



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:	January 23, 2019 –July 25, 2019: Report 3 Summary of work to date
Organization Submitting Report	Fragments of Hope

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1) Project Overview.

Outplanting corals (Activity #5) only occurs December-May of each year and almost 8,000 fragments were outplanted in four targeted sites in Southern Belize during this time frame. Much of the emphasis this year was on the latest technique: direct outplanting of micro fragments. Almost 300 staghorn corals from seven different genets were added to three different nurseries sites (Activity #3), bringing the total number of different staghorn genets in the nurseries to 14. Maintenance and monitoring of both coral nurseries and coral outplants occurs June-November of each year and has commenced. This includes structural maintenance/reinforcement of coral nurseries and regular cleaning/removal of fouling organisms (Activity #2). Monitoring of nursery corals (Activity # 4) includes survivorship, growth rate collection, surveying for bleaching and disease on 23 nurseries in eight sites in southern Belize (13 tables, six domes, four A-frames), and *in situ* temperature data collection, this has commenced and will continue over the next report period. Monitoring of existing coral outplants (Activity # 6) includes fish surveys and photo mosaics collected annularly on three sites at Moho Caye (January) and six sites in Laughing Bird Caye National Park (LBCNP). The photo-mosaics at LBCNP 2014-2018 and at Moho Caye 2015-2017 are summarized in this report, as well as the fish surveys at both sites. Training and recruitment of new participants (Activity #7) continues year round, with specific activities based on the time of year described above. Results were shared internationally, regionally and locally at three forums (Commonwealth Blue Charter in Australia, AMLC in the DR and the UB NRM) (Activity #8) during this time frame and monthly articles were contributed to the local Placencia Breeze, as well as all social media accounts kept updated. Fragments of Hope was

also featured on a German public television news program and in the Christian Science Monitor during this time frame.

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

- 2) **Project Successes.** FoH is sharing their results using photo-mosaics as a case study in a CRC/TNC hosted webinar on 25 July, 2019. Since Belize is co-champion with Australia and Mauritius for the Commonwealth Blue Charter Reef Protection and Restoration action group, FoH along with the Belize Fisheries Department was invited to present results at the meeting in Townsville, Australia early July 2019. FoH was featured on the German public television ARD (equivalent to PBS) prime time in early June, resulting in several donations to the website. The feature, albeit in German, can be seen at this link: <https://www.daserste.de/information/politik-weltgeschehen/weltspiegel/videos/Belize-das-gerettete-Riff-video-100.html?fbclid=IwAR0wcWoHxKd8RTMEFXdss-9pkLxxYfa3k7Vdw72tUEfB4XW0Mfm-COtw3QQ>. FoH was also featured in an article published last May in the Christian Science Monitor entitled, “Reef restored: How Belize saved its beloved coral”.¹ Buoyant growth rates for a star and brain coral species were shared by collaborators at the University of North Carolina who compared near-and off shore results by using the FoH False and Silk Caye nurseries for their experiments.

3) Progress on Activities and related financial issues.

Activity #2. Maintenance of over 16 nurseries in southern Belize continues, with regular cleaning and reinforcement of structures.

Activity 3# & #4. Since January 2019, 294 replicates of seven staghorn genets have been added to three different nursery sites in southern Belize. Total Linear Extension (TLE) growth rates

¹ <https://www.csmonitor.com/Environment/2019/0515/Reef-restored-How-Belize-saved-its-beloved-coral>

continue to be collected, and comparative growth rates for 14 different *A. cervicornis* genets in five different nursery locations are shared in Figure 1. Each genet has ~ 30 reps in each nursery and averages are made per 30 days for a monthly TLE rate-the caveat is that some genets are in the nurseries longer (44-91 days) than others, and the longer they are in the nurseries the higher the averaged growth rates becomes as they create more branches. The general trend observed for over ten years, of faster growth rates in near shore and more shallow nurseries, holds true (blue bars are outer reef nursery, Silks), with the one genet exception (Hatchet) because those corals have been in the Silks nursery 91 days versus only 44 days in the near shore nurseries (LBC and Moho)-at least one more set of measurements will be taken for these corals. This trend was also confirmed by collaborators at UNC with a brain coral (*P. strigosa*) and star coral (*S. siderea*) using a buoyant weight method for change total mass (growth rates), see Figure 2. The brain corals all grew faster in the near shore (False Caye nursery) and most telling, the transplanted offshore sourced (Silk Caye) star corals grew fastest in the near shore nursery. One theory for faster growth rates near shore is that higher nutrients (if not excessive) can boost corals' growth rates.

Temperature data is retrieved annularly from the *in situ* loggers, and will be collected over the next progress period.

