Quicklook Report
Coral Spawning 2020: Activities and Observations

Southeast Fisheries Science Center
Protected Resources and Biodiversity Division Report:
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Summary: A modified spawning effort

This year's Florida spawning effort was modified from our usual team effort in Key Largo to a collaborative effort with the University of Miami (UM-RSMAS) and SECORE split between two operations: Miami-based and Key Largo-based. For field operations in Miami, two SEFSC-CoRAL team members captained two UM vessels and led the gamete handling and larval propagation tasks. Observations and collections in Key Largo were led by SEFSC-CoRAL team members using a recreational dive charter vessel. All gamete and larval lab-work was performed at the University of Miami (UM-RSMAS) instead of our typical temporary lab space in Key Largo because of logistical constraints due to COVID-19 risk mitigation strategies. Overall, the 2020 spawning season proved successful with a large effort devoted to monitoring eight sites between the two regions, Miami, and Key Largo. This is the first year our team has participated in spawning observations in Miami and, to our knowledge, very little is known about the spawning history at the sites monitored (Rainbow Reef, Emerald Reef, Lirman's UM coral nursery, Bill Baggs State Park, and McArthur Causeway). In Key Largo, we were able to continue the ongoing spawning record at three sites, Horseshoe and Elbow Reefs where we have spawning observations dating back to 2000 and 2005, respectively, and North Dry Rocks Reef where we started observations last year.

We monitored seven coral species for spawning among the two regions: the three ESA-threated coral species Acropora palmata, A. cervicornis and *Orbicella faveolata,* as well as *Pseudodiploria strigosa, P. clivosa, Montastrea cavernosa,* and *Colpophyllia natans*. Key Largo observations were conducted only in August while observations in Miami were conducted in August and September. For *Acropora palmata*, we observed both wild and outplanted colonies at three sites off Key Largo: North Dry Rocks, Horseshoe and Elbow Reefs, and, for A. cervicornis, outplanted colonies were observed at North Dry Rocks and Horseshoe Reefs (Table 1). Approximately 20 *Orbicella faveolata* colonies, 1 *Pseudodiploria strigosa* and 8 colonies of *Montastrea cavernosa* were monitored at Horseshoe Reef, all assumed to be unique genotypes (Table 1). In Miami, nursery reared *A. cervicornis* was monitored at a UM coral nursery and two outplant plots at Rainbow Reef. Among both locations, approximately 15 unique genotypes were monitored (Table 1, 2). Six *O. faveolata* colonies were monitored at Rainbow Reef, and more than 10 *M. cavernosa* colonies were monitored at Emerald Reef, all of which are assumed to be unique genotypes (Table 1, 2). Along jetties at Bill Baggs State Park on Key Biscayne, 10 colonies of *M. cavernosa*, *P.*

strigosa, *Colpophyllia natans* and 30 *Pseudodiploria clivosa* colonies were monitored (Table 1, 2). Ten *C. natans* were also observed by UM one night along the MacArthur Causeway near Miami Beach (Table 2).

Gamete collection & larval propagation

Coral spawning was monitored over a period of seven nights following the August full moon (August 5th - 11th) and four nights after the September full moon (Sept 7th - 10th). In Miami, two SEFSC-CoRAL team members captaining vessels served as the gamete handlers once divers collected and brought the spawned bundles up to the boat. A single SEFSC-CoRAL member in Key Largo both collected the spawn in the water and handled the gametes on the boat at the end of the dive. For three of the nights in Key Largo, a UM-RSMAS PhD student assisted in operations and sampled sperm from the collected spawn for sperm motility analyses and cryopreservation research. Once bundles were brought up to the boat, the quantity collected from each parent was recorded, and bundles were mixed in proper proportions to maximize fertilization potential. All gametes were brought back to UM-RSMAS where the batches were properly diluted and allowed to complete the fertilization process (Fig. 1). Gametes collected in Key Largo were immediately transported to UM-RSMAS for the fertilization process.

