CORAL REEF REPLENISHMENT MANUAL

BELIZE

FRAGMENTS of HOPE

BELIZE FISHERIES DEPARTMENT

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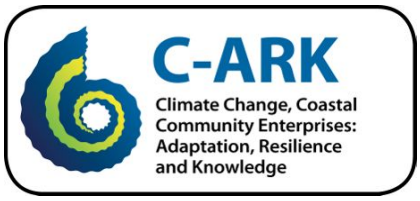

Contents

Abbreviation List

AGRRA	Atlantic and Gulf Rapid Reef Assessment
BFD	Belize Fisheries Department
DNA	Deoxyribonucleic acid
FoH	Fragments of Hope, Ltd.
GPS	Global Positioning System
GSSCMR	Gladden Spit and the Silk Cayes Marine Reserve
IUCN	International Union for Conservation of Nature and Natural Resources
LBCNP	Laughing Bird Caye National Park
MBRS	Mesoamerican Barrier Reef Systems Project
MPA	Marine Protected Area
NGO	Non-Governmental Organization
PACT	Protected Areas Conservation Trust
SCUBA	Self-contained underwater breathing apparatus
SEA	Southern Environmental Association
SWCMR	South Water Caye Marine Reserve

A message from the Belize Fisheries Department

In a world of weather variability due to climate change, countries that have coral reef systems are experiencing high coral mortalities. Some corals such as the acroporids, have experienced higher mortalities due to their narrow tolerance ranges in water temperatures and high sensitivity to pollutants. An approach to address coral loss is the establishment of coral nurseries to serve as genetic repositories for coral restorations after extreme bleaching events and impacts due to hydro metrological phenomena such as hurricanes.

In Belize, the Fisheries Department is partnering with Fragments of Hope in establishing multiple nursery sites at different locations to mitigate impacts of localized disturbances. Coral restoration can have major, positive impacts on localized resources by increasing the aesthetic value of coral reefs for tourism and creating reef habitat for fisheries purposes.

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Introduction and Special Considerations

Greetings!

If you are reading this manual that means you have been selected by the Belize Fisheries Department, Fragments of Hope or another Belizean NGO or entity to participate based on your existing experience and skill set. You may be a fisherfolk, a licensed tour guide, or work in one of the many MPAs here either for the government or an NGO. In some exceptions you may be a qualified student or community member. While SCUBA certification is not mandatory, it is most useful, and experience and knowledge of Belize's marine ecosystems is a must.

This manual is not a stand-alone tool for certification. It is to be used in conjunction with the training videos and a three- day hands-on training workshop conducted by Fragments of Hope, Ltd. While no one shoe fits all feet, what we present here are the coral restoration methods that have been working successfully in southern Belize since 2006. Many other methods and manuals exist, and these can be accessed at fragmentsofhope.org. Specific protocols (growth rates, fish surveys) and sample data sheets are provided separately, and also accessible at fragmentsofhope.org

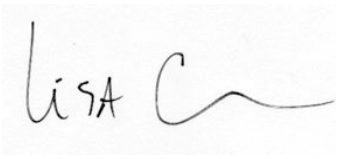
Fragments of Hope pioneered reef restoration in Belize and currently holds the only Research Permit for the work here. As the work expands, we need many more qualified Belizeans to assist, and you are part of the first true certification course vetted by the Belize Fisheries Department.

You will not find long paragraphs on the importance of coral reefs and the justification for this work in this manual; if you are here, you know this already. However, below is a brief list of facts you should know in your sleep. If any of it sounds unfamiliar please alert your instructor/trainers.

- Coral reef ecosystem services include shoreline protection, fisheries and nursery habitat, and aesthetic value for tourism. These services are valued at over US$3million/year in Belize alone.
- Corals are animals, living in symbiosis with single-celled algae called *Symbiodinium*.
- Corals are fully protected in Belize (no live export) and only a Research Permit and/or successful completion of this course allows for any handling of corals.
- The Caribbean acroporids are listed as Critically Endangered on the IUCN Red List, which is just one step away from Extinct in the Wild.

Finally, the knowledge and information shared in this course is the culmination of over 10 years of experience, a process of trial by error and learning as we go. New eyes and input are valid, and no question is a bad or dumb question, we want your feedback!

Thank you for taking an interest in protecting and actively restoring the critically endangered acroporid corals in Belize. More corals=more fish!



