

WWF technical Report

PART 1: GENERAL NARRATIVE REPORT

Project Title:	Facilitating coral reef resilience to climate-driven bleaching incidence through bioengineering as a means of lesson-learning: A continuation
Project Number:	DW50
Reporting Period:	Dec 16, 2019-June 30, 2020: Report 5 Summary of work to date
Organization Submitting Report	Fragments of Hope

Citation suggestion: Carne, L. (2020). Facilitating coral reef resilience to climate-driven bleaching incidence through bioengineering as a means of lesson-learning: A continuation. Technical Report 5. DW50. Fragments of Hope and the World Wildlife Fund.

Project Overview.

In addition to the global pandemic/crisis, Belize also had a severe bleaching event in 2019 that carried over in several sites through January 2020 (bleaching surveys were conducted in December 2019 and January 2020). For this reason, Fragments of Hope (FoH) delayed outplanting activities by two months, beginning in February as opposed to December when the hurricane season was over. Inclement weather has been an issue for most of 2020 to date as well, with fewer than usual days with appropriate conditions for outplanting with cement. While the COVID-19 State of Emergency restrictions in Belize did create a pause in fieldwork, FoH eventually secured the appropriate permissions for outplanting corals and focused on direct out-planting of *Acropora palmata* micro fragments at Silks, Moho and Laughing Bird Caye National Park (LBCNP). A total 3,925 fragments from four different coral species were outplanted at four different cayes through April 2020, which is roughly 50% of the amount outplanted during the first half of 2019. Of this total were 1,540 *A. palmata* micro fragments directly outplanted at three cayes (combined) with one week and one month survival rates of 84-96% at south Silk and Moho Caye, respectively. Over 2,300 nursery-grown *A. cervicornis* fragments were outplanted at Moho and LBCNP, and

experimental amounts of micro-fragmented *Orbicella faveolata* (N=30) and *Dendrogyna cylindrus* (N=25) were directly outplanted at Moho Caye. Other fieldwork included regular nursery and outplanted corals monitoring, addition of a new *A. cervicornis* genet to the False Caye nurseries and on site/field training of coastal community members since no formal training workshop was held this year. Prior to country wide restrictions, FoH assisted high school students via Belize Audubon Society (BAS) with presentations and a site visit to LBCNP, and FoH crew appeared on KREM live TV morning shows, twice, all part of Reef Week 2020 activities. FoH also gave a brief update to Belizean conservation partners at the Healthy Reefs Initiative Report Card launch in Belize City and appeared on a local station LOVE TV morning talk show in June 2020. FoH continued to work remotely with Dr. Steve Schill on the drone ortho mosaics from 2019, and produced the first product: a map of LBCNP demonstrating that over 2000m² of a hectare of available substrate (shallow fringing reef) is replenished acroporids-over 21% of an hectare. At invitation, FoH completed a case study chapter on LBCNP for Dr. David Vaughan's restoration textbook and continues to update its website and social media pages with all their latest data. FoH is also actively involved with the Fisheries Department/Hol Chan Marine Reserve in assisting with rescue nurseries for *D. cylindrus* due to the SCTL crisis, and so field priorities have shifted just recently.

Progresses on each activity are listed in Section 3 below in numerical order (Activity #1-9), while Project Successes (Section 2) are listed in chronological order.

Project Successes.

Fragments of Hope was nominated by the coral community as one of top 15 Coral Reef Research Contributors under the Protection category in the ECO-SI special edition magazine for ICRS 2021¹. Lisa Carne is an invited speaker to the online session entitled, "Solutions from the MAR" within the larger Global Coral Reef Week event scheduled in lieu of ICRS 2020. The talk is entitled "Scaling up coral restoration and measuring its success" and is planned for July 10, 2020². There is also a special Belize session hosted by the University of Belize and Healthy Reefs Initiative, and the abstract entitled "Accelerating shallow reef recovery: lessons learned from three years of directly outplanting micro-fragmented *Acropora palmata* in Belize" was submitted with Dr. David Vaughan (Plant A Million Corals) as co-author. The full abstract is

¹ <http://digital.ecomagazine.com/publication/frame.php?i=664239&p=1&pn=&ver=html5>

² <https://coralreefweek.wixsite.com/coralreefweek/mesoamerica>

shared in Annex I, p.1. FoH began a new collaboration with Dr. John Bruno's group at the University of North Carolina (UNC), who will assist with FoH fish data analysis, which actually stemmed from a Twitter post, illustrating the use of social media. Also via Twitter, FoH linked with the Earth Museum³, based in the UK, who has agreed to link 20 short underwater videos of restoration/reef in general to their World heritage Sites Explorer interactive GIS map online, planned for end of August 2020.

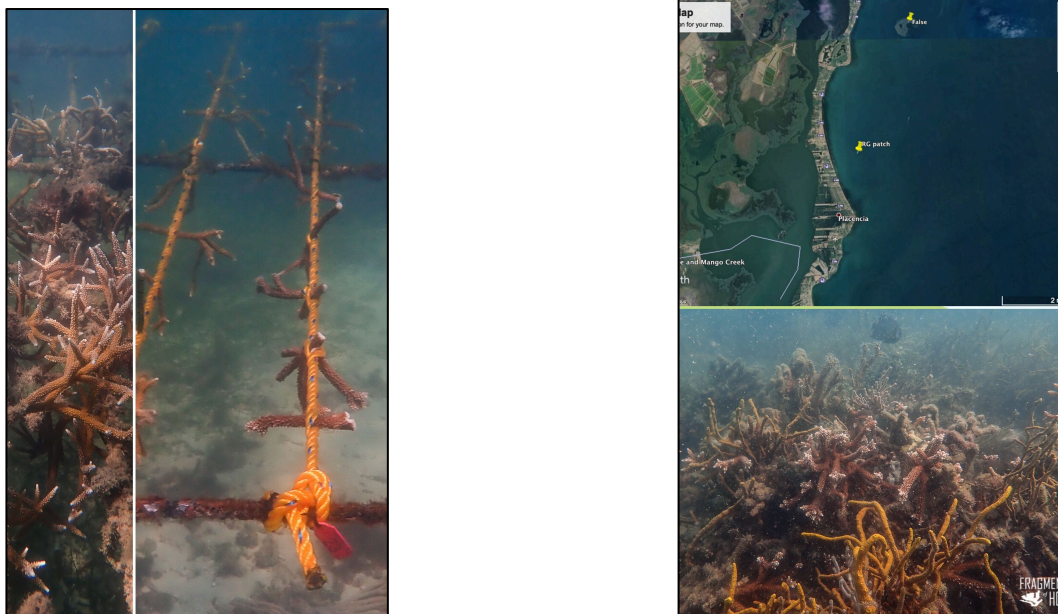
3) Progress on Activities and related financial issues.

Activities #1 & #2. Maintenance of over 16 nurseries in southern Belize continued, with regular cleaning and reinforcement of structures conducted to the best of our ability under State of Emergency conditions. As previously reported, there were only two *Acropora cervicornis* genets and one *A. prolifera* genet that survived the 2019 severe bleaching event at False Caye. The two *A. cervicornis* survivors were originally sourced from Frigate and Moho Caye and were restrung on ropes in the cleaned up nurseries (Figure 1a). A quick look back at the *in situ* temperature records at False Caye (shared in previous report) revealed ~0.6° Celsius difference in averaged temperatures at False Caye, April-November: 30.60°C in 2019, and 29.99°C in 2018 when no bleaching or mortality occurred. However, in 2019 temperatures exceeded 30°C April-November, exceeded 31°C May-October, and exceeded 32°C in June, September and October. Therefore yearly averages may not be the best way to interpret *in situ* temperature data. While the mortality rates of both nursery corals and outplants at False Caye were higher than ever recorded in over 10 years of restoration work in Belize and exceptional to False Caye, FoH considers this site worth further time and research as an example of extreme temperature and also likely nutrient loads (as evidenced by types and amount of macro algae, and proximity to the mainland/peninsula) example, with at least a few surviving acroporids (see also next section activity #3, monitoring outplants, Fig. 3f). By contrast, the tables at Moho and Silks (Figure 1c) need minimal cleaning, but maintenance still includes reinforcing structures as cable ties wear out and older nurseries become weighted with corals, especially at older nursery sites like LBCNP (Fig. 1d) and Whipray Caye (not shown but still a source of corals for outplanting, especially *A. palmata*).

