Fragments of Hope 2022 Summary report for Research Permit renewal 0010-22

Repopulate reefs within replenishment zones of Turneffe Atoll Marine Reserve and South Water Caye Marine Reserve with temperature resilient coral varieties and Continued reef replenishment with the critically endangered acroporid corals in southern Belize.

Abstract

Lisa Carne and Fragments of Hope (FoH) have been conducting active reef replenishment in Southern Belize since 2006, and in Turneffe Atoll Marine Reserve (TAMR) and South Water Caye Marine Reserve (SWCMR) since 2016. While trial replenishment work began in HCMR in 2011, it was revitalized in 2020-2022. This report summarizes work completed in 2022. Active reef restoration focus shifted in 2022 back to the Northern MPAs because of funding secured from UNEP for those MPAs but monitoring continued in all MPAs/locations listed on the Research Permit. FoH conducted two reef replenishment training courses (northern Belize in March and southern Belize in November) with a total of 20 participants. FoH outplanted a total of 9,273 corals in 2022 in nine different sites across five MPAs and two unprotected sites. A new table nursery site was established in Mexico Rocks; there are now five coral nurseries in the northern MPAs and 28 country wide.

SCTLD surveys and treatment were also a major focus in 2022. FoH conducted a total of 28 disease surveys in 2022, and treated 399 SCTLD affected coals across 14 sites in southern Belize. FoH completed 17 surveys specific for bleaching and funded another 12 site assessments via partners TIDE (the Toledo Institute for Development and Environment) and the Belize Fisheries Department in Caye Caulker and Bacalar Chico Marine Reserve. All bleaching and disease survey data has been uploaded to the AGRRA website.

Spawning was conducted at LBCNP in 2022 using SECORE's CRIB methodology. Gamete bundles were collected from six different *Acropora palmata* outplanted genets and cross fertilized to create ~272,000 embryos that were then added to 482 pre-conditioned substrates. These substrates are now in three different table nurseries (LBCNP, SWC and Tobacco Caye) for long term monitoring of survivorship. Significantly, one of the *A. palmata* genets that spawned, sourced from Mosquito Caye, were several colonies created by directly outplanting micro fragments in 2018, validating this re-population method for shallow reefs without any nursery time needed.

Seventeen diver-based mosaics were conducted, including two new baseline plots, prior to outplanting, in HCMR (Mexico Rocks) and CCMR, with coral cover of 4.25% and 7%, respectively. Twelve processed, diver based mosaic plots were annotated; the Moho Caye plots 1-3 had live coral cover of 37%-48% in 2021, from a baseline pre-outplanting of < 10% live coral cover, and plot Moho 3 jumped to 50% live coral cover in 2022. However in the Tobacco Caye plot, live coral cover decreased 2020-2022 from 24%-20%. SCTLD is present on this plot (2022), but even the outplanted acropora cover decreased from 5.5%-3.25%: this is primarily due to mortality by predation, further emphasizing the importance of well enforced no take zones for coral health, by maintaining a balanced food web.

Drone ortho-mosaics were conducted at LBCNP, Moho, and all three Silk Cayes, two inner caye *A. cervicornis* patch reefs and Monkey River in 2022, but all of these still need annotation. Even without annotation yet, of significance is that the four-year old elkhorn micfrorags are clearly visible at South Silk Caye. Water quality sampling was also conducted by USF partners at LBCNP, south Silk and False Caye.

Fragments of Hope was lead and co-author on four accepted talks at REEF Futures 2022 (Florida) and featured in others.

Introduction/Background

The Caribbean acroporids were listed as critically endangered (one step away from extinct in the wild) on the IUCN Red List in 2008. Their loss in abundance has been estimated at over 98% in recent decades (Aronson et al. 2008). They are keystone reef species since they are the fastest-growing, main reef-building, branching corals that provide shoreline protection and habitat for hundreds of other marine species. Reef replenishment efforts with the acroporids began at LBCNP in 2006 and to date over 87,000 nursery grown corals (all three *Acropora* taxa) have been outplanted in over one hectare of shallow fringing, degraded reef at LBCNP. Using photomosaics, we have shown increases in live coral cover of over 35% in less than five years (2010-2015) at LBCNP (Carne et al. 2016). Efforts expanded to South Silk Caye (in GSSCMR) and Moho Caye (unprotected, control site) in 2015. Expansion to SWCMR and TAMR began in 2016 under MCCAP. Inclusion of an additional near shore control site (False Caye) began in 2017 under MAR Fund.