Figure 1. Acropora palmata *gametes transported to the University of Miami's RSMAS campus and allowed to fertilize overnight.*

For most batches of spawn, fertilization rates were high, ranging from 70-90%. However, two batches of *O. faveolata* (August 10th and September 8th) had a low fertilization estimate of 30-50% and the *A. cervicornis* batch from Key Largo (August 5th) had 0% fertilization. Typically, batches with low fertilization (i.e., less than 60%) are released on the reef the following day as they require close attention because the unfertilized embryos break up, diminish water quality, and make it difficult to maintain the culture. This year, we used a portion of the *O. faveolata* from low fertilization batches to successfully determine the effectiveness of a new kreisel design in our seawater system. During the first 48 hours, they required more attention than a high fertilization batch, but ultimately the system proved useful in maintaining small batches of gametes (~3ml of gametes/kreisel) with low fertilization through to the larval and settlement stage. Overall, settlement on recruitment plugs for both high- and low-fertilization batches remained low for all species (avg of 2 recruits per plug for acroporids and *M. cavernosa*, and 6 recruits per plug for *O. faveolata*). We attribute this to inadequate conditioning of the plugs on the reef prior to use. Despite being conditioned for 3 weeks on the reef, the plugs that were available seemed to have only a light biofilm and had not accumulated any crustose coralline algae (CCA), both of which can attract coral larvae and facilitate settlement. Most larvae either ended up settling on the walls and floors of the kreisel, pieces of reef rubble (Fig. 2), or never settled and eventually died in the water column. Larvae maintained in our recirculating seawater

system that settled on plugs were provided to UM-RSMAS for restoration research purposes. All coral recruits provided to UM are planned for outplanting once their research is complete.

Species-specific spawning observations

During the 7-day window after the August full moon and the 4-day window after the September full moon, we monitored seven species of coral for spawning activity (*A. palmata*, *A. cervicornis*, *O. faveolata*, *M. cavernosa*, *C. natans*, *P. strigosa* and *P. clivosa)*; however, only four were observed to spawn. The date each species was monitored and observed to spawn are reported in Tables 1 and 2. Some additional notable findings are explained here.

Acropora palmata spawning tends to be episodic with peak spawning years and troughs where little to no spawn is observed. In the past two years, we saw little to no spawn in the upper Florida Keys from this species. This year was the first year since 2017 where we observed a relatively large spawning output, 11 colonies spawned at Elbow reef comprising six distinct genotypes and two 5-year-old outplanted *A. palmata* colonies, each genotypically distinct, spawned at North Dry Rocks Reef. The outplants spawning at North Dry Rocks Reef is particularly notable as these are the first outplanted colonies of *A. palmata* that have been observed to spawn in the Florida Keys. Larvae produced by the outplanted parents and a portion of the larvae produced from Elbow Reef parents were housed in our recirculating seawater system, and recruits that settled on plugs were provided to UM-RSMAS. The other portion of larvae produced from the Elbow Reef parents, approximately 175,000 larvae, were added to tanks at FIU with SECORE ceramic "gear" settlement substrates on August 7th. The larvae settled on substrates and were held in the tanks until they could be placed out on the reef in a collaborative effort among multiple agencies (UM-RSMAS, SEFSC-CoRAL, Biscayne National Park).

Past spawning observations of *A. cervicornis* on Ft. Lauderdale reefs indicate that they spawn earlier in the window relative to the known spawning window in the Florida Keys and other locations in the Caribbean making observations of *A. cervicornis* in Miami-Dade waters particularly important. This year, we observed outplanted *A. cervicornis* at Rainbow Reef and Diego Lirman's UM coral nursery spawning on nights 3 and 4 after the August full moon, which aligns with the spawning window observed for Florida Keys *Acropora* spp. Genotypic information for these individuals was not tracked during collection efforts. Though, it should be noted that original stock for these outplanted and nursery reared corals were primarily collected from Miami-Dade and Broward waters with one genotype originating from Key Largo. In Key Largo, numerous outplanted *A. cervicornis* colonies were monitored on night 2 and night 6 in August at North Dry Rocks Reef. On night 2 after the full moon, several (10-12)