Lisa Carne
Executive
Director/Founder
Fragments of Hope, Ltd.

History of coral reef restoration in Belize

Dead reef, hardly any fish. This photo was taken in 2006, but many sites still look like this today.

Nursery-grown out-planted corals provide habitat for countless other species, fish, invertebrates, etc. The corals in this photo were ~ 3.5 years old/out-planted.

After Hurricane Iris (2001) hit Placencia and Laughing Bird Caye National Park (LBCNP) most people gave up the reef for dead. Other impacts like bleaching and disease had also taken their toll. Observations of live broken elkhorn corals near San Pedro inspired the idea of 'replanting', and large live stands of elkhorn corals were still inside Gladden Spit and the Silk Cayes Marine Reserve (GSSCMR). The idea of transplanting corals to LBCNP was dismissed by many, saying there was only rubble left, the donor reef site was too far from LBCNP, and disease or bleaching might just kill them. Or people did not think there was a need, until 2006 when acroporids were listed by the US as Endangered Species (they made the IUCN Red List in 2008). That listing gave credibility to the need, and PACT funded the first restoration work in 2006, when 19 elkhorn fragments were transferred from GSSCMR to LBCNP. Part of that initial work included mapping elkhorn stands near Placencia. Seventeen of those original transplants are still alive today and have made many more 'satellite' colonies (>35) from natural storm fragmentation.

In 2009 six in situ nursery sites were established near Placencia using three culture methods from Dr. Austin Bowden-Kerby. We have modified much and today have 21 nurseries in southern Belize. We have out-planted > 26,000 acroporids and demonstrated their natural reproduction after out-planting. We are expanding from LBCNP to GSSCMR, and through 2020 will be working in South Water Caye Marine Reserve (SWCMR) and Turneffe Atoll.

Mapping/Scoping-for live (donor) corals, nursery sites and out-plant sites

Before beginning any restoration, you need to know what corals exist, and where, in proximity to your restoration sites, which ideally should be chosen first. We will map and scope for donor corals to the nursery, sampling for host and clade genetics (see sidebar), and looking for nursery and out-plant sites in the process, using the site selection criteria provided in this training.

But there are larger pictures to mapping acroporids. One is knowing the distribution and abundance of these Critically Endangered species, and another is using this information to better understand resilient sites (why some corals are still thriving in some areas). Even more important is our plan to create a computer simulated larvae dispersal (spawn) map. Given the extant coral mapping data, wind and current patterns, benthic substrate, and days until settlement, we can predict where corals should be naturally replenishing themselves, and then ground truth (physically monitor) the sites to look for recruits/healthy corals. Since it is impossible to restore all reefs, our best option is to use this plan to fill in the gaps with coral nurseries and restoration sites, to aid and accelerate natural reef recovery.

In other words, we would not waste time and money on restoration of sites that may naturally recover on their own, or that have no chance of recovering. Instead, we strategically choose sites that once restored, will contribute to reef regeneration by eventually spawning on their own.

Always have a GPS and backup batteries on your field trips! If you need a review of basic GPS settings (datum=NAD27 central, and units are UTM) ask your instructor/trainer.

Genetics

Corals are animals and can sexually reproduce. Although acroporids are hermaphrodites (male & female) they cannot self-fertilize and different individuals must be sourced for ensuring fruitful spawning. Lab analyses of the corals' DNA tells us if they are unique genets (individuals). How many different individuals of each species are needed for each nursery/site? No one knows for sure and that is part of ongoing research. Samples needed are only ~ 1cm, and the lab can also analyze the genetics of the algae symbiont.

For now, this work is sourced outside of Belize, and Fragments of Hope is leading the research. If you would like more information on this crucial component of restoration, ask your instructor/trainer and or visit fragmentsofhope.org.