Coral replenishment efforts have become increasingly accepted as a management tool (Rinkevich 2014), but many questions still remain, which we continue to address via this program: 1) does MPA status have an effect on the success of the outplanted corals? 2)

what is the desired number/density of outplants per plot/site that will achieve self-replication (increases through growth and asexual fragmentation, without adding additional corals)? 3) are there acroporid-associated biodiversity changes that accompany replenishment efforts? 4) what has contributed to the relative success at LBCNP and can the results be replicated, inside and/or outside of MPAs?

LBCNP is one of the oldest and most extensive restoration sites in the Caribbean and Western Atlantic and is widely considered the best example of true reef restoration. FoH work and funding will continue in SWCMR and TAMR in 2022 and in the southern sites through 2022. FoH is pursuring additional funding options/sources, as always.

Objective

New objectives were to create at least two new outplant sites in the Northern MPAs. The objectives at TAMR and SWCMR are to create at least three replenished sites in each MPA. The objectives in southern Belize are to increase coral cover by 10% at each targeted site.

Methods-(remain the same as 2020, new methods for SCTLD treatment added as Annex)

All of the methods for installing nurseries, monitoring nurseries (including growth rates), outplanting corals and monitoring outplanted corals are listed in the newly revised FoH Reef Replenishment Methods Training Manual, vetted by the Belize Fisheries Department. The full resolution PDF is housed here: https://drive.google.com/open?id=1ckRgmNp9j8yHNmZ6iqTE9TLo9C9QTowb.

The photomosaic technique was developed over a decade ago (Lirman et al. 2007) and has been used at sites around the world. Monitoring acroporid restoration has been one of the key applications of this technology, since it is difficult to track these species as individuals (Carne et al. 2016, Griffin et al. 2016, Gleason et al. 2007). Percent coverage of benthic organisms will be computed using the photomosaics of each site and the CPCe[1] software, which allows calculation of coral cover by species and other benthic organisms (*e.g.* sponges, crustose corraline algae) and thus can also track any changes in benthic composition over time, associated with repopulating the acroporids.

Mapping with drones: A Phantom 4Pro drone was purchased on Dr. Steve's Shill's advice and FoH was trained on how to program and fly 'missions'/ mosaics for shallow coral reef mapping

[1] http://cnso.nova.edu/cpce/index.html

with its accompanying app, DJI GS Pro. Heights are usually 200ft, with 80% overlap of images, and flight times are limited to under 20 minutes because of battery limitations. Conditions must be fairly calm, early morning or evening to avoid glare, with no rain. The software Pix4D (Dr. Schill's license) is used to process the images into a mosaic. Then the mosaics can be annotated (the corals identified, outlined and area measured) with ARC Map or Q-GIS.

Bleaching surveys are conducted using McField's (2009) Swim Bar Methodology, where at least 200 corals are surveys per site. This same method is used to assess SCTLD on sites. Temperature data is collected with HoBo U-22 loggers, set for one-hour increment data collection. Both of these methods are endorsed by the National Coral Reef Monitoring Network (NCRMN) and used country-wide.

In 2020 the bleaching data base was moved from UB to the AGGRA website[2]. FoH entered all bleaching data from 2017-2020, in anticipation of this website eventually generating maps for coral bleaching presence/prevalence & severity. This continued for bleaching & SCTLD in 2021. The current National Treatment Plan for SCTLD is attached as Annex I.

Spawning: The SECORE CRIB deployment guide is shared in the annex, as is the report for 2022 detailing all methods.

Results

Below are data on over 9,000 outplanted corals in 2022 by site and taxa (Table I), map of SCTLD spread in 2022 (Figure 1), and results from 29 bleaching surveys conducted nationwide in 2022 (Figure 2). Figures 3a-d are reduced images from processed photomosaic plots in Caye Caulker, Mexico Rocks in HCMR, both back reef, South Water Caye fore reef, and fringing reef at Moho Caye. Figure 3e is a graph illustrating changes in live coral cover on three plots at Moho Caye, including prior to outplanting in December 2015 (baseline data). Moho plot 3 had a baseline coral cover of 2% in 2015, and in 2022 increased to 50%. No corals are added to the plots used for photo mosaics after initial outplanting, and data from Moho supports data from LBCNP in in that even in these ideal shallow reef sites, it takes ~ 3-4 years after initial ouplanting for the corals to establish, spread and grow to achieve significant (5-10%) annual increases in coral cover. Figure 4 is the November 2022 course participant attendance sheet.