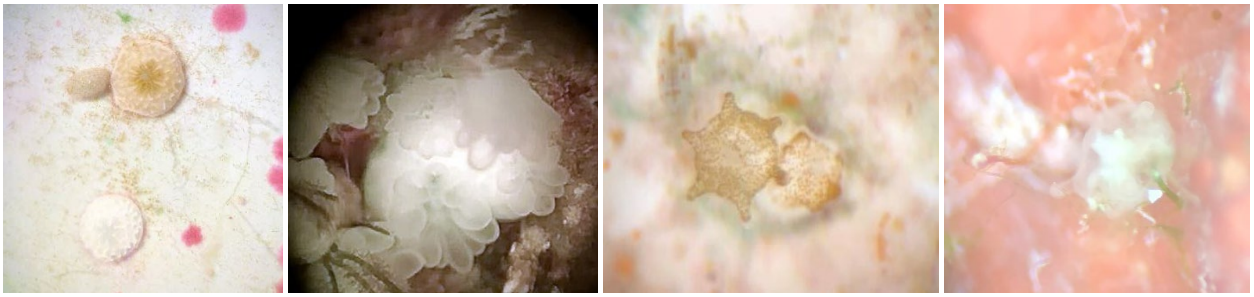

Figure 2. Coral recruits from left to right: Acropora palmata *(36 dAS),* Acropora cervicornis *(29 dAS),* Orbicella faveolata *(61 dAS),* Montastrea cavernosa *(29 dAS). dAS = days after spawning.*

colonies spawned at least partially, while some spawned completely. Spawn was collected from six colonies, but fertilization was 0% leading us to believe they were all one genotype. On night 5 after the full moon, the same three spurs were monitored, and only two colonies were observed to spawn and they only released a few bundles (none collected). Larvae produced from the Miami *A. cervicornis* were maintained in our seawater system through settlement, and settled plugs were provided to UM-RSMAS.

Orbicella faveolata is a prolific and reliable spawner. Spawn from this species was collected from both regions producing over two million larvae. Approximately 240,000 larvae were added to tanks at FIU with SECORE settlement substrates to be outplanted by UM and Biscayne National Park. Approximately 180,000 were kept in our seawater system through settlement. The remainder of the larvae were released at Emerald Reef, Miami. Most *O. faveolata* recruits that settled on plugs were given to UM-RSMAS for research and restoration purposes.

This year was the first year we monitored *M. cavernosa* for spawning. As this is a gonochoric species, directly releasing either sperm or eggs, the equipment required for gamete collection is specialized, and only the Miami team was prepared to collect spawn from this species. The Key Largo team observed this species serendipitously while observing *O. faveolata*. On night 6 after the full moon, eight colonies at Horseshoe Reef in Key Largo were monitored, and three of those were observed releasing sperm. The Miami team monitored *M. cavernosa* during nights 6-9 after the September full moon, collecting spawn the first three nights but only produced larvae on the first night from six genets (two males and four females spawned). The other two nights, only sperm was collected from a total of three individuals. Due to the difficult and inefficient collection method, relatively few gametes were collected on night 6 producing 1,000 larvae. These were maintained in our seawater system through settlement and provided to UM-RSMAS for grow out.

Colonies of *C. natans*, *P. strigosa* and *P. clivosa* were monitored by UM-RSMAS on nights of August 9th – 11th and September 7th – 10th along the rocky shore at Bill Baggs State Park with the addition of a second site near Star Island on the McArthur Causeway on September 10th. For these species, our team was prepared to assist in the fertilization process and house some of the larvae in our seawater system. However, no spawning was observed.

Outplanting

An additional outplanting component of this project in collaboration with SECORE was completed during September 28 – October 2, 2020. For this work, use of a NOAA vessel and NOAA divers was approved. Our team outplanted 116 SECORE-designed “gear” substrates with settled *A. palmata* larvae onto the reef at three sites in Key Largo (Elbow, Horseshoe and Sand Island Reefs; Fig. 3). Elbow reef is where the parent colonies are located, and Horseshoe Reef was selected because it is a site designated as part of the FKNMS ‘Mission Iconic Reefs’ plan. At each site, we cemented 38-40 substrates to the benthos with a total of approximately 130 recruits per site (Table 3). Each substrate was tagged and photographed to allow for future tracking of individual substrates and coral recruits. The cement we used was tested by the UM-RSMAS Lirman lab and found to be structurally suitable for this task and safe for use in close contact with corals. After the substrates were cemented, we were able to re-visit two of the sites to evaluate the short-term (1-2 day) ‘retention’ of the substrates. At the two sites we re-visited, all substrates remained in place. Although the coral recruits only measure about 1mm in

diameter and are nearly translucent, we were able to observe some of the recruits in the field immediately after the substrates were cemented, and, again, when we re-visited the substrates 1-2 days later.