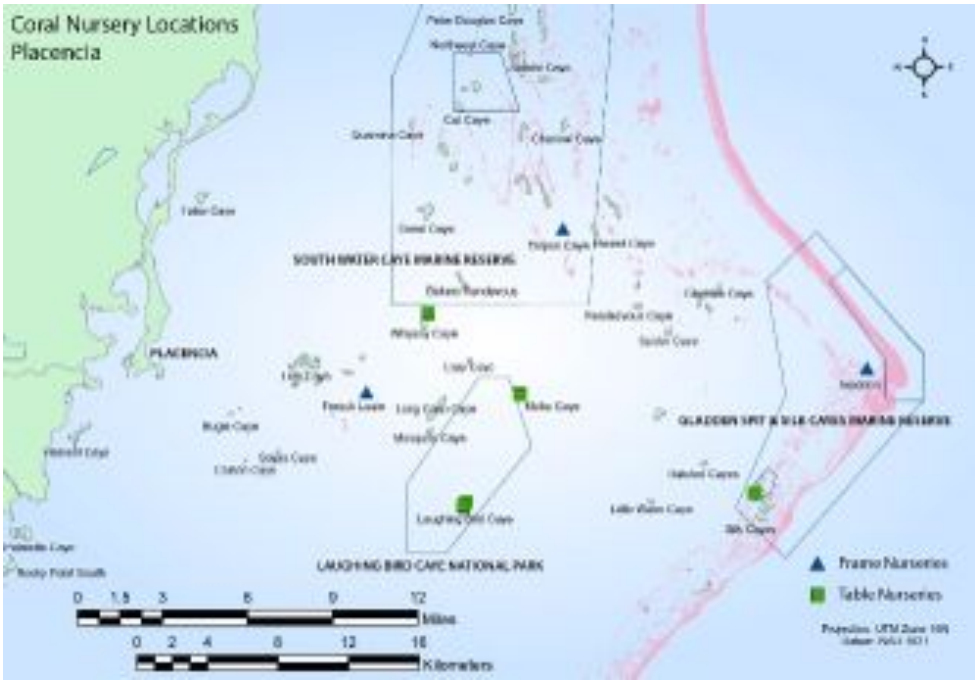
Nursery Site Selection Criteria

- Accessibility (fuel considerations)
- Optimal depth 2-5m
- Clear, good water quality and flow (presence of healthy corals)
- Protection from high surge (leeward side of cayes, nestled amongst large coral heads)
- Sand and/or rubble substrate or sparse seagrass and sand (test with probe and mallet)
- Permanent residents on caye or nearby
- MPA status/protection
- Permission /endorsement from managers/co-managers if in MPA
- Stakeholder support
- ***Proximity to out-plant site and cross reference with out-plant site selection criteria-see photos p. X***

Outplant Site Selection Criteria

- Accessibility (logistics for long-term monitoring)
- Evidence of acroporids (dead and alive)
- Clear, good water quality and flow (presence of healthy corals)
- Low macro-algae cover
- Crustose coralline cover
- Presence of diadema
- Presence of parrotfish/surgeon fish
- Solid/fixed substrate (not rubble-can use domes on rubble)
- No-Take (replenishment) zone status)

- ***After the larvae dispersal maps are completed, these will be used with the above criteria, for stragetically located replenished outplant sites to promote natural reef regeneration.***



Map of southern Belize nursery locations: green squares are table nurseries and blue triangles are frame nurseries (not discussed here).

Nursery types

1. Tables (with ropes and cookies)

2. Domes

3. ~~Frames~~ (not using anymore)

Mapping/Scoping

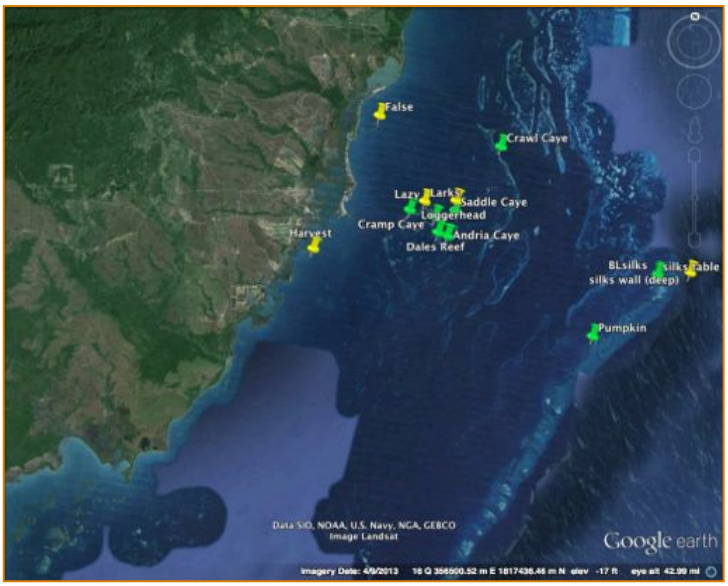
Materials needed:

- Computer/laptop
- GIS and/or Google earth
- Access to pre-existing data (AGRRA, MBRS, satellite images, *community/ stakeholder knowledge*)
- GPS
- Underwater digital camera
- Slate or underwater notebook/paper
- Pencils
- Transect tape
- drone?