[2] https://www.agrra.org/coral-bleaching/

All other 2022 results are shared in several annexes: https://drive.google.com/drive/folders/19zFqA1cIUoJdF2iSUawBjR9dJp05QqX7?usp=share_link

- Water quality report for LBCNP, False and South Silks Caye
- SCTLD reports
- Two UNEP reports
- 2022 Spawning report & CRIB deployment manual
- WWF reports on replenishment work
- CANARI case study on FoH Community led reef restoration at LBCNP

Table I. Number of coral outplants by taxa, and site and for 2022 with grand totals in the far right column.

SITES	TAXA outplanted 2022						TOTAL 2022	TOTAL
	ACER	APAL	APRO	MCAV	OFAV	DCLY		
LBCNP	2013	0	0	0	0	7*	2,020	89,287
SILKS	732	0	0	0	0	0	732	15,058
MOHO	0	339	216	0	0	0	555	24,497
FALSE	2523	0	0	0	0	0	2523	8,444
SWC							0	6,641
TOBACCO CAYE							0	11,597
BLACK BIRD CAYE							0	6,429
CALABASH CAYE (& nearby, new site)	621	0	0	0	0	0	627	4,887
Mexico rocks	391	0	0	0	0	0	391	391
HCMR by nursery	297	0	0	0	0	0	297	297
HCMR Hol Chan	0	0	0	0	0	0	0	329
Caye Caulker plot 1	0	150	0	0	0	0	150	267
caye caulker shark ray	0	0	0	0	0	0	0	133
Caye caulker by tables	1362	0	616	0	0	0	1,978	1,978
TOTAL							**9,273**	**170,235**
						* whole colony/large transplants		

SCTLD spread in 2022 and October 2022 bleaching.

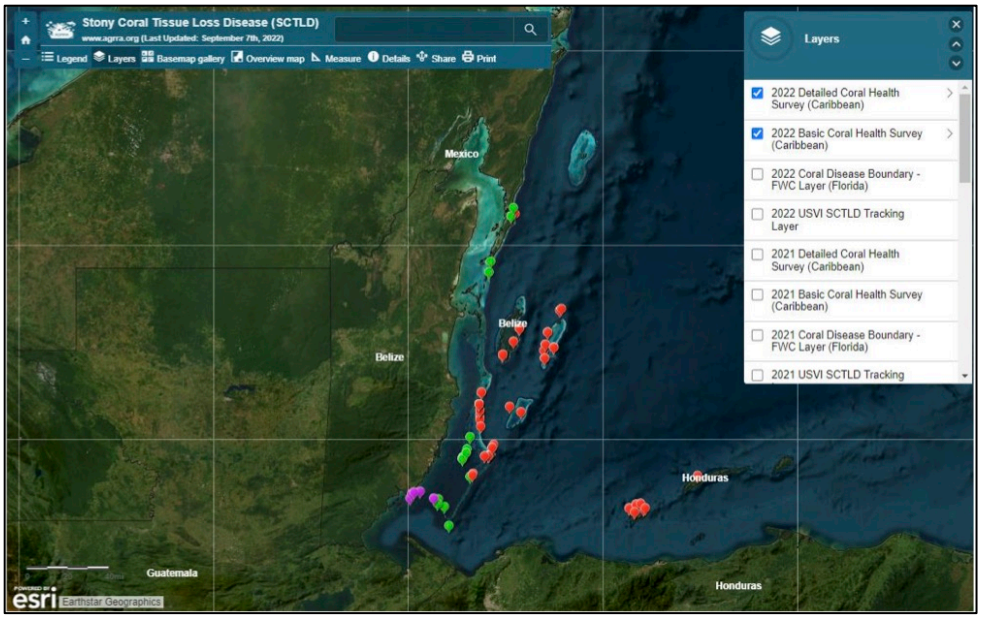


Fig. 1. SCTLD reports in 2022.