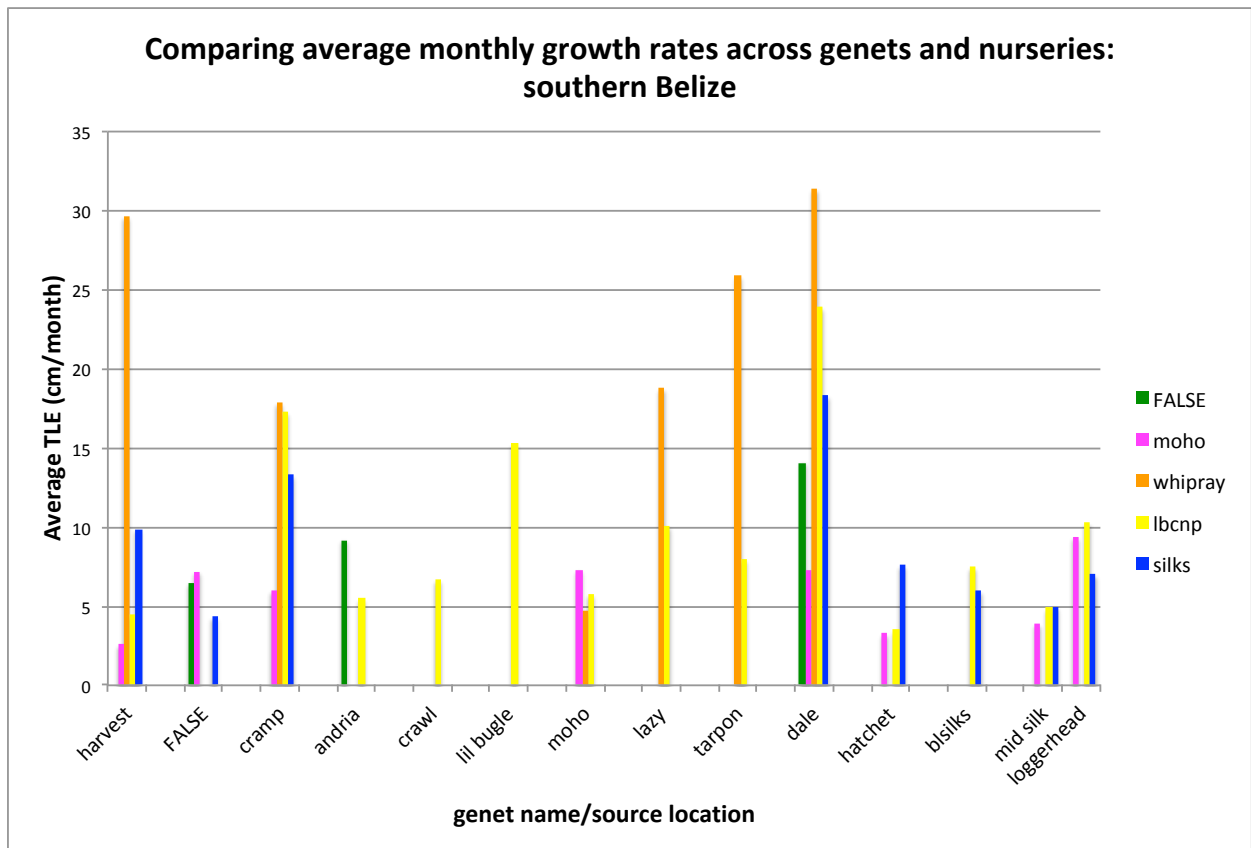


Fig. 1. Comparing averaged Total Linear Extension growth rates (y-axis) per 30 days for 14 different *A. cervicornis* genets (X-axis) across five different nursery locations (colors, legend) in southern Belize.