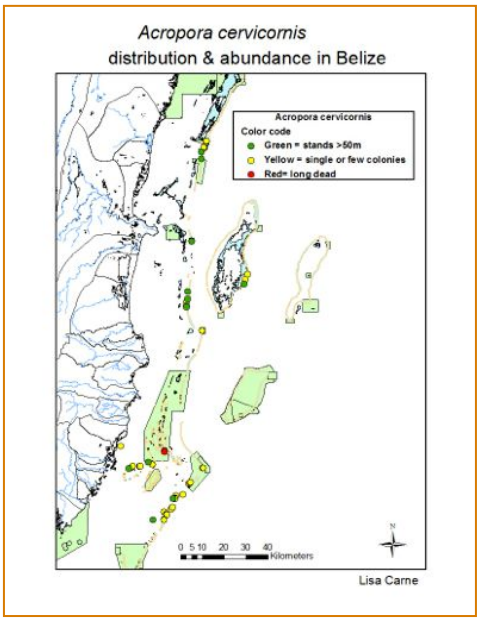
Collecting

(for nurseries, as above plus)

- Chisel/hammer
- Plastic containers/tubs/ small plastic baskets
- Bailer or smaller container to transfer water
- Cable ties and/or tags
- Extra weights for containers
- Ruler and/or small tape measure (sewing kit)



Above: Map of *A. cervicornis* stands using Google earth: green markers indicate stands >50m, yellow markers indicate single or few colonies. Below: maps with GIS software (ARC map).



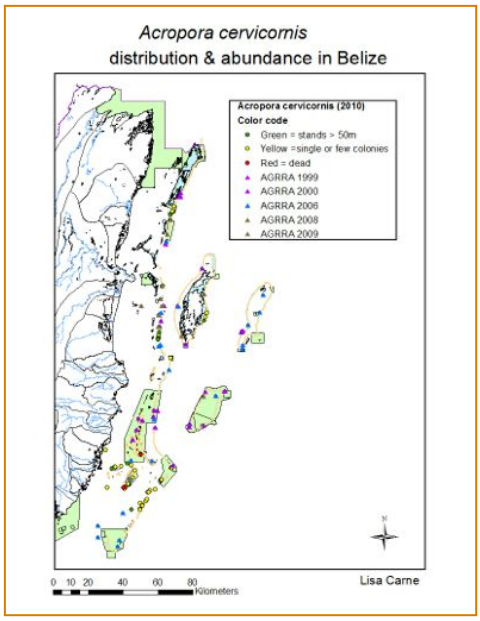
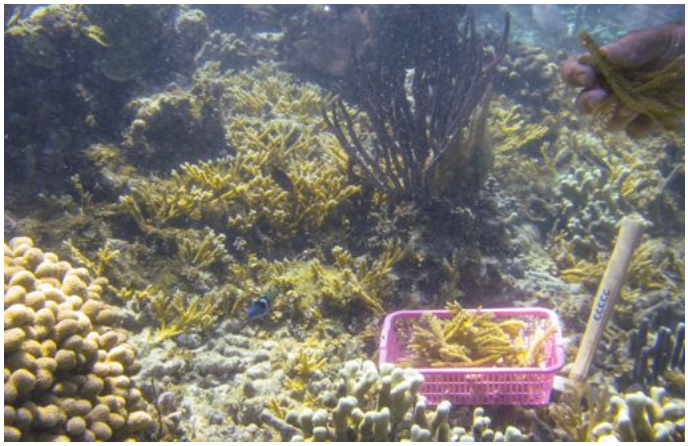