Activity # 2 is adding new corals to nurseries; this activity had decelerated not knowing if future funding will be secured, but with unofficial approval/confirmation of another MAR Fund grant, a

³ <https://theearthmuseum.co.uk>

previously identified new, near shore *A. cervicornis* genet was added to the False Caye nurseries in March 2020 (Figure 1b). Like the single *A. cervicornis* genet previously sourced at False Caye, it is a little deeper (~5m) than the nursery tables and conditions are almost always murky. Whether or not these corals can be conditioned for more shallow and more exposed light conditions (such as the nurseries and shallow outplanting sites) needs more time to tell-as the False Caye genet has done well at Moho and Silks nurseries with more light, but still died in the False Caye nurseries. Worse case scenario is that some genets may only thrive in certain conditions (e.g. lower light, turbid areas). Which is not negative or surprising, but would be a lesson learned to consider in future restoration efforts.



Figs. 1a-b. *A. cervicornis* survivors restrung (L) and a new *A. cervicornis* genet added to False Caye (R).



Figs. 1c-d. Table nurseries at Moho & Silk Caye (L) need minimal cleaning, but all nurseries, especially older ones like at LBCNP (R) and Whipray (not shown) need regular reinforcement/maintenance.

Activity #3: Monitoring of nurseries and outplants has also continued, mostly piggy-backed onto the few outplanting days over this time frame (February-April 2020). Because field days have been limited, and some of the outer district sites inaccessible due to the State of Emergency, FoH was better able to generate short-term survival data on directly outplanted micro fragments. For example at Silks Caye, which has traditionally had the lowest survival rate (until False Caye in 2019) of all sites for all three acropora taxa outplanted, this year we documented 84% survival of directly outplanted *A. palmata* micro fragments after four days (63 dead from 398 micro frags of six different genets). Last year we documented 70% survival rate of directly outplanted *A. palmata* after one month (226 dead of 769 micro frags from five different genets) on this site, which was prior to the 2019 bleaching event. Those survivors are now thriving one year later (Figs. 2c-d). Last year (2019) we attributed most mortality (prior to bleaching) to inexperienced practitioners (in training and/or their first time outplanting). But historically even the *A. cervicornis* has lower survivor rates at Silks, primarily due to fire worm predation (and damsel fish to some extent). The fire worms approach even during outplanting (Figure 2a). Contrast this with results at Moho Caye in 2020 where the micro fragged *A. palmata* had 96% survival after 33 days (five dead of 147 frags), 84% survival for the pillar corals, and 100% survival of the 30 *Orbicella faveolata* outplanted fragments. Even the outplanted staghorn do better at Moho Caye

(Fig. 2b), an unprotected site, than they do at S. Silks, a no take zone. Moho Caye is an ‘inner caye’ just north of LBCNP and corals seem to be surviving more similar to nearby LBCNP outplants than other sites.

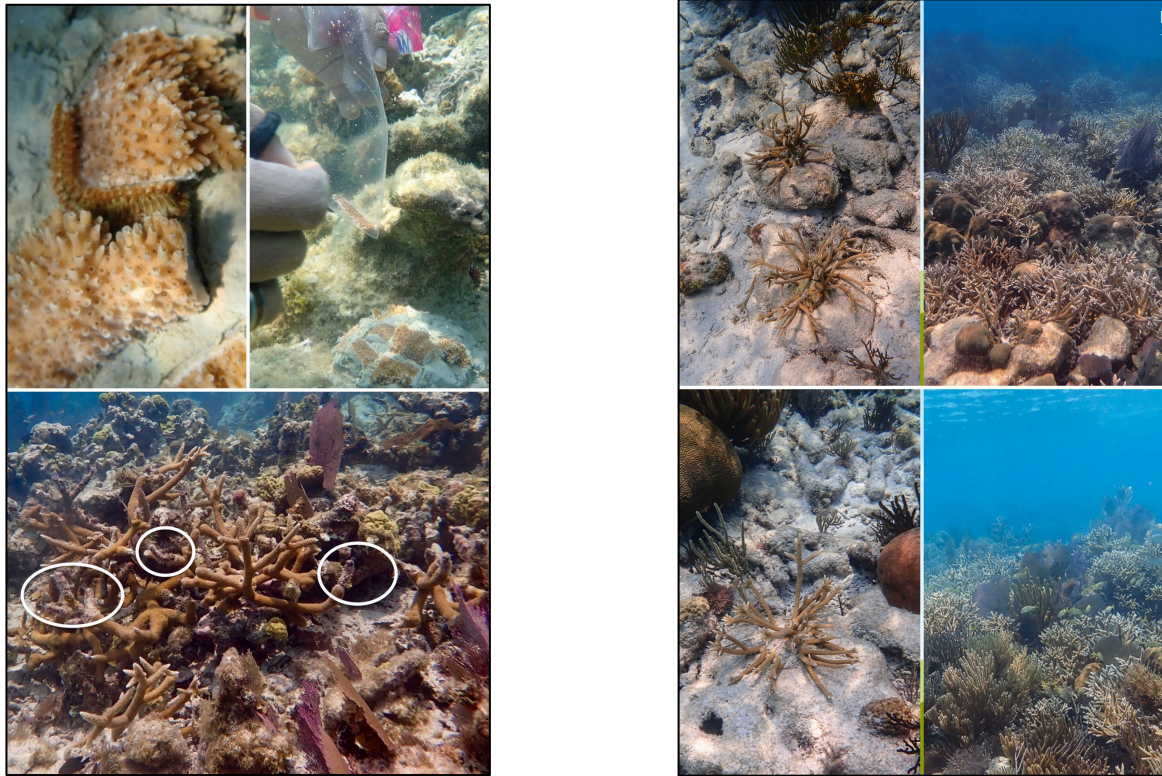


Fig. 2a-b. Predation from fire worms at Silk Caye (L) on just outplanted *A. palmata* (top) removed when possible and evidenced on staghorn in bottom photo (predated tips circled). Outplanted staghorn at Moho Caye (R) at two months and four years, left to right.