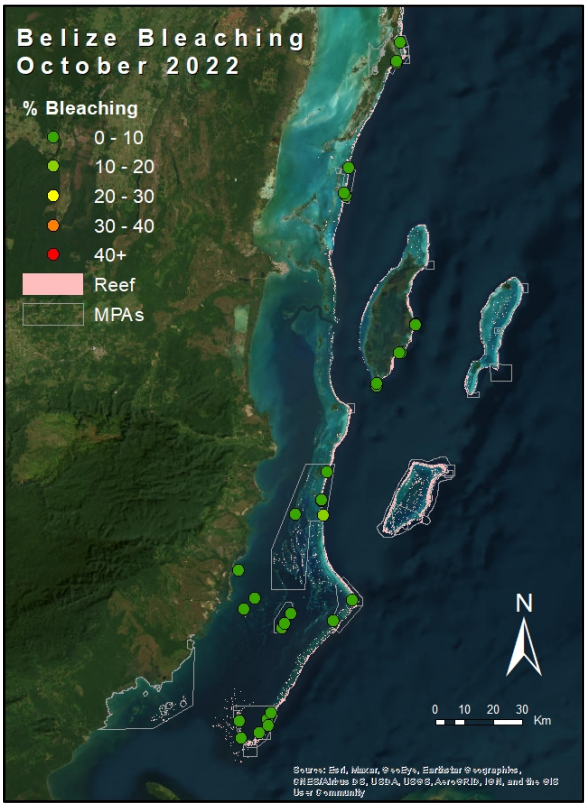
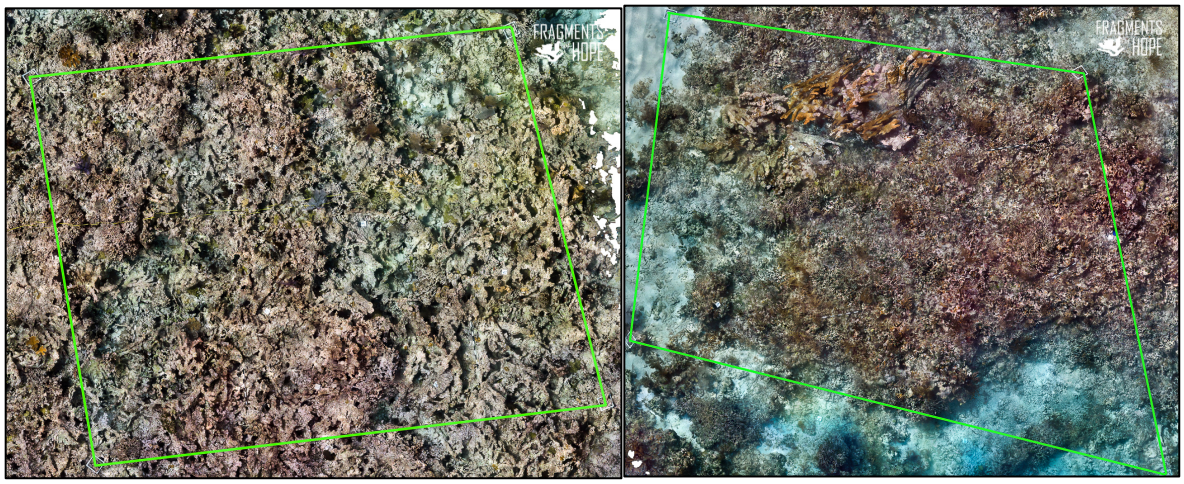


Fig. 2. October 2022 bleaching in Belize, each site surveyed is 200 corals, and only Partially bleached and wholly bleached colonies included (no Pale).



Figs. 3a-b. Reduced examples of the baseline photomosaics at Caye Caulker back reef (L) and Mexico Rocks in HCMR back reef (R). Total live coral is 7% on the CC plot, including the 267 *A. palmata* microfragments outplanted 2020 & 2022. Total live coral in the Mexico Rocks plot is 4.25% not including the 391 *A. cervicornis* outplanted later in 2022.