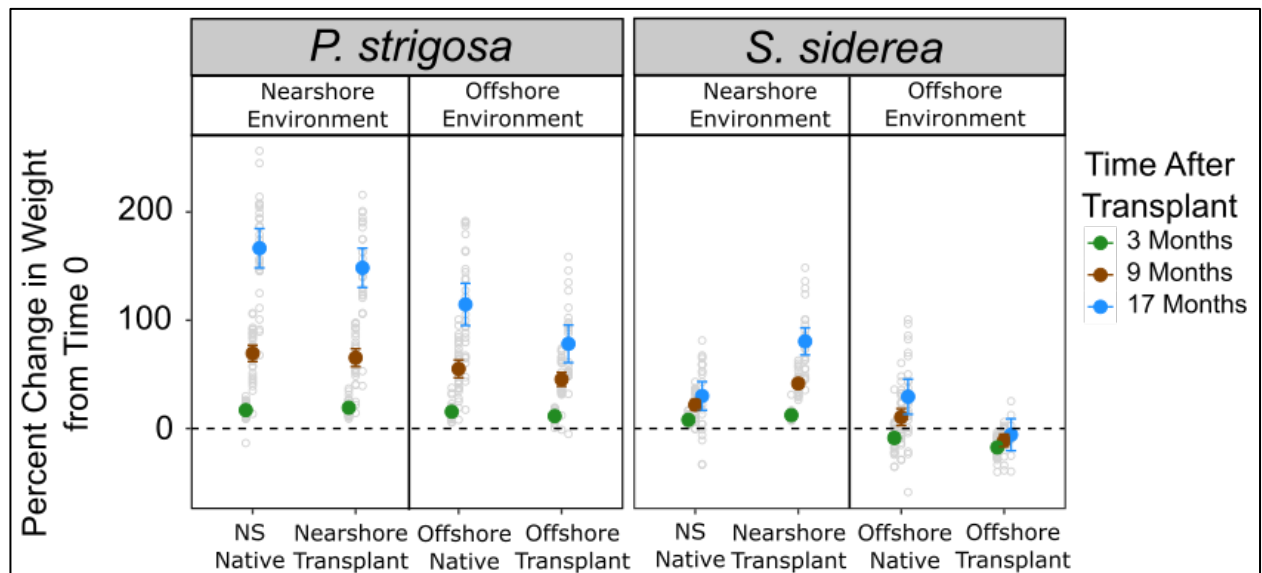


Fig. 2. Data from UNC colleagues' experiment using FoH nurseries at False (near-shore) and Silk Caye (off-shore) nurseries, comparing growth rates using buoyant weights for a star and a brain coral species in a reciprocal transplant experiment for 17 months.

Activity #5. During this year, based on initial successes 2017-2018, the emphasis for outplanting was on the newest technique: direct outplanting of micro fragments, especially for *A. palmata*, eliminating nursery time. FoH purchased a portable generator to facilitate working on remote cayes with the diamond blade saw (Fig. 3). While we anticipate with continued practice the team will become more efficient, to date the most micro-fragments outplanted in one day was just over 500, compared to thousands achievable with the faster growing, more branching, nursery-grown *A. cervicornis* and *A. prolifera*. The focus for these latter species had been to clean off the nurseries and outplant them all, as until recently, it was unknown if funding was secure for the next year in southern Belize.

In addition to the *A. palmata*, trials with just a few replicates have been made with directly outplanting *O. annularis* and *M. cavernosa*, both of which were sourced from a 2009 nursery. After April, the donated larger table saw from UNC froze up, and while FoH is working to source repair parts, a smaller saw was purchased in country.



Fig. 3 Example of micro fragmenting with table saw (diamond blade) and portable generator, on remote offshore caye (this is Middle Silk Caye) in GSSCMR.

Table I. List of outplanted corals by site name, species/taxa, totals for January 2019-May 2019 and total number corals at each site on the far right column.

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

Activity #6. Monitoring coral outplants is best achieved by using photo-mosaics on representative smaller plots (40-180m²) combined with CPCe software to calculate changes in coral cover and other benthic organisms. Figure 4a illustrates these results to date: no additional corals are added to any of these sites, so the yearly increases (see Fig. 4b) is all natural growth and spreading: the decreases in yellow (2016) are from Hurricane Earl, a Category One storm that passed in August of that year. However the majority of the sites completely rebounded by 2017 (green bars) and seemed invigorated by 2018 (blue bars). Figure 4c is a photograph of sub-site 21, taken in July 2019. This growth pattern for sub-site 21 is circled in Figure 4b where each year the growth increases; after the 8% loss in the storm coral cover increased by 10% and then by 17% in the following year.