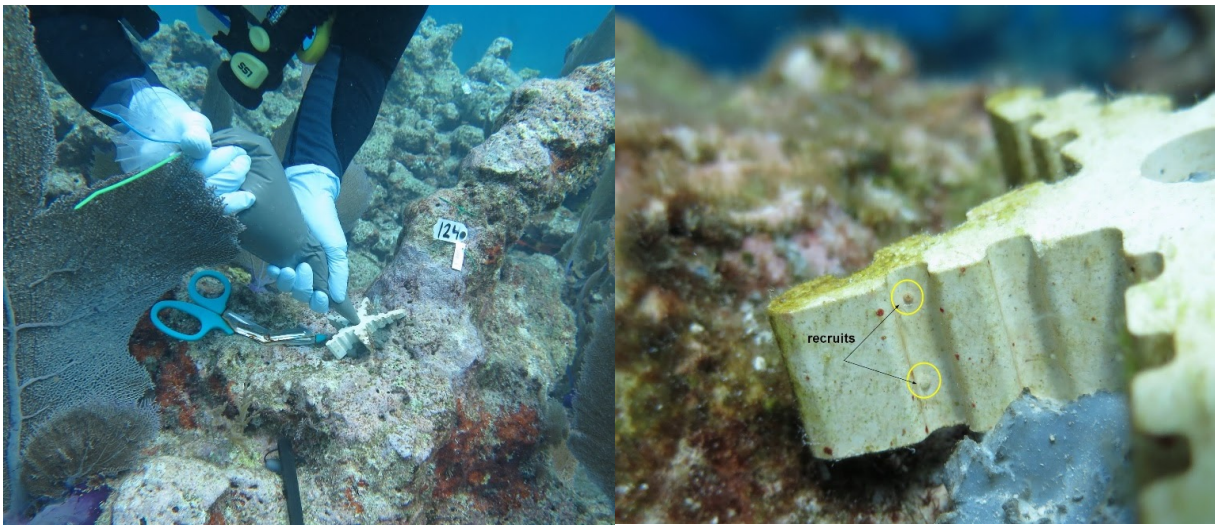

Figure 3 Left: Cementing SECORE "gear" substrates to the reef. Right: Two recruits on a "gear" substrate (circled in yellow).

Funding and Permits

This work was funded by NOAA's Coral Reef Conservation Program and the Key Largo portion was conducted under permit: FKNMS-2018-163-A2. Collections at Bill Bagg's State Park was permitted by Florida Department of Environmental Protection (permit # 07272015), and collections at Rainbow Reef and Emerald Reef were permitted by Florida Fish and Wildlife Commission (SAL-20-1723-SCRP & SAL-20-1794-SCRP).

Field Participants

UM-CIMAS/SEFSC-CoRAL Team: Dana Williams, Allan Bright, Annie Peterson, Carl Anderson

UM-RSMAS: Diego Lirman, Andrew Baker, Liv Williamson, Alexandra Wen, Joe Unsworth, David Ehrens, Dalton Hesley, Martine D'Alessandro, Jane Carrick, Maddie Kaufman, Richard Karp, Hayden Tompkins, Kelsey Johnson-Sapp, Hanna Babbitz, Corinne Allen

SECORE: Margaret Miller, Miles McGonigle, Nico Rivas

Florida DEP: Keri Korrigan

Larval/Recruit Recipients

Our 2020 coral spawning work produced more than 2,600,000 larvae (Table 1, 2). We provided ~550,000 larvae from two ESA-listed species of coral and >1,700 settled coral recruits from four different species of coral to our three different research partners. Of these, 240,000 *O. faveolata* larvae and 175,000 *A. palmata* larvae were provided to SECORE for settlement on uniquely designed substrates engineered for immediate outplanting to the reef. Sixty-thousand *O. faveolata* larvae were provided to UM, as well as 1,537 *O. faveolata* recruits (115 plugs), 133 *A. palmata* recruits (57 plugs), 94 *A. cervicornis* recruits (54 plugs), and 27 *M. cavernosa* recruits (17 plugs). These larvae and recruits will be used for restoration related research. Additionally, we provided 25,000 *O. faveolata* larvae to research partners at the University of Southern California, for use in temperature tolerance experiments.