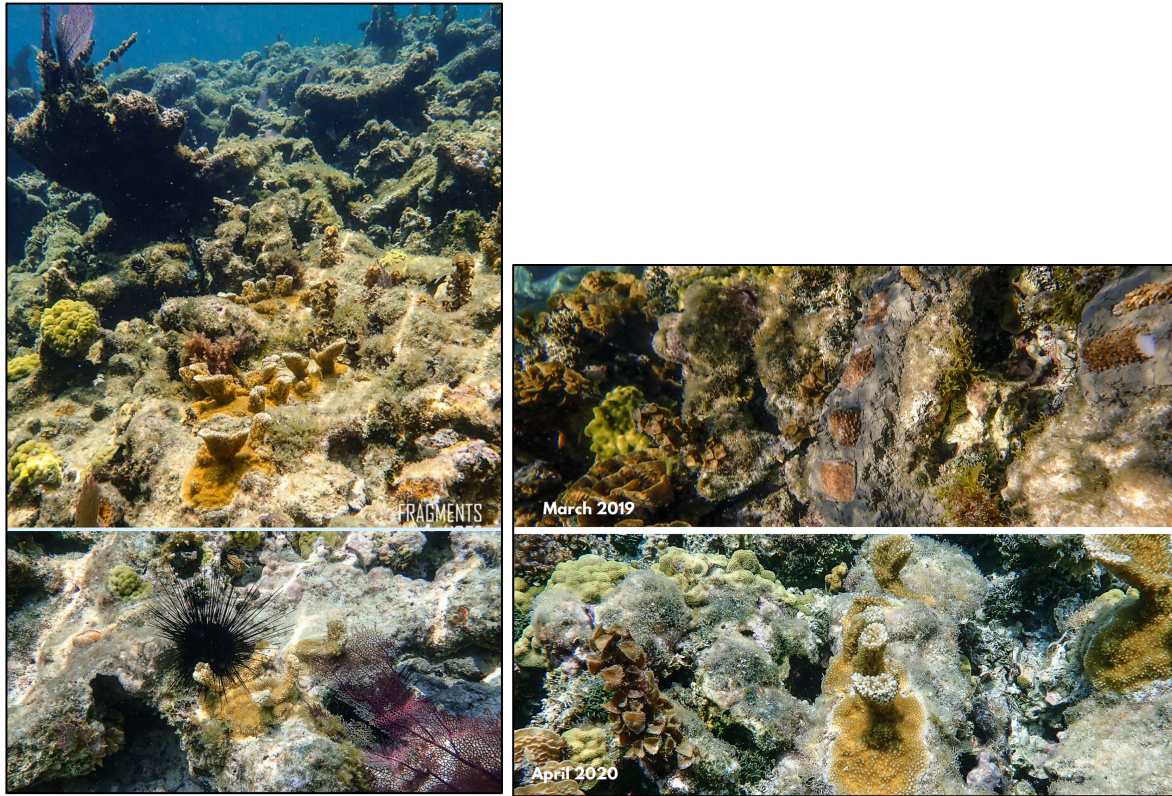
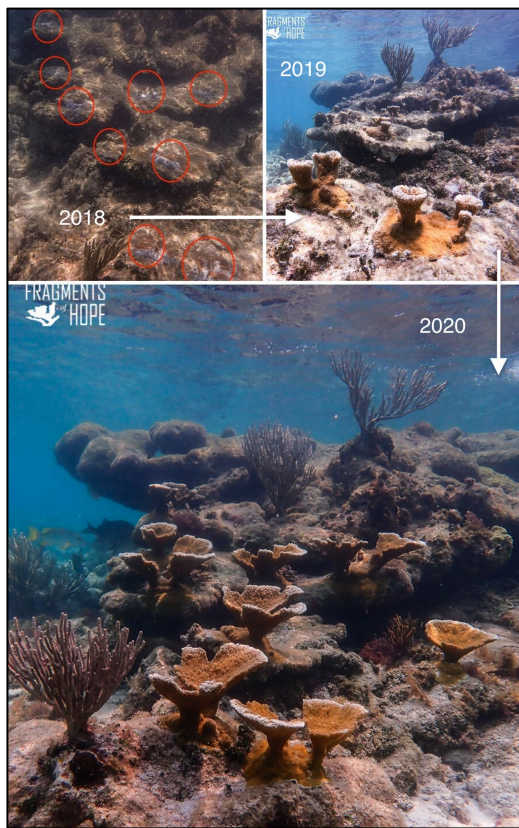


Fig. 2c-d. One-year old *A. palmata* micro fragments directly outplanted on the shallow fringing reef at S. Silk Caye; on the right is exact same corals Day 0 (top) and 13months later (bottom).

LBCNP remains superior in terms of outplant survival rates, with almost 95% survival of 109 *A. palmata* (micro fragged) outplants after two years (Fig. 3a) and unprecedented growth and survivorship after ten years (Fig. 3b-d) of all three acroporid taxa. Figures 3c-d are examples of ten-year time series of the exact same corals outplanted at LBCNP in 2010. These outplanted corals either never bleached or recovered if they did (very few ever did bleach). Figure 3e is just another example of a single outplanted *A. palmata* after six years, no bleaching (sub-site 22). Compared to False Caye, where only a few of the ~280 *A. prolifera* outplants survived (Fig. 3f), and more than 2,300 outplanted elkhorn and staghorn died in the 2019 bleaching event. This is the most mortality recorded at any site since outplanting began in Belize in 2010.



Figs. 3a-b. Two-year old *A. palmata* microfragments at LBCNP (L) and before and after ten years of outplanting at sub-site 13, LBCNP.



Fig. 3c. Ten-year time series of same *A. palmata* outplanted coral at sub-site 13, LBCNP.

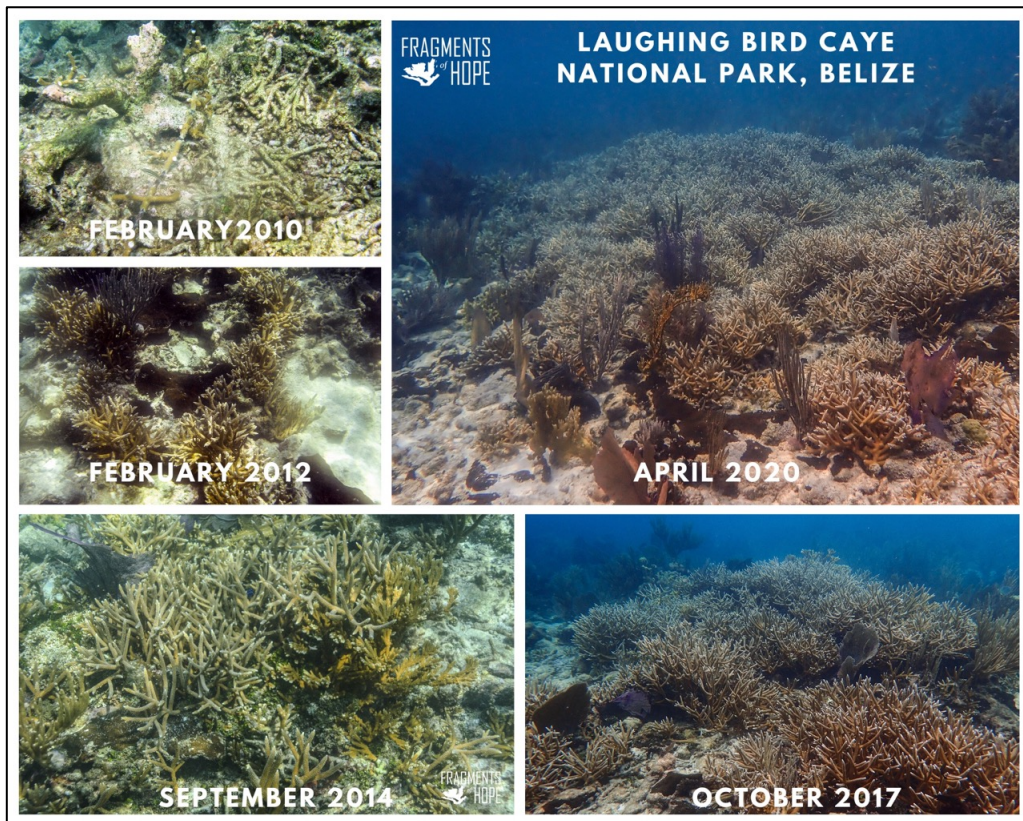


Fig. 3d. Ten-year time series of less than 40 *A. cervicornis* frags outplanted on two ropes at LBCNP (sub-site7).