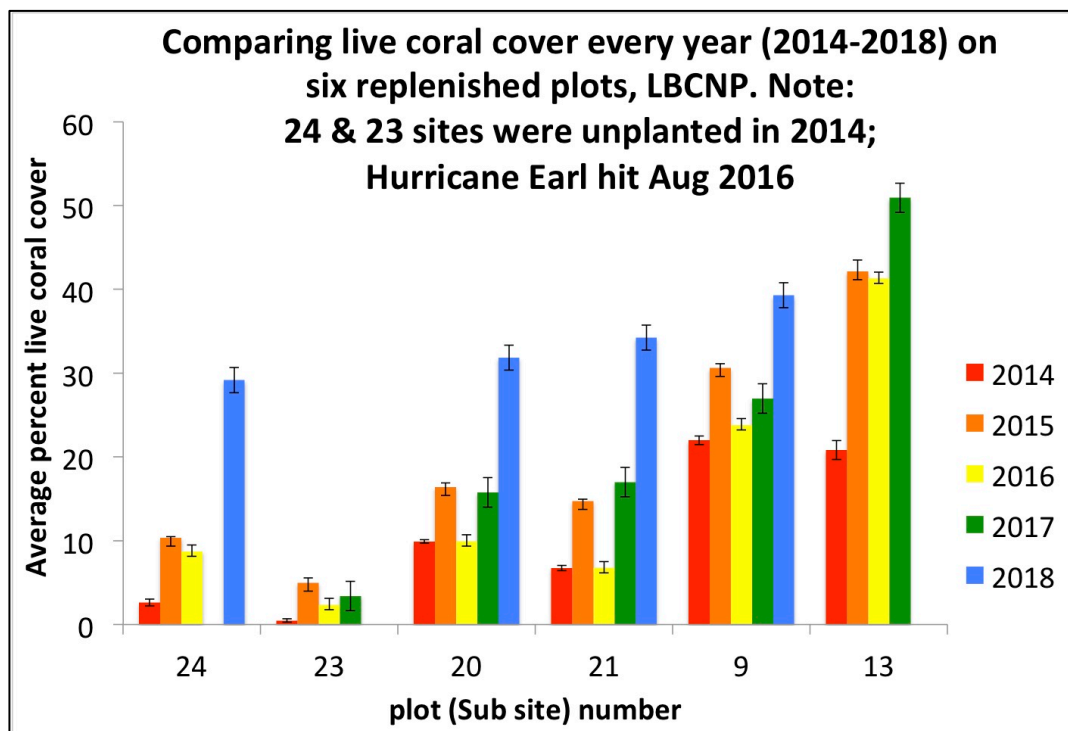


Fig. 4a. Total live coral cover (y-axis) on six plots at LBCNP (x-axis) assessed with photo-mosaics and CPCe software by year (color/legend). Note that only #23 & #24 were unplanted in 2014, all other sites had already been outplanted in 2014. However, no new corals are added in these plots, so all yearly increases are natural growth (and decreased in 2016 from Hurricane Earl).

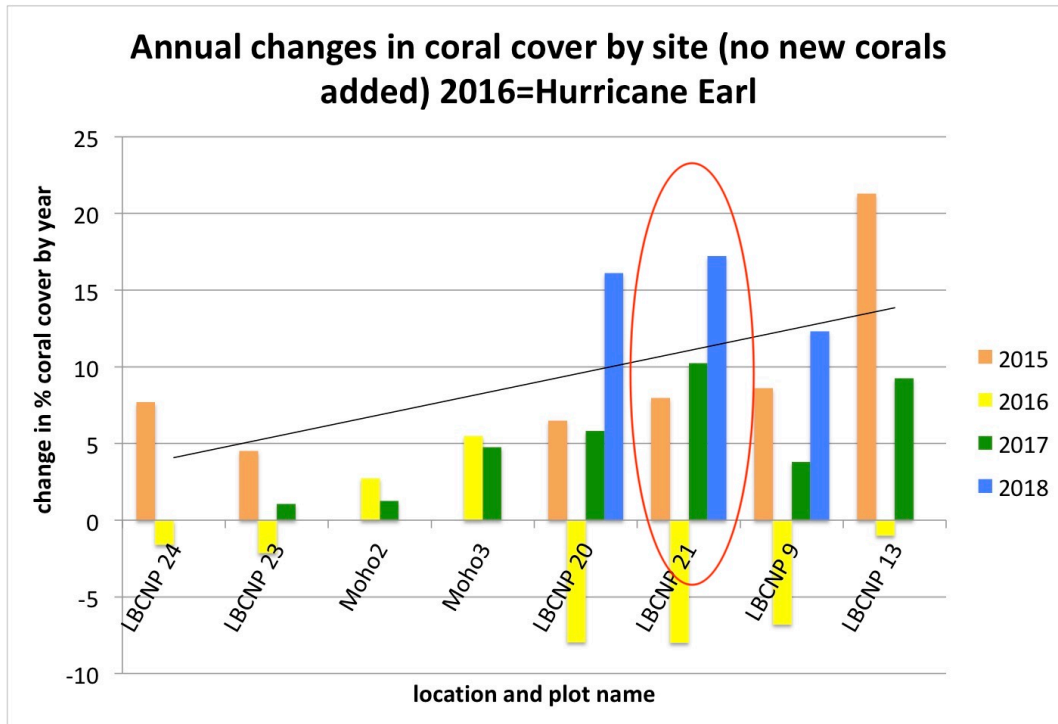


Fig. 4b. Illustrating the annual changes in coral cover (y-axis) by site (x-axis). Yearly changes are color coded.



Fig. 4c. Sub-site 21 at LBCNP was outplanted in Feb-May of 2014, first ‘mosaiced’ in August 2014, and despite being flattened by hurricane Earl in 2016, by 2018 had almost 35% live coral cover from a baseline less than 6%-without adding any additional corals. Photo taken July 2019.

At near-by but outside of the MPA, Moho Caye, the outplanting did not begin until December 2015, and the three plots were mosaicked prior to outplanting. Here only staghorn genets (and a few *A. prolifera*) were outplanted. One data set (Moho plot 1, 2016) is still being processed by Dr. Art Gleason. Unlike at the 2016 plots at LBCNP, which were mosaicked immediately following hurricane Earl, the 2016 plots at Moho were completed ~ five months after the storm. The live coral cover on plots 1 and 3 more than doubled in two years; plot 2 is very shallow, on the windward side, and mostly rubble, so when disturbed, loose staghorn fragments may not as easily catch back as they do on plot 3, which had more rugosity to being with, albeit less live coral cover, from large dead *A. palmata* stands. Moho plot 1 is a little deeper, on the south side of the caye, and also far more rugose with many large star corals, thus allowing faster growth in the same time period (see Fig. 5a). Both plots 1 and 3 were outplanted with ~ 11 frag/m² in December 2015.