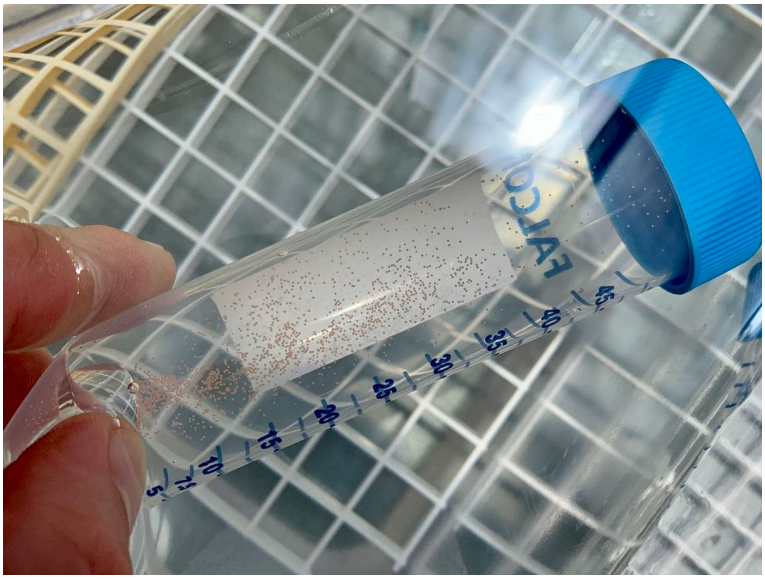

Figure 4 Orbicella faveolata *larvae packed for overnight shipment to the University of Southern California (USC).*

SECORE – 240,000 *O. faveolata* larvae; 175,000 *A. palmata* larvae

UM-RSMAS – 60,000 *O. faveolata* larvae; 115 plugs with 1,537 *O. faveolata* recruits; 57 plugs with 133 *A. palmata* recruits; 54 plugs with 94 *A. cervicornis* recruits; 17 plugs with 27 *M. cavernosa* recruits

University of Southern California – 25,000 *O. faveolata* larvae

COVID-19 Obstacles and Operational Changes

The COVID-19 pandemic resulted in logistical obstacles making spawning observations and collections difficult; yet, despite this, we were still able to meet our project goals. Restrictions to the operation included, but not limited to, travel restrictions that prevented setup of a Key Largo field lab, restrictions on the use of NOAA vessels largely limited us to working from UM owned and chartered vessels for field operations, and NOAA divers were not approved for dive operations limiting the number of in-water participants to CIMAS and UM divers. Even with UM and chartered vessels, the number of people on the boat was limited. In all, our Key Largo effort was approximately one third of past years efforts. These restrictions, however, did encourage more collaboration than typical with UM-RSMAS and SECORE. Additionally, as most of the UM-RSMAS team had not participated in spawning before, this allowed our team to lead and supervise spawning efforts providing practical hands-on training that is difficult to learn without experienced guidance. UM also provided space at the RSMAS Hatchery to set

up our recirculating seawater system for larval propagation and settlement, which is typically set up at our temporary field lab in Key Largo (Fig. 5).