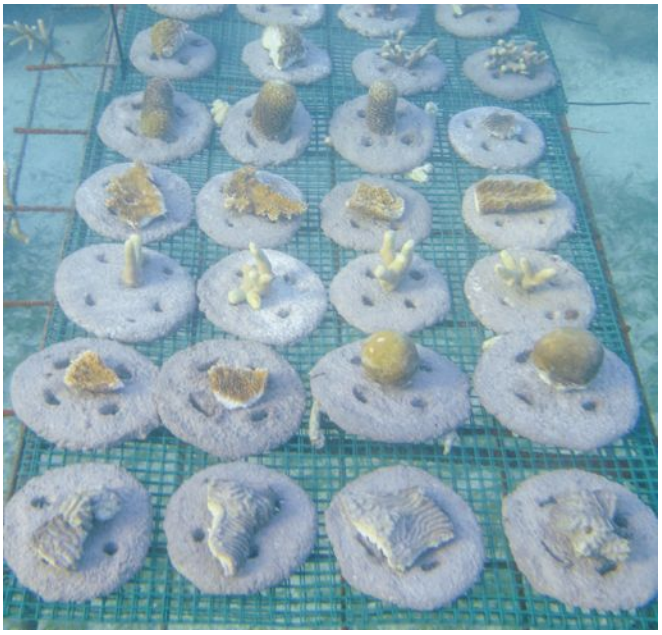
Photo: Guadalupe Rosado

Collecting for nurseries: 5-12 cm branches of *A. cervicornis*, and *A. prolifera*, 5-20cm for *A. palmata*.

Coral species and best culture method	
A. palmata	cookies
A. cervicornis	ropes/domes
A. prolifera	ropes/domes
Other species* we have worked with:	
Dendrogyna cylindrus	cookies
Undaria tenuifolia	cookies
Colpophyllia natans	cookies
Orcibella annularis	cookies
Orcibella favelota	cookies
Orcibella franksi	cookies
Diploria strigosa	cookies
Pseaudodiploria clivosa	cookies
Porities furcata	cookies
Montastrea cavernosa	cookies

General rule for collecting:
Never take more than 10% from the mother/donor colony





Day of planting (day 0): March 2009

Over six years' growth! June 2015
Note: lesion healing on brain corals (all elkhorn, where you see empty spaces, were out-planted).

Nursery Assembly and Installation

Table Nursery: Materials

- 11-10ft lengths of 5/8' steel +1 or 2 extra lengths for braces
- 2 length (2 x 10 ft each) of construction fabric (4" x 4")
- plastic coated wire mesh (¼" x ¼") (or similar) for trays; make 2ft x 2ft squares (or similar) collecting pic
- polypropylene rope in 11 ft lengths (8-10 per nursery)
- lighters
- transect tape
- large mallet
- cable ties (all sizes)
- tags
- fishing line (40# test or so)
- cement (Portland II) and sand, gloves, fresh water for cookies
- knife/scissors

See video and Methods p. 7-10

Photo: Avelino Franco

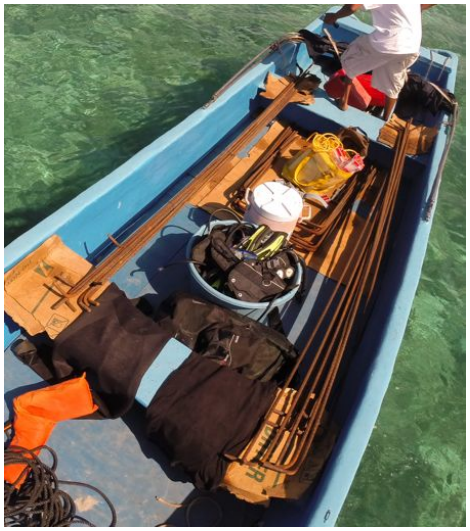


Photo: Didier Laplace

A. Assembling nursery

Need minimum 2 strong divers. Test substrate 1st as legs need to go in at least 24". Lay out nursery, add legs.

B. Assembling nursery

Note the bent ends of the steel. Note the extra bars for bracing.

Note cable ties are placed (2) in x fashion over each junction.

C. Assembling nursery

The grids are the construction fabric (4" x 4") and are to support weight of cookies. **We have had variable life spans of this material (<1 ->6 years).**

D. Making ropes

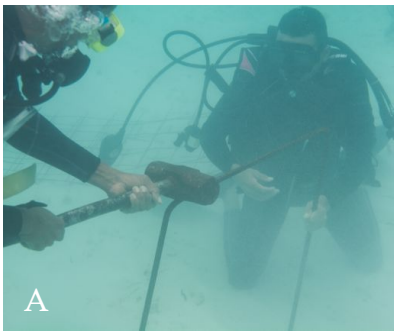
Ropes can be made in the boat, in shallow water, using SCUBA. We usually put 10-15 replicates of the same genet on each rope, 10-15 cm apart. Coral/frag size 4-10cm. **NOTE ropes should be measured (~11ft) and burn the ends so they don't fray.**

E/F. Affixing ropes

We affix them in a secure knot, that can be easily untied at a later date, to either move or out plant. If the rope is short you can affix with a cable tie. Ropes need a cable tie on the middle bar so they cannot slide/swing into each other.