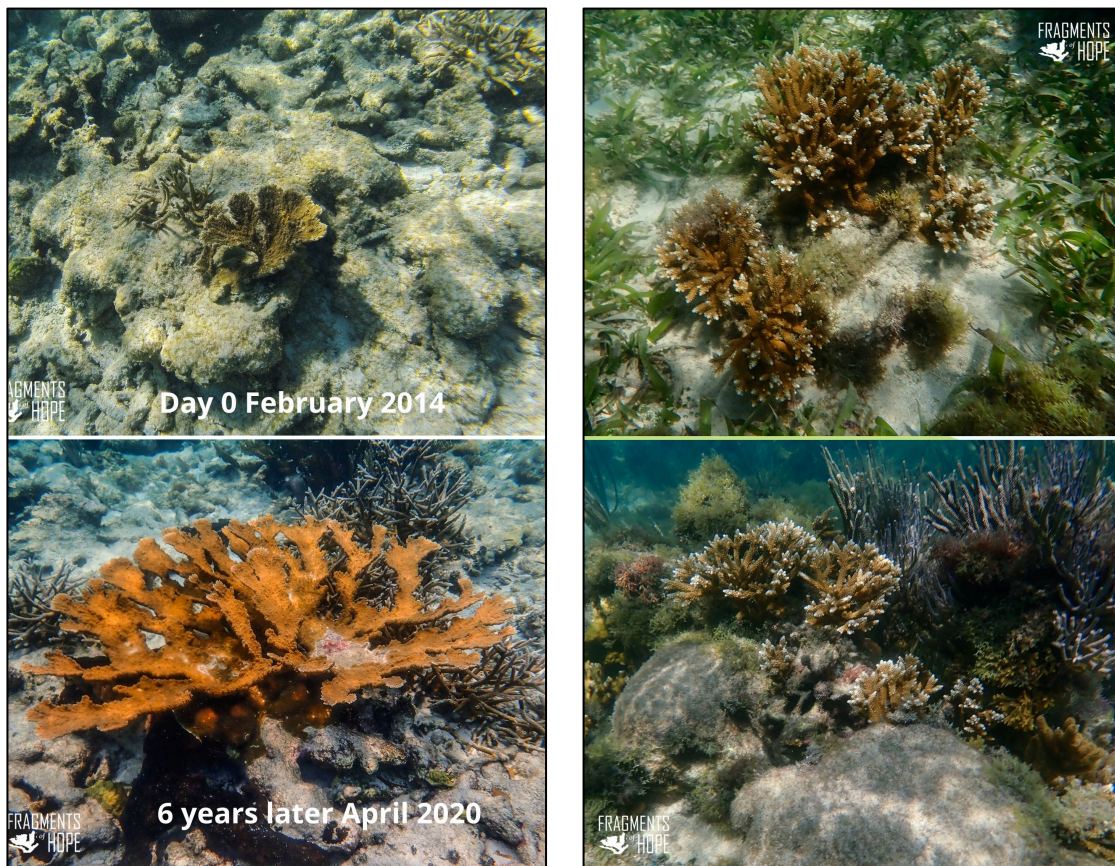


Fig. 3e-f. Illustrating six years growth of a single *A. palmata* at LBCNP sub-site 22 (L), and the only surviving outplants at False Caye are of a single *A. prolifera* genet (R).

Activity #4: Outplanting

Because outplanting began two months behind schedule (due to severe and long lasting bleaching from 2019, see next section), some field days were lost during the initial phases of the State of Emergency in-country due to COVID-19 beginning March 2020, and a focus on emergency nurseries in Northern Belize due to SCTLTD there shifted priorities in May 2020, only eight outplanting days were conducted in southern Belize, February-April 2020. While the focus was planned for direct outplanting of *A. palmata* and non-acroporids, two days did include outplanting nursery grown *A. cervicornis* at Moho (979 fragments of two different genets) and LBCNP (1, 256 fragments of three different genets) because the ropes were heavy with growth/ready to be harvested (Fig. 4a). This brings the number of nursery-grown *A. cervicornis* fragments outplanted at Moho Caye to 18, 615 (2015-2020, Table 1) and representing 14 distinct different genets or individuals (Table IIa). At Laughing Bird Caye National Park, outplanting began in 2010 and the *A. cervicornis* genets added in 2020 bring the number of nursery-grown outplanted fragments to over 74,500 (Table I) representing 20 different genets (Table IIa).

The additional field days did focus on directly outplanting micro fragmented *A. palmata* at three locations (Moho, Laughing Bird and South Silk Caye) with two small trials using *Dendrogyra cylindrus* and *Orbicella faveolata* at Moho Caye (Figs 4b-c). When the sources for micro fragmenting are wild colonies, never more than 10% of that colony is removed, and usually far less than 10% is taken. The justification for this is to increase genetic diversity at the outplant locations: although the older nursery sites continue to produce source corals from harvested ones that grow back, these are the same genets or individuals that have already been outplanted over several years. Source locations for *A. palmata* are listed in Table IIb, where the number of distinct individuals (genets) surpass the latest recommendations from Baums et al. (2019)⁴ of at least five-ten to maximize potential for cross fertilization during sexual reproduction. While Moho Caye is currently only at eight different outplanted genets, there do exist > eight natural *A. palmata* colonies spread out around the caye (See Fig. 6c) so FoH has effectively doubled the *A. palmata* genetic diversity in two years. However, these corals may not reach sexual reproduction for at least three-five years, since they were outplanted as micro-fragments.

The *D. cylindrus* outplanted at Moho Caye were sourced from three different colonies at LBCNP and outplanted next to the wild *D. cylindrus* at Moho Caye (all colonies were sampled for genetics but the samples are still in Belize and not yet sent for genetic analysis due to COVID-19). The *O. favelolata* micro-fragged and outplanted at Moho Caye was sourced from LBCNP: in November 2019 a large tree washed out from rivers was smashing up corals at sub-site 19; FoH towed the log out to deeper water and rescued and wedged as much of the broken *O. favelolata* pieces as possible for this planned trial.

The number of all coral outplants in 2020 is listed underneath the numbers for 2019 in Table I. With multiple new challenges (bleaching, COVID-19, SCTLTD focusing priorities) and including a pause on outplanting at False Caye due to mass outplant mortality in the 2019 bleaching event, and continued frequent adverse weather days, numbers in 2020 were just over half of the outplants placed on the reefs in 2019 in southern Belize sites near Placencia (not including South Water Caye Marine Reserve outplants).

⁴ <https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/eap.1978>



Fig. 4a. Outplanting of nursery-grown *A. cervicornis* occurred at Moho (two genets) and Laughing Bird Caye (three genets) during 2020 prior to hurricane season. Pictured (clockwise) are L. Carne, A. Neal, N. Gibson and V. Faux.