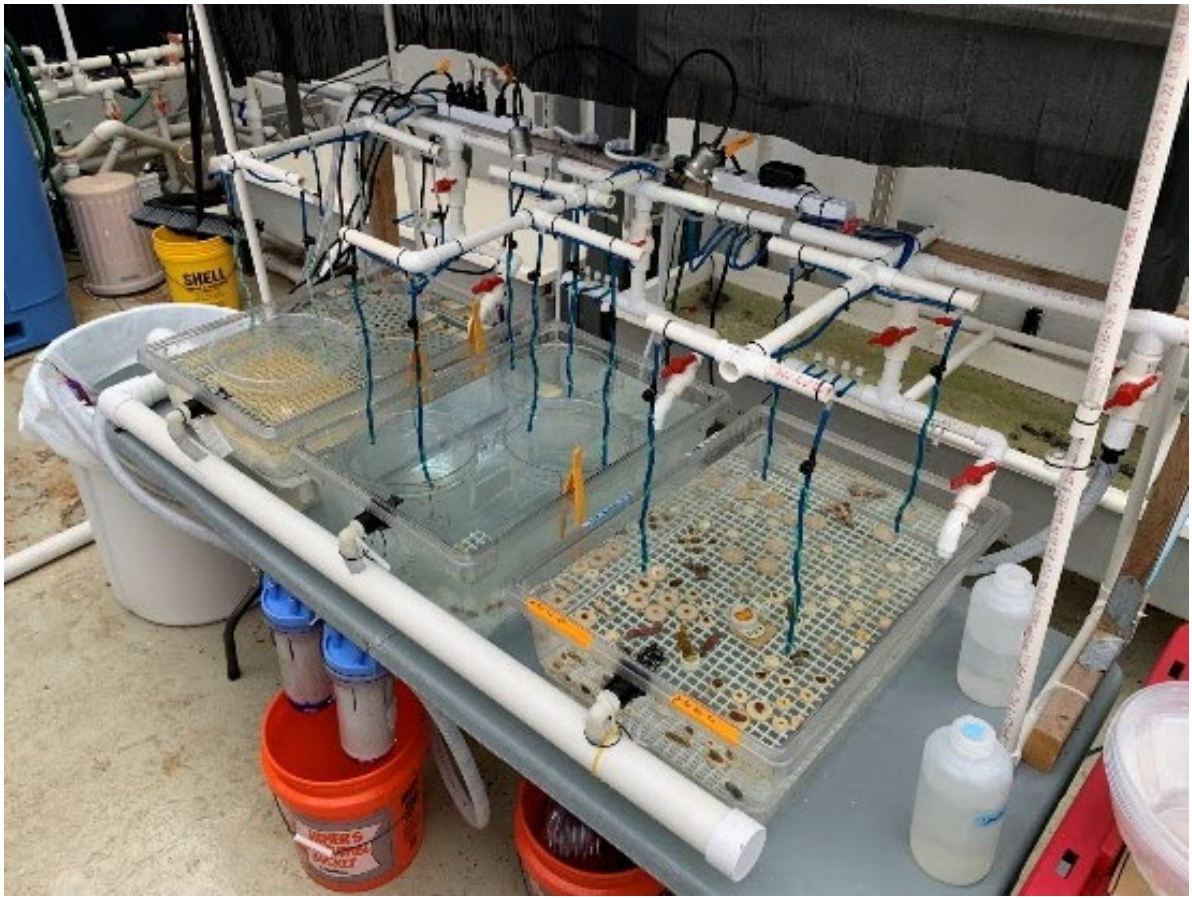

Figure 5 Temporary recirculating seawater system housing coral larvae and recruits.

Table 1. Spawning observations and collections for August 2020. The August full moon was on 8/3/2020 11:59:01 AM EDT, observations began 2 days after the full moon (dAFM). We do not have genotypic data for *Acropora cervicornis* colonies at North Dry Rocks and Horseshoe, thus, "# Genets Monitored" is unknown ("Unk"), for boulder coral species, individual colonies are presumed to be unique genets.