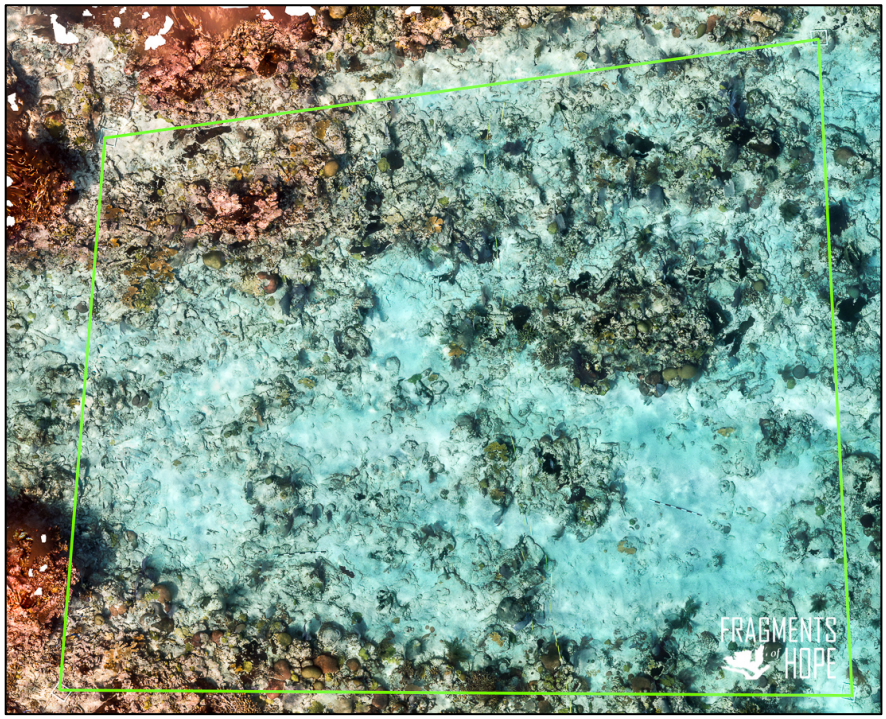


Fig. 3c. Reduced photo mosaic of the shallow plot at South Water Caye, fore reef, from 2021. *A. palmata* microfrags were outplanted in 2017 & 2018, and are visible. Percetn live coral not yet calculated, the 2020 and 2021 mosaics were just recently processed.

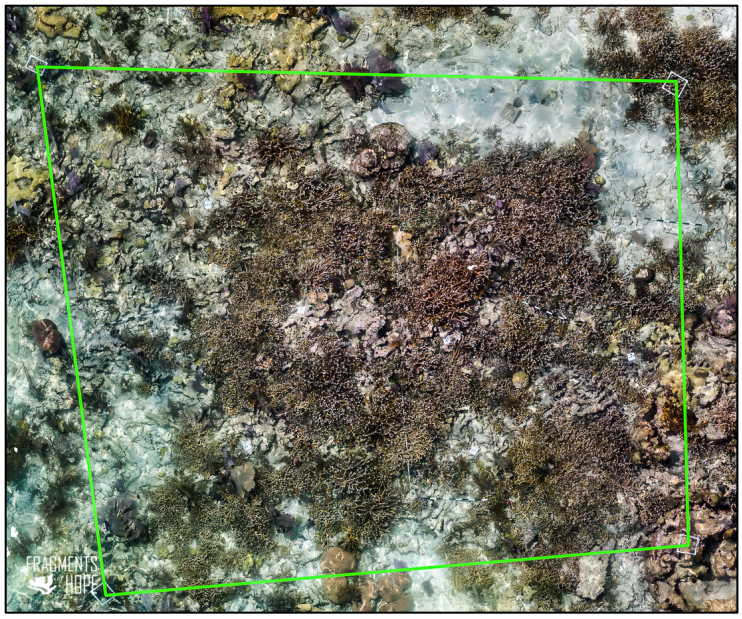


Fig. 3d. Moho Plot 3 from 2022, reduced mosaics; live coral cover at %0% from less than 2% prior to outplanting in December 2015.

