 post-fragmentation.



Photo C-34c. *Acropora cervicornis* colony #34 immediately post-reattachment.



Photo C-34d. *Acropora cervicornis* colony #34 30 days post-reattachment.

ATTACHMENT 1

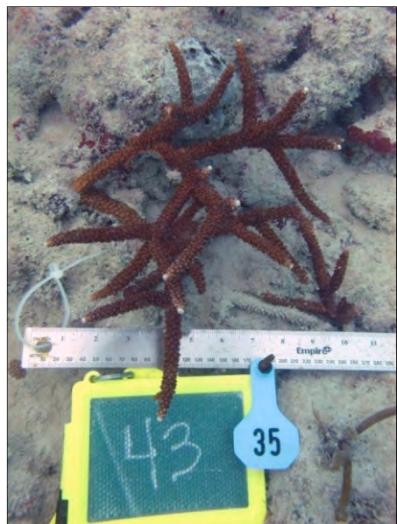


Photo C-35a. *Acropora cervicornis* colony #35 pre-fragmentation.



Photo C-35b. *Acropora cervicornis* colony #35 post-fragmentation.



Photo C-35c. *Acropora cervicornis* colony #35 immediately post-reattachment.



Photo C-35d. *Acropora cervicornis* colony #35 30 days post-reattachment. Epoxy was used to reattach detached fragments during monitoring survey.

ATTACHMENT 1

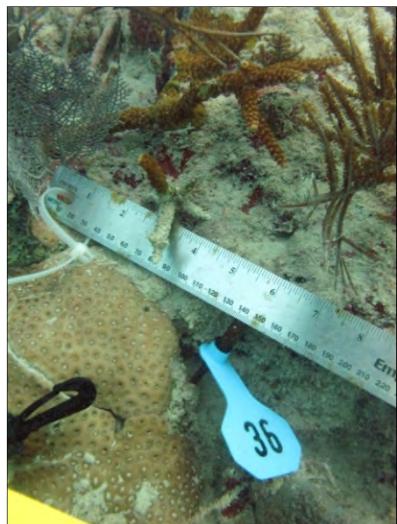


Photo C-36a. *Acropora cervicornis* colony #36 pre-fragmentation.

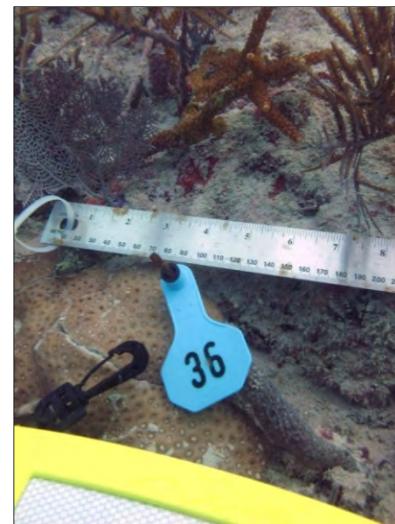


Photo C-36b. *Acropora cervicornis* colony #36 post-fragmentation.



Photo C-36c. *Acropora cervicornis* colony #36 immediately post-reattachment.



Photo C-36d. *Acropora cervicornis* colony #36 30 days post-reattachment.

ATTACHMENT 1

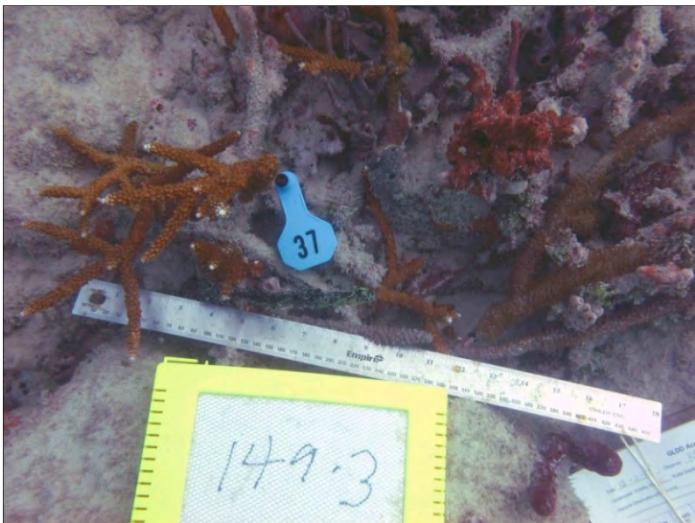


Photo C-37a. *Acropora cervicornis* colony #37 pre-fragmentation.

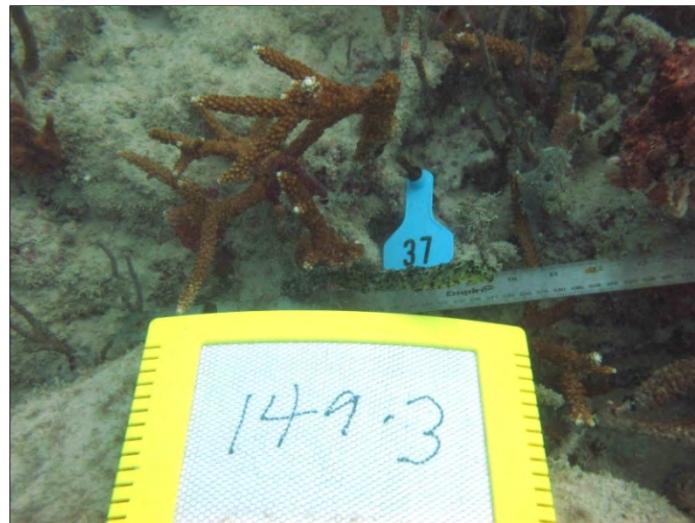


Photo C-37b. *Acropora cervicornis* colony #37 post-fragmentation.