G-I. Tagging ropes

The metal tags are cheap and easy to clean, but glare in the sunlight. The neon tags show well but are expensive. TIP put all your tags on the same end of the nursery. For growth measurements see next page.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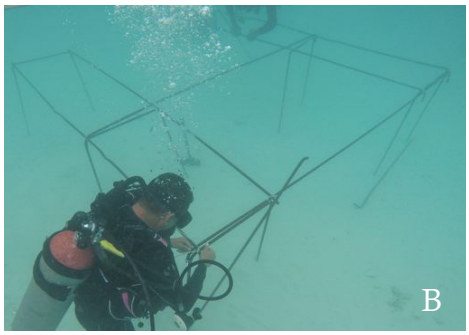
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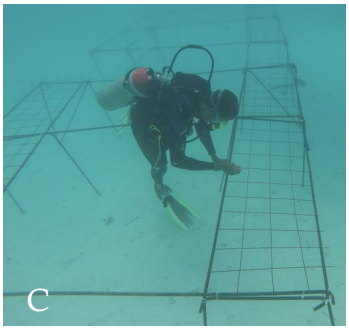
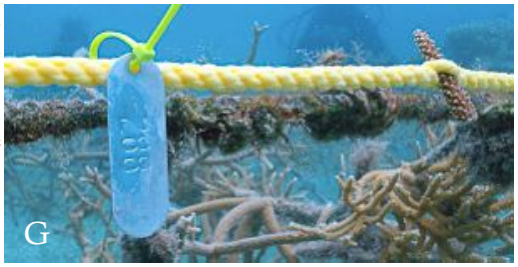

C


D


E


F

Photo: Annelise Hagan


G


H

Photo: Louie Wray


I

Table Assembly: Refer to photos A-I previous page, and the training video. FoH members will assist with any new nursery assembly at least through 2020.

The 10ft lengths of steel will be assembled thusly: six lengths (the table top) will have the ends bent into curves for better securing the corners (C). Six lengths are bent into U-shaped legs, four' legs and 2' across (B). One 10' length is left straight, that is for the middle bar that supports the weight of the corals on the nurseries (B). The order the bars are placed does matter; the bars that support the ropes' weight should be placed last, on top. Large (50lb.) mallets are necessary for pounding the legs into the substrate at least 2' deep. Junctions are secured with two thick cable ties and/or tying wire. We use a short piece of steel to probe all corners first, to ensure the nursery will be installed evenly. Water movement at the site should be taken into consideration for orientation of the ropes and with maximum stability of the table in worst-case weather conditions.

Ropes: Three-strand, twisted (not braided!) 1/2" marine polypropylene ropes are used. Cotton ropes snag on the corals. If different colors can be sourced, that is useful for separating different genotypes of the same species, but tags (G, H) should always be used (color coding with plastic cable ties does not work as their color fades over time). The ropes are cut in 11" lengths and the ends must be burned so they do not unravel.

Each rope should have only one genotype, than you only need tag one end of the rope, not every coral, and begin measurements from the tagged end. Starter fragments are ~ 4-10cm and placed 10-15cm apart by twisting open the rope. We usually place 10-15 fragments on each rope. Ropes are secured toe ach end of the table with knots and/or cable ties-you want them secure but also easy enough to remove for out-planting or transfer to another nursery. The ropes should be cabled to the middle bar so they cannot swing into each other, and also placed 10-15cm apart on the table.

TLE=Total Linear Extension (I) is the best method for *A. cervicornis* growth rates, 0-6months (Kiel *et al* 2012). This paper/method (and a sample data sheet) is provided in Annex X to the manual.

Fig. 1. Coral secreting protective mucus.

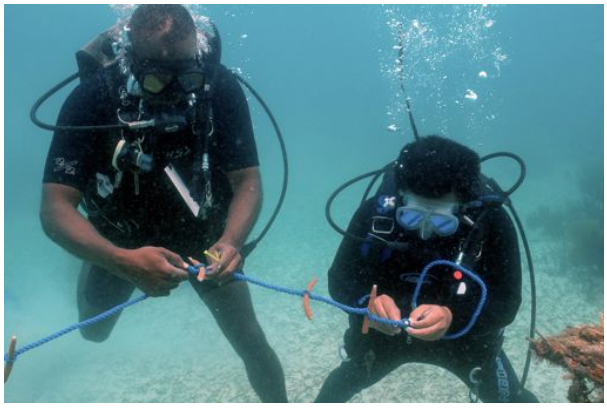


Fig. 2. Assembling ropes on SCUBA is easy.