								# Genets		
Date	**dAFM**	**Region**	**Site**	**Wild / Outplant**	**Species**	**Spawning Observed**	**Spawn Collected**	**Monit -ored**	**Spawned**	**Larvae Produced**
5-Aug	2	Key Largo	North Dry Rocks	wild	*A. palmata*	No	No	3	0	---
				outplant	*A. palmata*	Yes	Yes	4	2	5,000
				outplant	*A. cervicornis*	Yes	Yes	4-6	1	0
		Miami	Rainbow Reef	outplant	*A. cervicornis*	No	No	10+	0	---
			Lirman Nursery	nursery	*A. cervicornis*	No	No	5+	0	---
6-Aug	3	Key Largo	Elbow Reef	wild	*A. palmata*	Yes	Yes	11	6	200,000
		Miami	Rainbow Reef	outplant	*A. cervicornis*	Yes	Yes	10+	5+	30,000
			Lirman Nursery	nursery	*A. cervicornis*	Yes	Yes	5+	1	
7-Aug	4	Key Largo	Elbow Reef	wild	*A. palmata*	Yes	Yes	11	1	0
		Miami	Rainbow Reef	outplant	*A. cervicornis*	Yes	yes	10+	5+	90,000
			Lirman Nursery	nursery	*A. cervicornis*	Yes	Yes	5+	8	
8-Aug	5	Key Largo	Elbow Reef	wild	*A. palmata*	No	No	11	0	---
			North Dry Rocks	wild	*A. palmata*	No	No	3+	0	---
				outplant	*A. palmata*	No	No	4	0	---
				outplant	*A. cervicornis*	Yes	No	Unk	2	---
9-Aug	6	Key Largo	Horseshoe Reef	wild	*A. palmata*	No	No	1	0	---
				wild	*A. cervicornis*	No	No	Unk	0	---
				wild	*O. faveolata*	Yes	Yes	20	~14	2,100,000
				wild	*P. strigosa*	Yes	No	1	1	---
				wild	*M. cavernosa*	Yes	No	8	3	---
		Miami	Rainbow Reef	wild	*O. faveolata*	No	No	6	0	---
			Bill Baggs	wild	*C. natans*	No	No	10	0	---
				wild	*P. clivosa*	No	No	30	0	---
				wild	*P. strigosa*	No	No	10	0	---
10-Aug	7	Miami	Rainbow Reef	wild	*O. faveolata*	Yes	Yes	6	6	120,000
			Bill Baggs	wild	*C. natans*	No	No	10	0	---
				wild	*P. clivosa*	No	No	30	0	---
				wild	*P. strigosa*	No	No	10	0	---
11-Aug	8	Miami	Bill Baggs	wild	C. natans	No	No	10	0	---
				wild	P. clivosa	No	No	30	0	---
				wild	P. strigosa	No	No	10	0	---

Table 2. Spawning observations and collections for September 2020. The September Full moon was 9/2/2020 1:22:01 AM EDT; the days after the full moon (dAFM) are counted starting from September 1st due to the early hour of the full moon.

Date	dAFM	Region	Site	Wild / Outplant	Species	Spawning Observed	Spawn Collected	# genets Monit-ored	# genets Spawned	Larvae Produced
7-Sep	6	Miami	Emerald Reef	wild	*M. cavernosa*	Yes	Yes	10	6	1,000
			Bill Baggs	wild	*M. cavernosa*	No	No	10	0	---
				wild	*C. natans*	No	No	10	0	---
				wild	*P. clivosa*	No	No	30	0	---
				wild	*P. strigosa*	No	No	10	0	---
8-Sep	7	Miami	Emerald Reef	wild	*M. cavernosa*	Yes	Yes	10	1 (male)	N/A
			Rainbow Reef	wild	*O. faveolata*	Yes	Yes	6	2	60,000
			Bill Baggs	wild	*M. cavernosa*	No	No	10	0	---
				wild	*C. natans*	No	No	10	0	---
				wild	*P. clivosa*	No	No	30	0	---
				wild	*P. strigosa*	No	No	10	0	---
9-Sep	8	Miami	Emerald Reef	wild	*M. cavernosa*	Yes	Yes	10	2 (male)	N/A
			Bill Baggs	wild	*M. cavernosa*	No	No	10	0	---
				wild	*C. natans*	No	No	10	0	---
				wild	*P. clivosa*	No	No	30	0	---
				wild	*P. strigosa*	No	No	10	0	---
10-Sep	9	Miami	Bill Baggs	wild	*M. cavernosa*	No	No	10	0	---
				wild	*C. natans*	No	No	10	0	---
				wild	*P. clivosa*	No	No	30	0	---
				wild	*P. strigosa*	No	No	10	0	---
			McArthur Cswy	wild	*C. natans*	No	No	10	0	---

Table 3. Number of SECORE "gear" substrates and *Acropora palmata* recruits per reef.

Reef	Site	# Substrates	Total # Recruits
Elbow	EL-A	20	76
	EL-B	18	54
Horseshoe	HS-A	20	84
	HS-B	20	51
Sand Island	SI-A	20	60
	SI-B	18	63