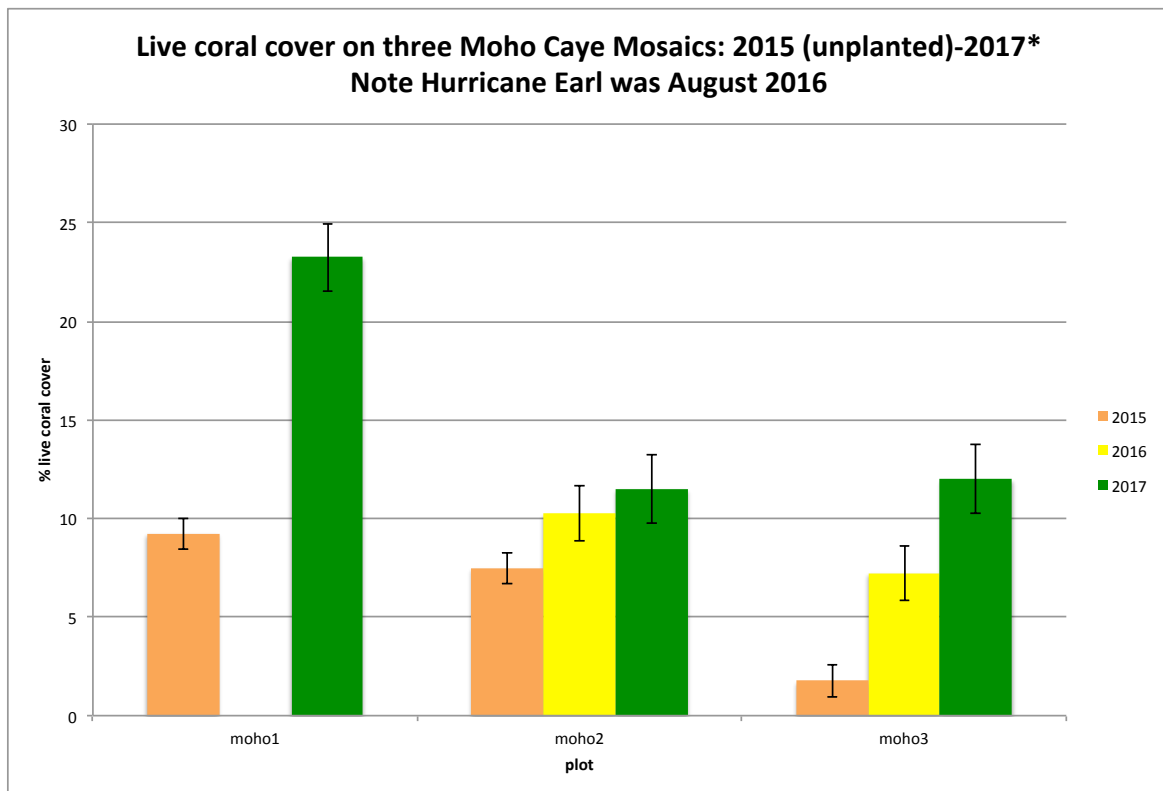


Fig. 5 Results at Moho Caye using photo mosaics and CPCe: all three plots were unplanted in 2015 (orange bars); Moho plot 1 2016 is still being processed by Dr. Art Gleason.



Fig. 5a. Moho plot 1 went from < 10% live coral in 2015 to almost 25% live coral two years after outplanting, in 2017 (see Fig. 5a). This photo is from March 2019.

Fish surveys are conducted annually on the same plots as the mosaics at both LBCNP and Moho Caye using a protocol designed by Dr. Kes Kaufman (Boston University) in 2014. The diver surveys the inside and outside of the plot perimeter, and also across a traditional belt transect (30m) laid across the plot. The size classes are in 5cm (vs 10cm) increments, and every fish species is meant to be documented, not just the traditional species in typical fish surveys. For ease in comparing at both locations (protected and unprotected) and over time, results from the six plots at LBCNP and the three plots at Moho Caye were averaged and are shown in figures 6a-b by plot and belt results. There are three control sites, which are all natural staghorn stands, outside of MPAs, in the near shore inner reefs, close to Placencia. In the plot analyses (Fig. 6a) there appears to be a downward trend on all sites over time, for reference, the latest HRI Report Card (2018) lists an average of almost 62g/m² for the southern barrier reef ‘complex’², although they use different methods and reporting (commercial and herbivorous fish per 100 m²). So in general, the fish biomass is much higher at all three surveyed locations than the average for the entire southern barrier reef complex. Because the belt data does not show the same decreasing trend over time, there may be diver interference when collecting the plot data, as these surveys are typically done at the same time the mosaics are being conducted. Furthermore fish data collectors changed in 2018. Both data sets reflect similarities in fish abundance for LBCNP and the control sites, which is logical as these have the highest acroporid coral cover. Further

² <http://www.healthyreefs.org/cms/wp-content/uploads/2012/12/2018-MAR-Report-Card-Web.pdf>

analyses will be shared reflecting the changes in fish community groups, and adding 2019 data, in subsequent reports.