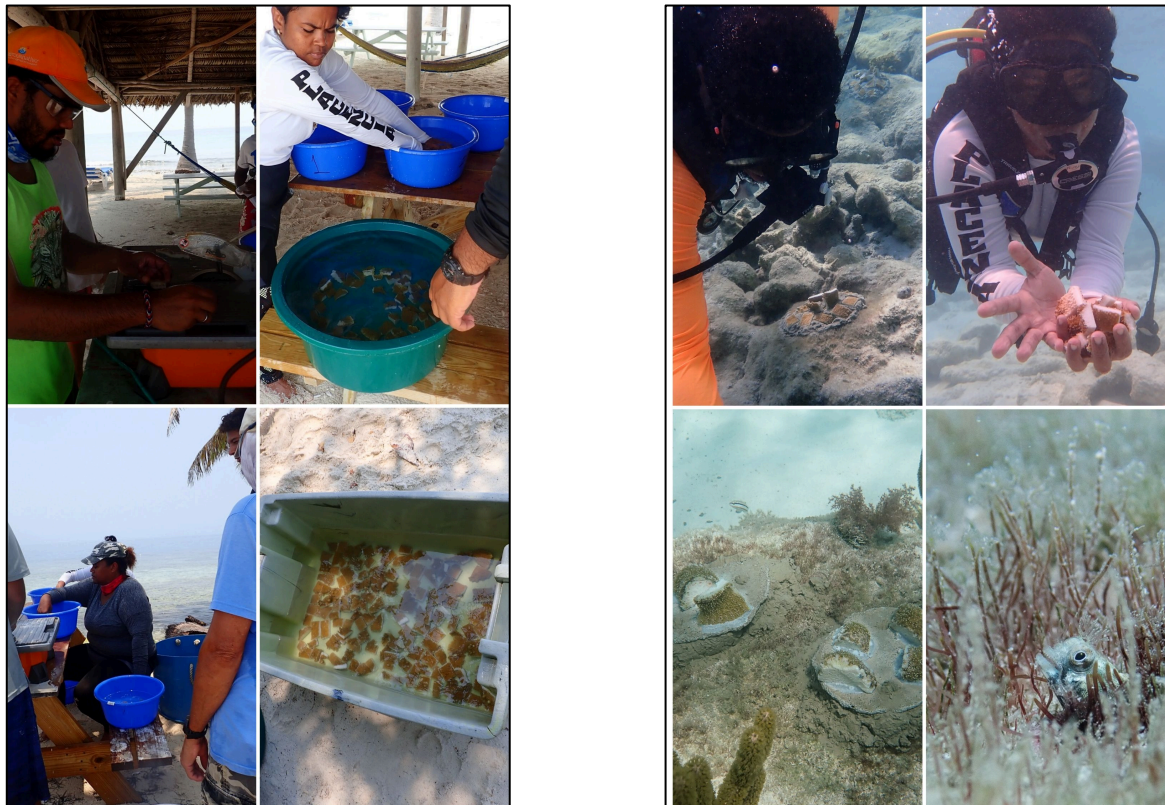


Fig. 4b-c. Examples of the FoH team micro fragmenting on small, off-shore cayes (using a portable generator, L), and just planted *A. palmata* (directly in cement, top R) and *D. cylindrus* (super glued onto cement 'cookie', then outplanted in cement, bottom R) and the small blennies we always look for to avoid cementing over their homes.

Table I. Number of coral fragments outplanted by taxa, across sites, and separated by year (2019 top, 2020 bottom). ACER=*Acropora cervicornis*, APAL=*A. palmata*, APRO=*A. proliferata*, DCLY=*Dendrogyra cylindrus*, OFAV=*Orbicella faveolata*.

SITES	TAXA outplanted 2019				TOTAL 2019	TOTAL
	ACER	APAL		APRO		
LBCNP	1,905				1,905	82,879
SILKS	801	1,114			1,915	12,695
MOHO	267	597			864	18,750
FALSE	129	345		2,401	2,875	5,037
TOTAL					7,559	119,361

SITES	TAXA outplanted 2020					TOTAL 2020	TOTAL
	ACER	APAL	APRO	DCLY	OFAV		
LBCNP	1,256	303	0	0	0	1,559	84,438
SILKS	0	675 (micro frags)	0	0	0	675	13,370
MOHO	979	562 (micro frags)	0	25	30	1,596	19,784
FALSE	95	0	0	0	0	95	5,132
subtotal	2,330	1,540	0	25	30	3,925	
TOTAL					3,925	122,724	

Table IIa. Number and source location of *A. cervicornis* (ACER) genets/individuals at each of three outplant locations in southern Belize: Moho, Laughing Bird and South Silk Caye.

genet source ACER	Outplant locations		
	Moho	LBCNP	Silks
saddle	X	X	
lazy	X	X	X
gladden buoy		X	
gladden pillar patch		X	
tarpon	X	X	X
whipray	X	X	X
glens bank		X	
loggerhead	X	X	X
moho	X	X	
FALSE	X	X	X
harvest	X	X	X
hatchet deep	X	X	X
mid silks	X	X	X
bl silks		X	X
cramp	X	X	
crawl	X	X	X
andria	X	X	X
dale's reef	X	X	
lil bugle		X	
LBCNP		X	
Total <i>A. cervicornis</i> genets	14	20	11

Table IIb. Number and source location of *A. palmata* (APAL) genets/individuals at each of three outplant locations in southern Belize: Moho, Laughing Bird and South Silk Caye.

genet source APAL	Outplant locations		
	Moho	LBCNP	Silks
gladden buoy	X	X	
gladden pillar patch	X	X	X
gladden crest	X	X	X
loggerhead1	X	X	X
loggerhead2	X	X	X
bugle		X	
larks	X	X	
larks2	X		X
s silk caye s			X
s silk caye n			X
middle silk caye1			X
middle silk caye2			X
nursery patch silks1			X
nursery patch silks2			X
nursery patch silks3			X
french louie	X		
Mosquito caye1		X	
mosquito caye2		X	
mosquito caye 3		X	
17 genets from 2006		X	
Total <i>A. palmata</i> genets	8	28	12

Activity #5 Photo-mosaics, fish surveys and bleaching

Figure 5a is a graph of bleaching survey results in southern Belize sites showing results from some surveys conducted in November, December 2019 and January 2020. October was previously the peak bleaching time for Belize, so October results 2017-2019 are compared to results from November and December 2019, and January 2020, where surveys were done. The site names are on the X-axis and from left to right represent near-to off shore, the gap between two groups of sites separates sites near Placencia (L) versus sites in South Water Caye Marine Reserve (R), see map in Figure 5b. A continuing trend over the years is that off shore sites bleach more severely than near-shore sites, supporting the long held hypothesis that near shore sites have some level of thermal adaptation already (Fig. 5b). All are shallow sites (1-5m) with the exception of LBC Site 12, Wypt 16 and 1194, which are at depths of 12-14m on the fore reef. The results from deeper outer fore reef sites also revealed a similar counter-intuitive trend: the

deeper sites bleach more severely than the shallow sites (see sites on right side of X-axis from SWCMR)-the two fore reef sites bleached more severely than the shallow sites and remained bleached through January 2020 compared to the shallow sites (at less than 10% bleached). Each site represents at least 200 corals surveyed and the percentage of those surveyed that are partially or wholly bleached (Y-axis); the pale category is not included. Figures 5c-d are photographs illustrating severe bleaching on several species at Silks and Gladden (outer reefs) even in December 2019 and the inner caye sites (False and Bugle) in January 2020. Notably most acroporids (wild and replenished) remained resistant to bleaching in 2017 and 2019, a trend that was noted country-wide in Belize since 2017.

The Moho Caye photo-mosaics and fish surveys were conducted on schedule for three plots in January and February 2020. The LBCNP photo-mosaics are usually conducted each August; the fish surveys are usually conducted at the same time as the photo-mosaics. Figure 5a shows the transect tape for the belt survey over Moho plot 1, and Figure 5b illustrates different fish species at LBCNP. None of the fish data collected to date has been analysed (since 2018); FoH just entered a new collaboration with John Bruno's lab at the University of North Carolina (UNC); under his direction an undergraduate will put the data together and a post-doc will apply some statistics to the data. The photo-mosaics collected to date are not processed as yet due to restrictions at the University of Miami campus since COVID-19.