Photo C-37c. *Acropora cervicornis* colony #37 immediately post-reattachment.



Photo C-37d. *Acropora cervicornis* colony #37 30 days post-reattachment. Epoxy was used to reattach detached fragments during monitoring survey.

ATTACHMENT 1



Photo C-38a. *Acropora cervicornis* colony #38 pre-fragmentation.

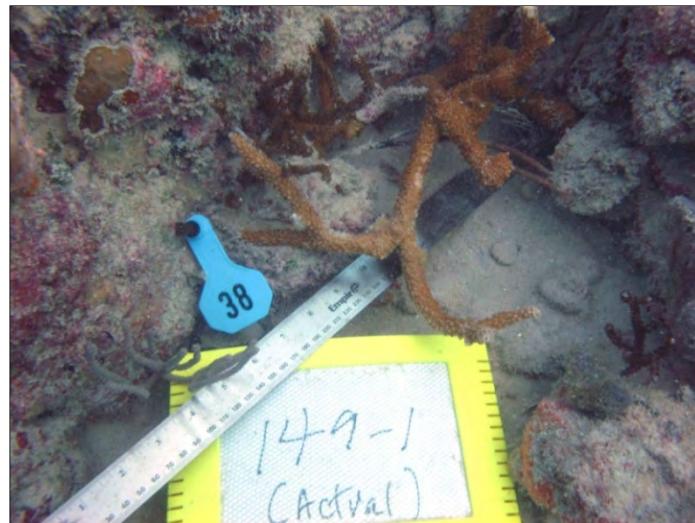


Photo C-38b. *Acropora cervicornis* colony #38 post-fragmentation.

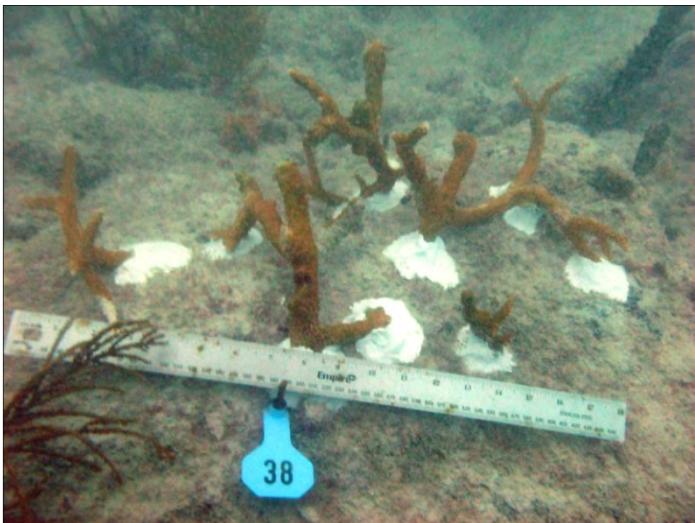


Photo C-38c. *Acropora cervicornis* colony #38 immediately post-reattachment.



Photo C-38d. *Acropora cervicornis* colony #38 30 days post-reattachment.

ATTACHMENT 1



Photo C-39a. Reference *Acropora cervicornis* colony #196.

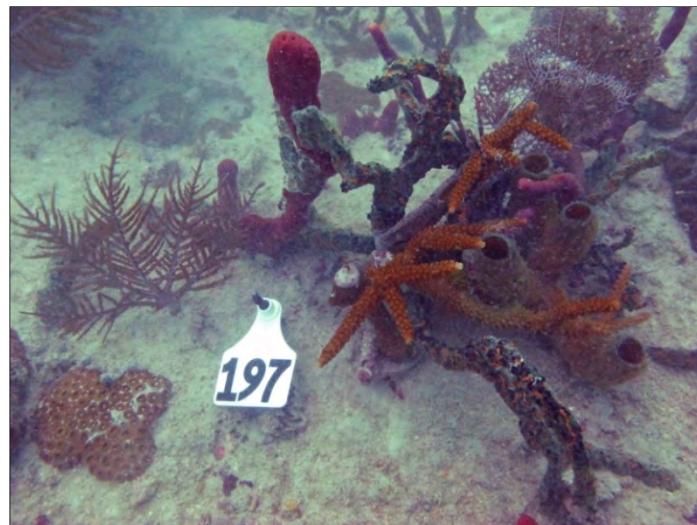


Photo C-39b. Reference *Acropora cervicornis* colony #197.



Photo C-39c. Reference *Acropora cervicornis* colony #198.



Photo C-39d. Reference *Acropora cervicornis* colony #199.