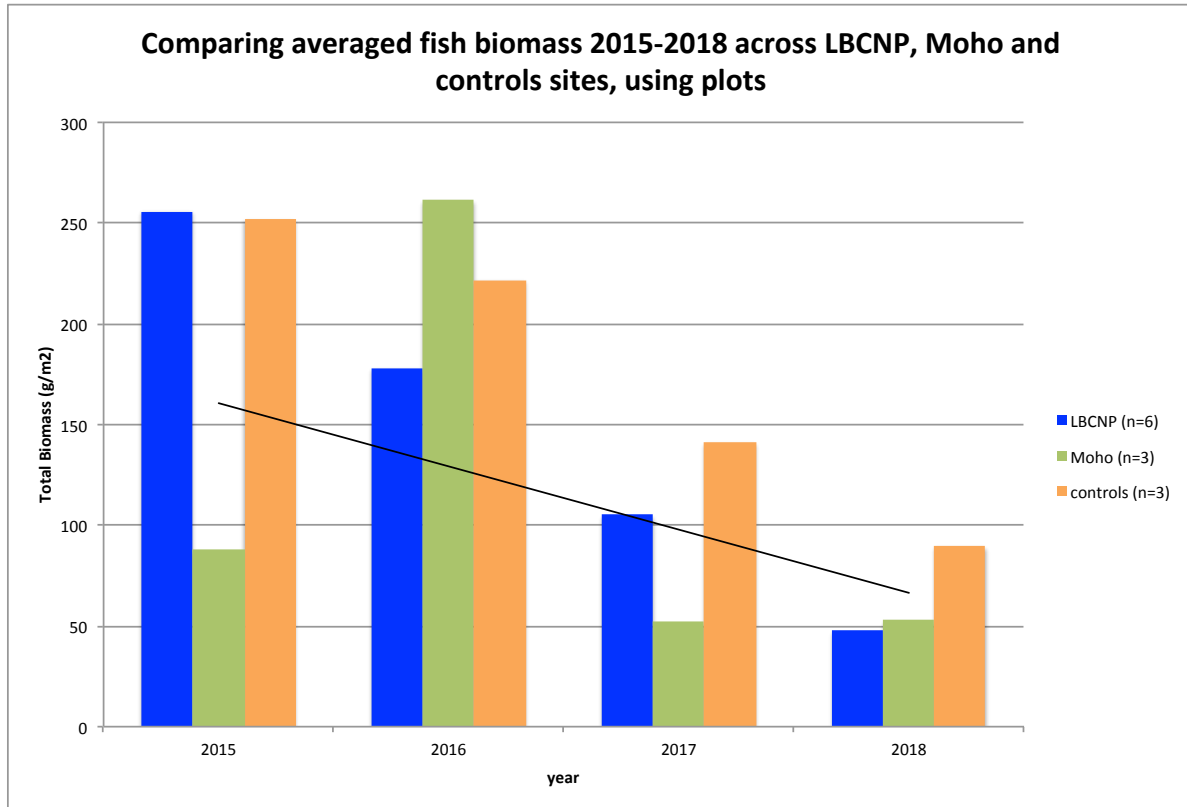


Fig. 6a. Fish data from the plot surveys at LBCNP (n=6), Moho Caye (n=3) and control sites (n=3) 2015-2018. LBCNP is fully protected No-Take Zone whereas Moho Caye and the control plots are unprotected.