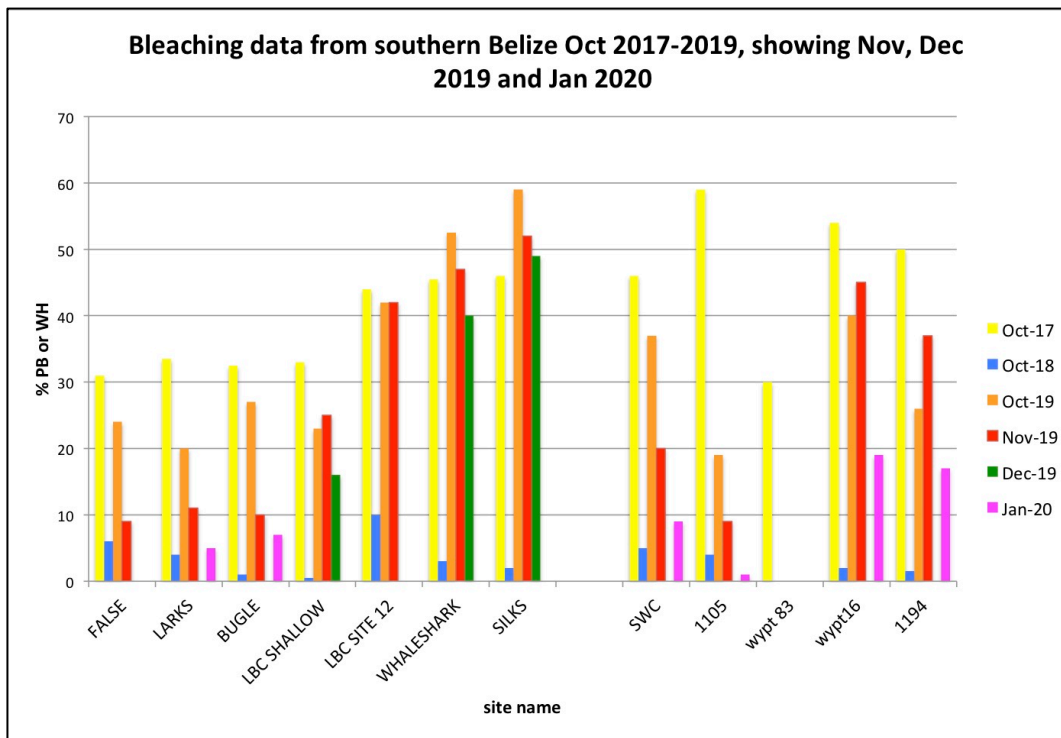
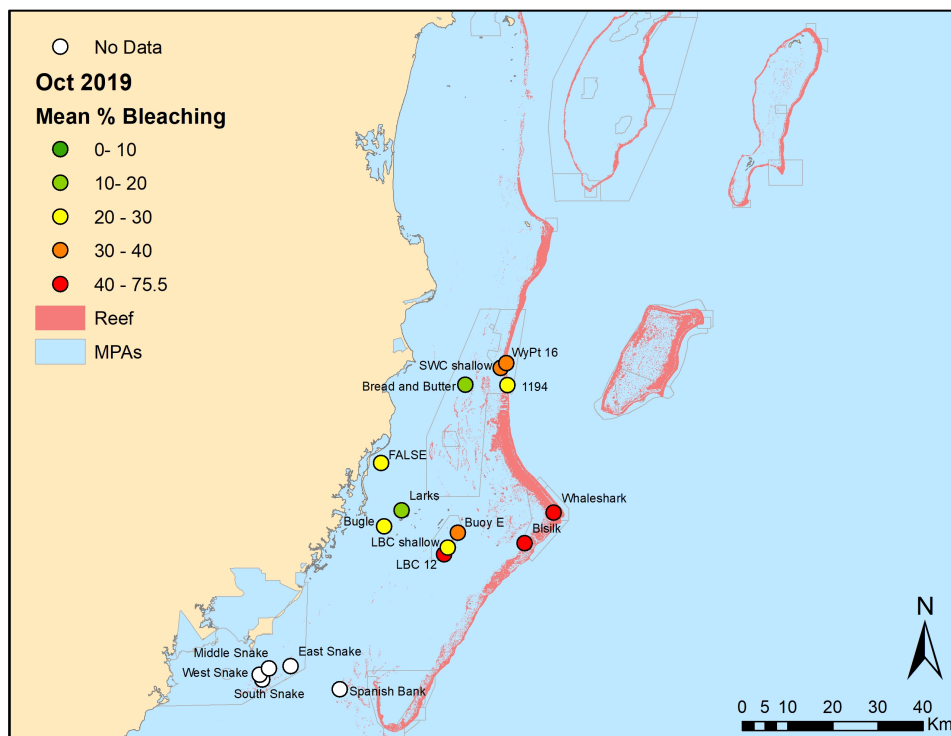
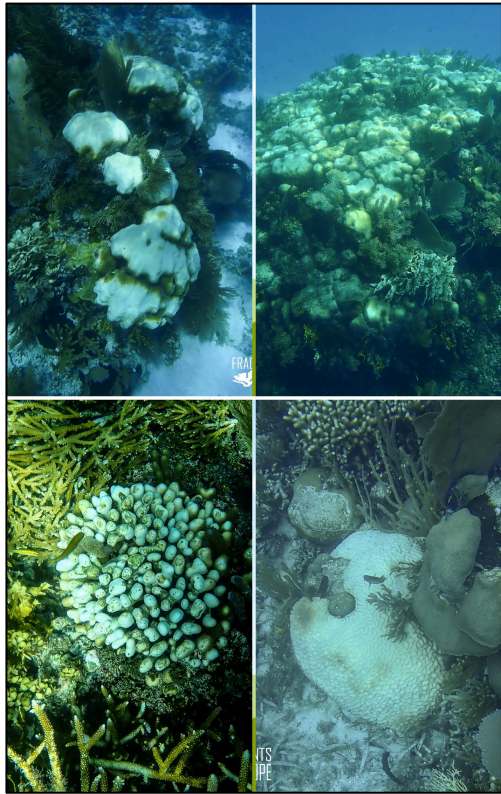


Fig. 5a. Comparing bleaching results from October (previously the peak month for bleaching in Belize) 2017-2019 to results in November, December 2019 and January 2020. Site names on x-axis are listed near shore-to offshore left to right, with sites in SWCMR on the far right. The y-axis is per cent of partially or wholly bleached colonies out of at least 200 corals surveyed.



Figs. 5b. Map of bleaching sites in Figure 5a for geographical (near shore/offshore) reference, data is from October 2019.



Figs. 5c-d. Images of bleaching corals from the outer reefs in December 2019 (L), and at near shore reefs in January (2020-R), including corals in the False Caye nursery (top R).