Ropes may be assembled in shallow water, in the boat, underwater with SCUBA (Fig. 2). But they must be kept submerged as much as possible. Corals are living animals and secret a protective mucus when stressed (Fig.1).
Use NO SUNSCREEN (no lotions, no hair products, no perfumes) and wash bare hands thoroughly before handling corals.


J

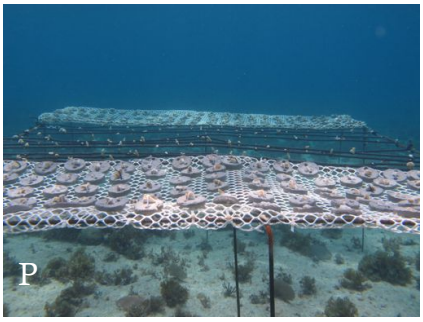

K


L


M


N


O


P

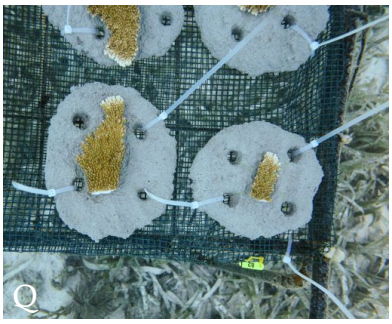

Q

Photo: Valeria Pizarro Coralina-
Universidad de Los Andes agreement No. 013-2014.

Cookies are made from Portland II cement, **sand** and **fresh** water. Mixed and molded by hand they need to dry > 24 hours (J). Four holes are made to allow fishing line to tie down the coral fragments. Fishing line only works with fast-growing corals; marine epoxy may be used with other species (expensive). The green plastic coated mesh (¼"x ¼") is ideal (K) for the trays to hold the cookies; we made the trays 2' x 2' for simplicity in keeping track of genets. However use what is available (M, P, R). Note the use of smaller baskets for keeping your genets separate (N). **The most important aspect is keeping the corals in the water, and making sure they are snug on the cookie.** Cookies can be affixed to the trays by fishing line (tedious) or cable ties (expensive). Make sure you remove all the long ends of cable ties as they will collect algae (Q, R). Temperature loggers may be placed on the nurseries (in ziplock bag, R).

Domes (for *Acropora cervicornis* and *A. prolifera*):

The idea for domes came about after the earthquake in 2009: How could we replant corals if no large dead coral heads were present? The idea came from http://reefscapers.com who were planting multiple species on each dome. We modified this with a single genet of a single species, to form a colony, and placed several domes with different genets on them in proximity to each other. So that if/when they spawn, there is diversity to allow successful reproduction.

Colombia and St. Barth's have modified the size and shape of their domes; the important aspect is welding the legs for pounding into the substrate. We used Ospho* as a rust prevention, and also 'cure' the domes in sea water at least overnight. If placed over rubble (where live staghorn used to thrive) any dropped branches have a better chance of survival. The domes are considered permanent and can represent both out-planted corals and a gene bank/nursery as long as you keep a single genet on each dome, and keep track of those genets.

Photo: Marion Carr

Welding gives strength.

Note welded legs for ease of installation.

Approximately two years' growth on dome.

Materials

We used 5/8" steel, but expensive! Can try the next size down (1/4")

Columbia and St. Barth's trying different size/shapes

Crucial is welding the legs to pound into substrate (ideally 24')

Small cable ties to affix corals

NOTE placement of corals on vertical bars

*Ospho (rust prevention) and brush

Photo: Valeria Pizarro-Coralina-Universidad de Los Andes agreement No. 013-

Colombia's version: Note they did not weld legs.

St. Barth's version, ready for installation

*http://www.ospho.com/directions.htm

Nursery Maintenance and Monitoring

Please always budget/plan/schedule monthly maintenance and monitoring trips for your nurseries! Depending on growth rates at your sites, corals must be trimmed every 6-11 months or else they become very heavy and compromise the nursery.

Regular maintenance includes checking the stability of structures and cable ties. Cable ties can become brittle over time and need replacing (especially on ID tags).