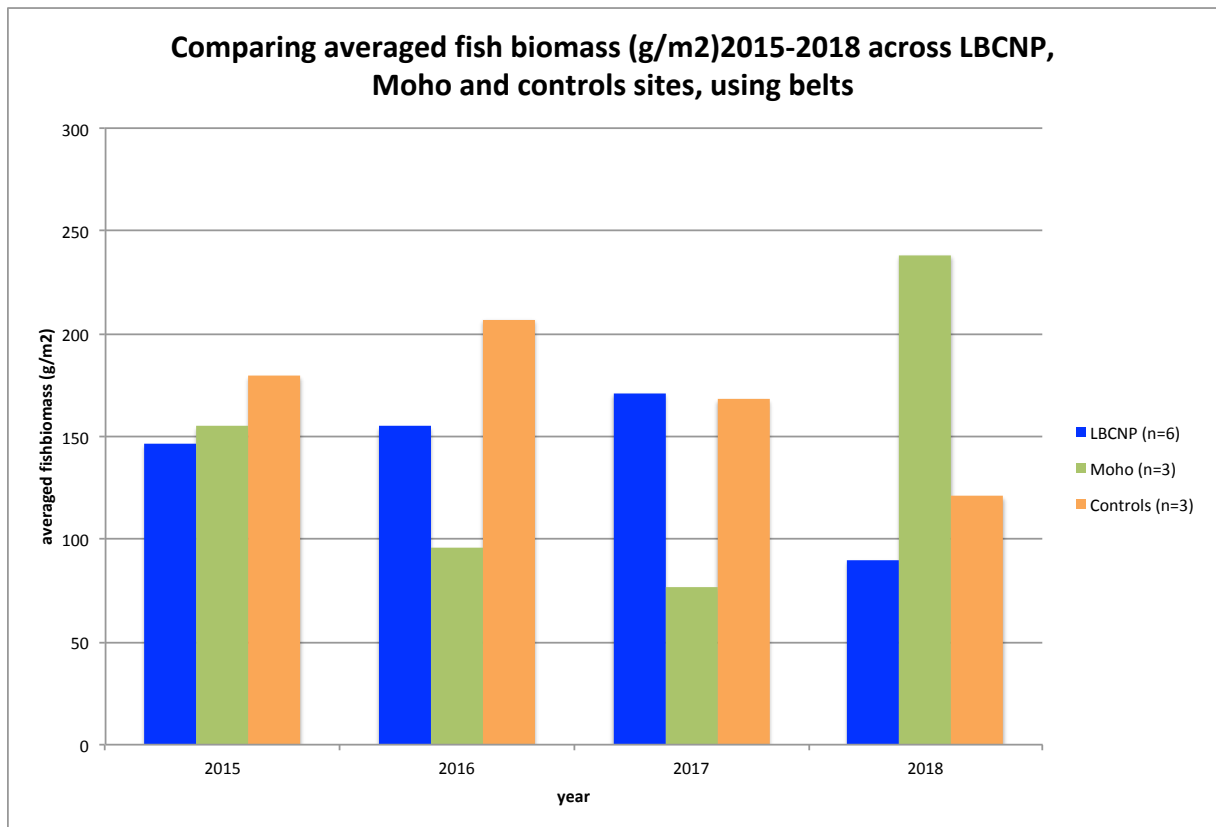


Fig. 6b. Fish data from the belt surveys at LBCNP (n=6), Moho Caye (n=3) and control sites (n=3) 2015-2018. LBCNP is fully protected No-Take Zone whereas Moho Caye and the control plots are unprotected.

Activity #7 Recruits and training. FoH completes its annual formal training workshop each year in mid-January (2016-2019). Prior to creating this formal curriculum, and outside of the scheduled dates, FoH allows interested Belizeans to volunteer, enough times and per activity, until they acquire the skills to earn the daily stipend. For example, Ms. Nancy Young, working on her tour guide license and just 20 years old, mother of two, has volunteered enough times to be sufficient at adding new staghorn corals on the ropes and taking Day 0 growth data, but she cannot yet outplant corals. FoH also hosted two members of the San Pedro tour operator group that installed nurseries there, on an outplanting day last March. FoH has regularly used Jonathan Natividad, a resident of Hopkins, and David Ortiz (from Placencia) since they took the formal course last January.

Activity #8. Reporting/record progress & findings. This is the 3rd report for WWF since July 2018. Much more analysis time needs to be spent on both the benthic and fish community changes over time at LBCNP and Moho Caye; this will be in the next report. Snapshots of data analysis updates are shared on social media pages, and later this year further stakeholder consultations will be scheduled to present the latest findings.

4) **Problems and Constraints.** FoH has multiple concurrent funders and grants, and all want their reports at the same time, invariably, so flexibility in reporting due dates is much appreciated. FoH is also experiencing growing needs for additional full time staff-although FoH now has an Outreach Officer, that does help with basic administration needs, FoH needs to identify either staff, consultants or collaborators to assist with the ever growing volume of data collected needing to be analysed and reported on, and ideally, published. Other issues may be the fish data collection protocol; this may need revisiting, and the fish data may need to be collected more often. Dr. Gleason currently processes all of the FoH mosaics, which often leads to a lag time or bottleneck; FoH is working with Dr. Gleason on how best to address this, although this is still the plan for the LBCNP 2019 mosaics to be collected soon (and the 2019 Moho mosaics already collected).

5) **Unexpected effects.** FoH has been invited to a NSF grant by Dr. Iliana Baums, who believes that due to new advances in acroporid genetic analyses, and having visited FoH sites last year, that we can finally ask whether or not phenotype correlates with genetics, using a set of morphological and ecological characteristics (e.g. bleaching history, disease resistance, growth rates, etc.). Ms. Carne was also invited to nominate two individuals for the Pew Fellowship; Dr. Baums and Dr. Gleason were selected, and she herself was nominated but needed to defer until next year. FoH has also been invited by WWF and TNC to partner for IKI grants for restoration in Belize, and the Getch Foundation has donated private funds to PACT for restoration work. FoH collaborators at UNC successfully applied for funds from the Rufford foundation, that were given directly to FoH (~BZD\$35k). Dr. Janie Wulff (sponge expert) returned to LBCNP end of April to assist with several sponge transplant experiments, in hopes that ‘good’ sponges may inhibit ‘bad’ sponges from compromising corals (see Figures. 7a-b). More details will be shared on this trial in subsequent reports: in total five different “good” sponge species were transplanted in hopes of inhibiting the ‘bad’ encrusting sponge species (*Cliona tenuis* or *Cliona caribbaea*) seen in Fig. 7b (the dark brown).