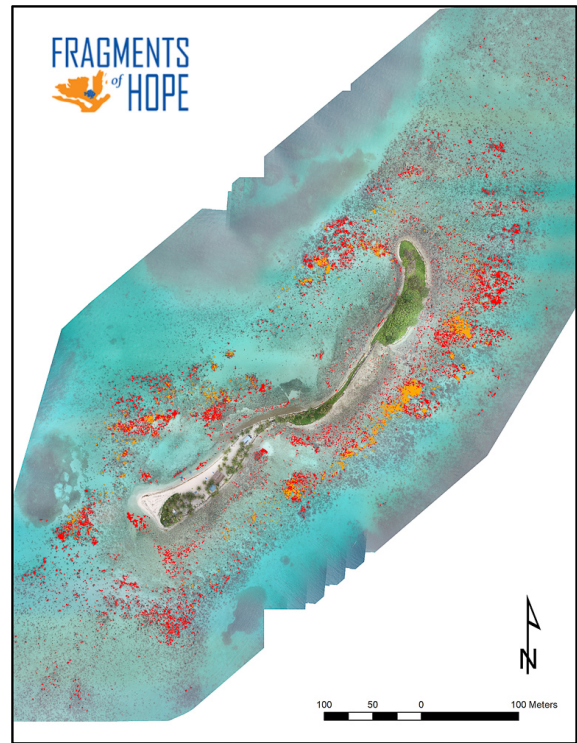
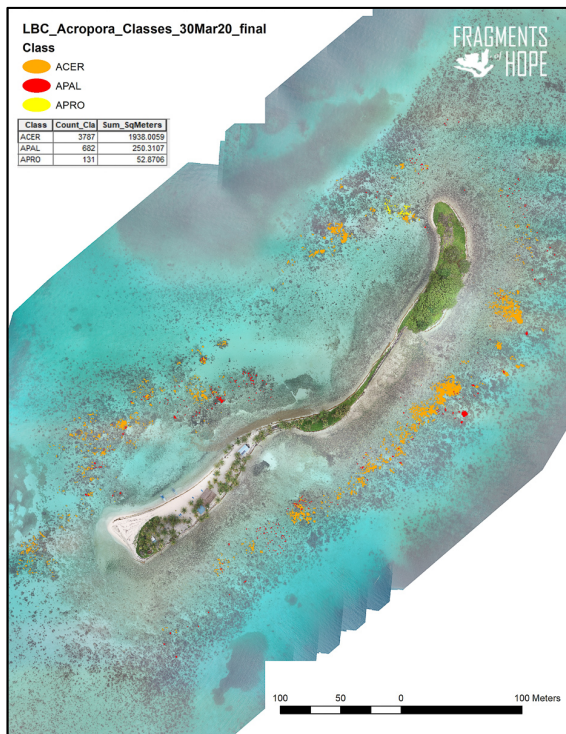
Figs. 5a-b. The transect tape for belt surveys (part of the fish surveys) at Moho Caye plot 1 (L) and examples of fish utilizing replenished acroporid habitat at LBCNP.

Activity #6 Recruits and training.

Training remained on-site, in the field only, no formal training workshops were conducted. New participants in this time frame include Tara Westby and Dwight Myvett. Since COVID-19 eliminated tourism, there have been many new requests from tour guides to get involved. In late May 2020 Fragments of Hope conducted on site training for nursery installation, *A. cervicornis* nursery ropes, and micro-fragmenting *D. cylindrus* for *in situ* nursery placement, in Hol Chan and Bacalar Chico Marine Reserve. This is in response to the reported SCTL D loss there and included two BFD staff from each of those reserves and two staff from the Caye Caulker Marine Reserve. The San Pedro Tour Operator Association (SPTOA) also requested on site training, but there was no time/room on this emergency planned trip. FoH hopes to work closely with the marine reserves in northern Belize and the SPTOA to train interested parties and together create a strategy for restoration efforts in light of SCTL D.

Activity #8. Mapping

Working remotely with Dr. Steve Schill, Lead Scientist at the Nature Conservancy, Caribbean Division, and one of his former students, Emily Peterson, maps of quantified, replenished acroporids were created for Laughing Bird Caye National Park (Figure 6a-b) and Moho Caye (Figure 6c). In Figure 6a, only the three acroporid taxa at LBCNP are highlighted in color: orange = 1,938m² *A. cervicornis*, red =>250m² *A. palmata* and yellow =>52m² *A. prolifera* (from July 2019). Figure 6b shows LBCNP with all three acroporid taxa in a single color (orange) and combined live and dead corals in red. Imagery was acquired on July 31, 2019 using a Phantom 4 Pro flying at 300ft AGL. The photos were captured in the early morning (7am-9am local time) to avoid sun glint. The 467 photos were processed into an orthophoto mosaic (2cm RGB) using Pix4D 4.5.2 and segmented using eCognition 9.5. Segments were then manually classified using image interpretation techniques. For simplicity, all three acroporids are highlighted in orange on the map. The red color represents a combination of live star corals (*Siderastrea siderea*, *Orbicella annularis*, *O. faveolata*), and dead coral including dead coral with encrusting sponge (*Cliona caribbaea*) or zooanthids (*Palythoa caribaeorum*). These other areas of live and dead coral (not including rubble) were estimated to cover just over one hectare. These results allow FoH to finally quantify their work at LBCNP and demonstrate that 21% of a hectare of the existing shallow fringing reef has been replenished with live acroporids. FoH will continue to work with Dr. Schill and others to refine this process and repeat the flights at all their sites on an annual basis.



Figs.6a-b. The left image shows the three acropora taxa color coded (orange =ACER 1938m², red=APAL 250m², yellow=APRO 52m²) versus the image on the right which combines all three acroporid taxa in one color, orange: Object-based classification of coral features based on an orthophoto mosaic (2cm RGB) acquired with a DJI Phantom 4 Pro flying at 300ft on July 31, 2019. The orange class represents all three replenished acroporid taxa (combined 2,190m²) and the red class represents star corals and dead coral structure, but not rubble (10,273 m²).

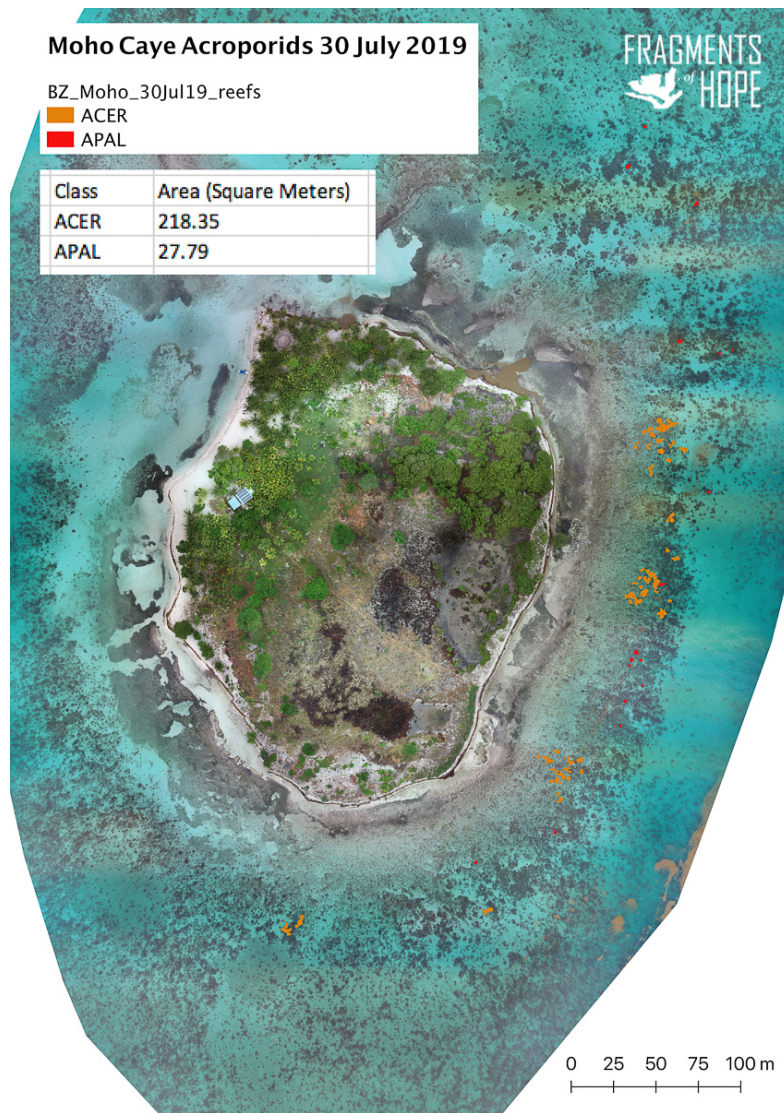


Fig. 6c. Object-based classification of coral features based on an orthophoto mosaic (2cm RGB) acquired with a DJI Phantom 4 Pro flying at 300ft on July 30, 2019. Here, the orange is replenished *A. cervicornis* (~218m²) and the red is natural/wild *A. palmata* (~27 m²).