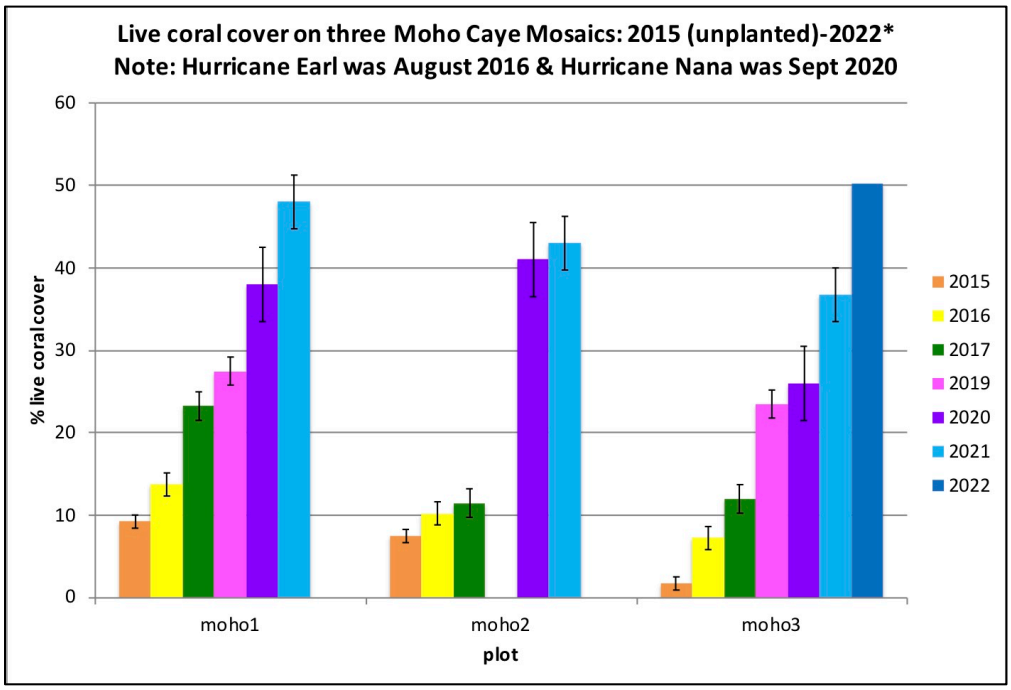


Fig. 3e. Live coral cover changes on three replenished plots at Moho Caye, including baseline data before outplanting in December 2015.

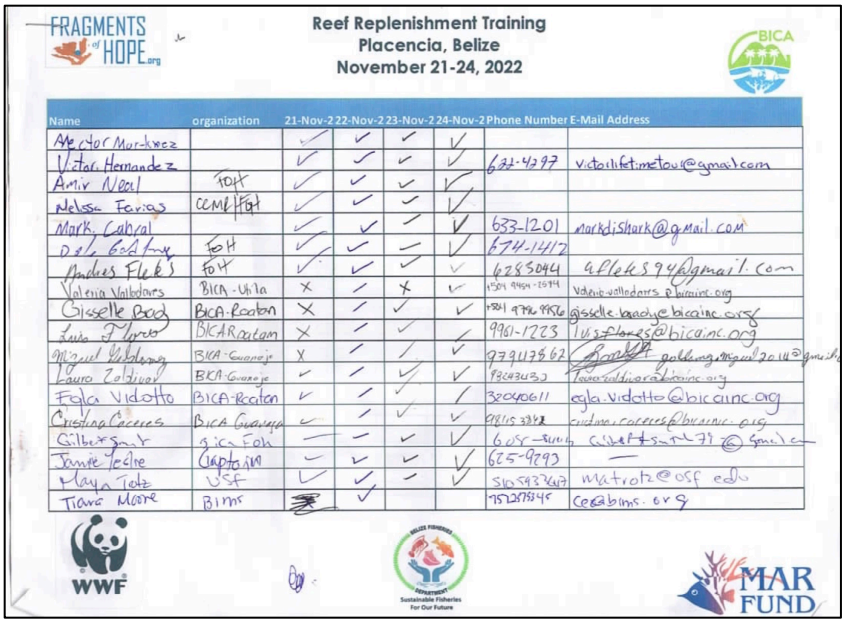


Figure 4. November 2022 FoH course participants.

Discussion, Recommendations & Future Plans

Discussion on creating Belize's national restoration plan and updating its existing restoration policy were tabled due to COVID and SCTLD emergence. With the current IPCC reports as dire as ever, increased tourism to Belize since COVID, and popular headlines and misconception about reef restoration, this should be a priority national discussion. Funds exist for a consultant to tackle the skakeholder component to prioritize new sites, given well established site selection criteria including connectivity data. Mapping, genetics and thermal data all exist and for the acroporids; methods used in Belize are proven with long-term results-only funding and political will is needed to prioritize the importance of restoration were appropriate. Given that prevention is worth more than any cure, relevant departments must work in tandem to prevent losses of essential habitat in jeopardy not only from climate change, but importantly from coastal development, more easily avoided/controlled.

Regarding the current trend for sexual propagation, FoH recommends this be tabled until better survivorship can be established, and studies by partners and colleagues are now ensuing on increasing the efficiency of substrates used and methods employed. Rather than investing heavily in this and land based nurseries, and especially relevant for SCTLD, FoH recommends instead initially exploring mapping and then transplanting those non-Acroporid coral species that have survived SCTLD to date (medium size corals that in theory are large enough to sexually reproduce) to affected areas for a trial period to see if any SCTLD lesions re-appear. Belize is in a unique position in the

Caribbean with the amount of extant reef, the amount of remaining SCTLD susceptible corals, and uniquely regularly accessible field sites.

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