Figs. 7a-b. On the left is a natural occurrence of the sponge species *Amphimedon compressa* interacting with acroporids in a LBCNP nursery, and on the right is an example of a transplanted sponge species, *Verongula rigida*.

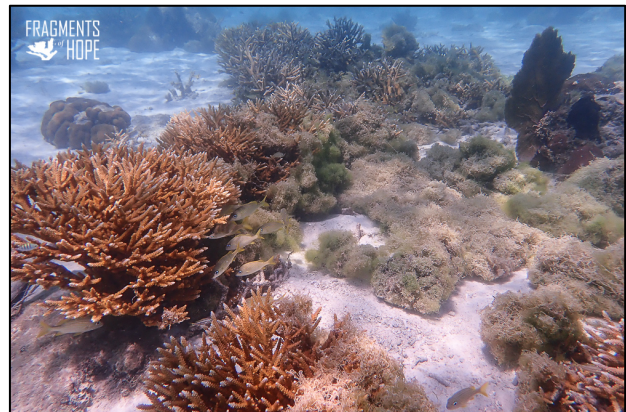
6) Learning and Sharing. June 2019 was exceptionally busy with the planned Mexico portion of the MAR Fund Belize/Mexico exchange, and several planned and unplanned university and other visitors to LBCNP. UNC came for their last data collection under the Rufford awarded to FoH, the University of South Florida brought environmental engineering and anthropology students under their program “Strong Coasts”, the University of the US Virgin Islands sent both undergrads and grad students here, as they will soon begin restoration in their islands, but they also shared their recent experience with SCTLTD in the UVI. The GIS Citizen Science group, also from University of South Florida visited again with their drones, but as in 2018, the resolution of the work done at LBCNP is only good for shoreline changes and not for mapping shallow reefs. Dr. Steve Schill from the TNC Caribbean Program will be arriving end of July to train FoH and a few BFD staff on the use of drones for mapping live shallow reefs. Over the last project period FoH also hosted a German public TV news crew, The Getch Foundation and their video team,

7) Adaptive Management. Since Stony Coral Tissue Loss Disease (SCTLTD) has been reported in Bacalar Chico (June 2019) FoH has worked with HRI and BFD to take the lead on response. Earlier this year through a contract with GCFI and partnership with MPA Connect, FoH produced underwater ID cards of the disease, and awareness posters, all distributed in the NCRMN and to local dive shops. FoH and HRI appeared on the Open Your Eyes morning talk show to alert viewers. FoH will work with HRI and MAR Fund to secure emergency response funds as the disease is known to spread rapidly and in the USVI, followed water currents.

8) Communications/ Stories. The FoH full time Outreach Officer, has submitted updates in each monthly publication of the Placencia Breeze, which is distributed peninsula wide with hard

copies (free) and posted online via their Face Book page³ and on a website⁴ as well. FoH was featured in the ARD German public TV news show, and the Christian Science Monitor. FoH will also share their results from the photo-mosaics as a case study in the webinar on photo-mosaics hosted by CRC/TNC on July 25, 2019.

9) **Challenges.** See Section 5 **Problems and Constraints.** Unpredictable weather patterns also continue to be a challenge, although expected. Another new challenge was the increased amount of visitation (tourism) this year: many days it was difficult to get enough SCUBA tanks, and there was increased impact evident at both LBCNP and Moho Caye from higher visitation, both physically, and by an high nutrient-indicator green algae species, *Chaetomorpha linum* that while seasonal, is in higher abundance than any year previously at LBCNP (Fig. 8a-b) since it was first observed in 2015. FoH has requested permission to physically remove as much of this as possible from the corals and is waiting to hear back from SEA and the Forestry Department.



Figs. 8a-b. The green algae species, *Chaetomorpha linum*, a high-nutrient indicator species, at LBCNP. Photos from July 11, 2019.

10) **Overall Assessment of Progress.** FoH is current with its expected deliverables for this WWF project timeline, with the exception of the slight delay on this report, and the next priority steps include continued monitoring of nurseries and outplants-with the LBCNP 2019 mosaics scheduled for August 2019 (Moho mosaics were conducted in January 2019 but not yet processed). Monitoring emphasis will be on bleaching (with an Alert from Belize already issued from the NOAA Coral Watch program) and disease, since SCTLD has been identified in Bacalar Chico and is known to spread rapidly. Outplanting will resume, weather permitting in December.

³ <https://www.facebook.com/ThePlacenciaBreeze/>

Report completed by:	
Name	Lisa Carne
Position/ Title	Executive Director/Founder
Organisation	Fragments of Hope
Date	22 July 2019

Thank you!