4) **Problems and Constraints.** Although FoH received permission to continue outplanting during the State of Emergency, it came with a caveat of requiring the recommended social distancing in the boat, which required using a larger boat size than normally needed on each field day, which costs more than a smaller skiff and therefore the funds under this budget line were used up rapidly. COVID 19 also prevented Arthur Gleason from accessing campus at the University of Miami, so he could not process the photo-mosaics; FoH has requested a six-month no cost extension to allow him time for this activity. ICRS 2020 was cancelled, but accepted abstracts remain valid for proposed 2021 date, as do paid registration fees.

5) **Unexpected effects.** Because the interest in reef restoration has skyrocketed, with non-Belizean entities applying for research permits in Belize-the Belize Fisheries Department asked

the National Coral Reef Monitoring Network (NCRMN) to strengthen the Reef Restoration policy drafted several years ago (Annex I, pp. 2-4). Now the NCRMN is consulted by the BFD for any new research permit applications for reef restoration, in efforts to keep some standards in place for Belize. Lisa Carne was nominated to apply for the Pew Marine Fellowship this year, a three-year proposal, if awarded. The emergence of SCTLTD in Belize has also shifted attention to acroporid restoration, since these species are not susceptible to SCTLTD.

6) Learning and Sharing. In January 2020, FoH was invited to give a presentation to the University of Belize’s Integrated Coastal Management undergraduate course, visiting Placencia (the attendance sheet is shared in Annex I, p. 5). The 21 students, including 14 females, were extremely attentive and asked many questions (Fig 7a). In February 2020, FoH hosted a site visit to LBCNP via UNDP funding with the following regional and local agency representatives: UN Resident Coordinator, Deputy Resident Representative UNDP and wife (from Barbados), UN Coordination Analyst, SGP National Coordinator Cuba, Soil Scientist INIFAT Cuba, SGP National Coordinator Belize, SGP UB Intern, NSC Chairperson, UNDSS Security (Fig. 7b). Discussions on the site visit were lively and included a Cuba/Belize exchange proposed the SGP National Coordinator for Cuba, for coral restoration, sponge farming, and also a recycling initiative in Cuba that repurposes all types of plastic into outdoor furniture such as picnic tables, lawn chairs, refuse containers. At the time the exchange was planned for end of 2020 but due to COVID 19 is likely postponed. In early March 2020, for Reef Week, FoH gave an invited presentation to high school students from Chunox, hosted by the Belize Audubon Society, at Cockscomb (Annex I, p. 6). The following day FoH trained restoration practitioners and licensed tour guides accompanied the group to LBCNP.



Figs. 7a-b. L. Carne presenting to UB’s Integrated Coastal Management undergraduate course January 2020 (L) and group photo at LBCNP with local and regional UN and SGP representatives.

7) **Adaptive Management.** Because the SCTLD was reported in Hol Chan Marine Reserve (HCMR) in March 2020, and confirmed in Caye Caulker Marine Reserve (CCMR) by early May 2020, FoH switched focus to accommodate the urgent request from BFD and these marine reserves (including Bacalar Chico Marine Reserve, BCMR) to install two ‘emergency’ table nurseries in BCMR and HCMR with a focus on the pillar coral, *Dendrogyra cylindrus*, as this species is rare and highly vulnerable to SCTLD. While FoH has had success working with this species in sites near Placencia and in South Water Caye Marine Reserve (SWCMR), this has been in the absence of any SCTLD and most of if not all the reefs in the northern marine reserves now have SCTLD in varying degrees of severity (number of colonies affected). Therefore, the agreed upon restoration strategy is to continue focusing on acroporid population enhancement in the worst case scenario that many other coral species will succumb to SCTLD. In this light, FoH did on-site training with three different marine reserve staff (two staff from each marine reserve) for nursery installation, set up staghorn ropes on their two nurseries in addition to a crash course in micro-fragmenting for the pillar corals.

8) **Communications/ Stories.** Andrea Polanco from Belize Channel 5 made a site visit to LBCNP after the Belize City meetings in October 2019, and aired an in depth news piece on FoH and LBCNP, and the 2019 bleaching event in December 2019 entitled “Fragments of Hope reseeded and replanting Belize’s reef”, saved on YouTube⁵ and re-shared on FoH’s social media pages. In February 2020 FoH met with World Bank representatives and their film crew in Turneffe Atoll Marine Reserve to demonstrate outplanting under the MCCAP Project and with the Belize Fisheries Department (BFD), and Turneffe Atoll Sustainability Association (TASA). Their team produced a short video entitled, “Investing in Nature, Investing in the Future of Belize”: released in time for Biodiversity Day, and shared again for World Ocean’s Day. It has almost 2,000 views on YouTube⁶, and has been shared widely on the World Bank Caribbean, the Adaptation Fund and FoH’s social media pages. The World Bank also featured FoH on the World Bank website in an article here:

<https://www.worldbank.org/en/news/feature/2020/05/20/investing-in-nature-investing-in-the-future-of-belize>. Lisa Carne was invited to speak about the 2019 bleaching event to conservation partners/stakeholders in Belize City during the Healthy Reefs Initiative Report Card launch on February 13, 2020 in Belize City. Fragments of Hope also had two time slots on KREM TV during Reef Week in March 2020 when it was broadcast from Cozy Corner restaurant in

⁵ <https://youtu.be/sQKJMScZHq8>

⁶ <https://youtu.be/em6FyhoZJDK>

Placencia (Fig. 8a). L. Carne was invited to discuss the health of Belize’s reef on the LOVE TV morning show, June 17, 2020 (Fig. 8b). Organized by WCS to celebrate Fishers’ month in Belize, other guests were N. Bood (WWF) and N. Craig (HRI); the Facebook live video had over 6k views⁷ (the reef discussion is the last hour of the program). An article was published in the German magazine Galore, which features in depth interviews⁸.



Figs. 8a-b. Three FoH representatives on the Krem morning show broadcast live from Placencia for Reef Week March 2020 (L), and screen shot of live LOVE TV morning show June, 2020.

9) **Challenges.** See Section 5 **Problems and Constraints.** COVID 19 has been a challenge for everyone, FoH included. FoH did received special permission to continue outplanting from the Belize Fisheries Department and the regional police under “aquaculture” and later the SI was changed and officially listed all environmental organization as ‘essential workers’. SCTLD has presented a challenge with a shift in national reef priorities right before FoH outplanting season ended (when hurricane season begins, June 1).

10) **Overall Assessment of Progress.**

While the amount of coral outplants is less than originally planned, given the multiple emerging issues (extreme bleaching, SCTLD, COVID-19) and (now) regular adverse weather set backs, progress completed in this time frame is satisfactory. FoH greatly appreciates consideration for the six-month no-cost extension, to allow for processing and annotating the photo-mosaics, as well as analysing the fish data for the final report.

⁷ <https://www.facebook.com/lovefmbelize/videos/577077976293155/UzpfSTExNjgzMTQ0NjI6MTAyMjAzMTc4NTQ5NTQzNDU/>

⁸ <https://www.galore.de/interviews/people/lisa-carne/2020-01>

07?fbclid=IwAR2EwJT9pey9BqS8PAvDb5qBcszJEOcDogrIKH5t4ENOUqjShYbtQuc-2ao

Report completed by:	
Name	Lisa Carne
Position/ Title	Executive Director/Founder
Organisation	Fragments of Hope
Date	30 June 2020