Algae removal from corals/nurseries is essential, especially in warmer months. Use a lobster or gardening glove, and cover up, as stinging hydroids also grow on the nurseries (non-lethal, but uncomfortable itching!) A great job for volunteers! ☺

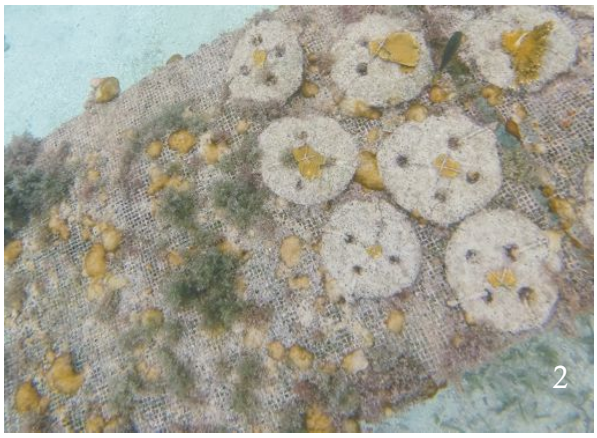
Monitoring (photographs and underwater slates for data collection) includes survivorship, growth rates, bleaching and/or disease events, recording biodiversity (macro and micro fauna recruiting to or utilizing the nurseries) and *in-situ* temperature loggers. Nursery monitoring details follow on next page with photos: survival, growth, bleaching, disease, biodiversity, and in situ temperature.

Figures 1. Removing algae from ropes, 2. Macro-algae on table.

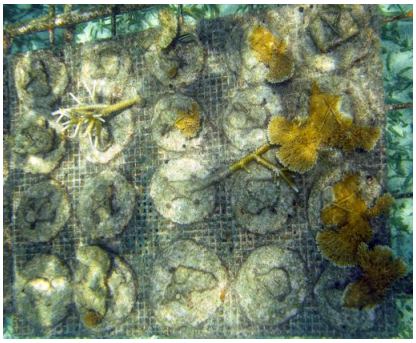
Materials

- Camera (software, laptop, external drive)
- Slate and pencils
- Ruler or small measuring tape
- Gloves
- Knife, and wire or tooth brush
- Cable ties/clippers or scissors
- Temperature loggers (and shuttle and software)

Mariko Wallen removing algae growth from ropes with a lobster glove.



Macro-algae should be removed from the nurseries, even if it is not around live coral.

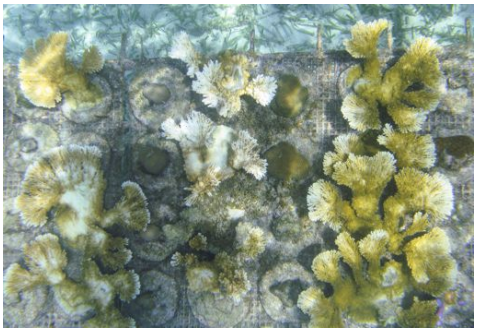


Survival/mortality

If you missed the mortality event, you cannot say what caused it, only that they are dead.

Growth

Total Linear Extension (TLE) measures every branch on staghorn. For elkhorn and other cookies, use AGRRA methods: (maximum diameter, perpendicular to that, and height).

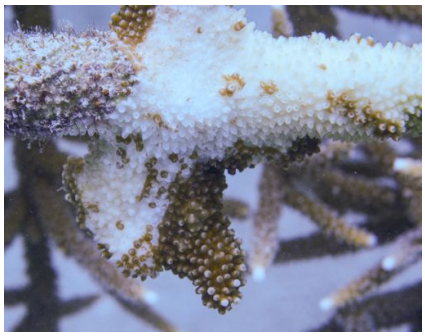


Bleaching

Bleaching will rarely affect single corals/replicates and it has an uneven edge. Use AGRRA: codes P (pale), PB (partially bleached), WH (whole bleached).

Disease: White Band (WB)

WB has a sharp line of mortality (compare to bleaching) and can affect single or few reps only.



Disease: Rapid Tissue Loss (RTL)

RTL also has an uneven edge, but unlike bleaching, you can see the tissue sloughing off.

Disease: Vectors?

It has been proven that coral-eating snails can transfer disease (vectors); ongoing studies look at butterfly fish, damselfish and fire worms for their potential to spread disease.

Biodiversity: macro-fauna

Multiple species of fish, rays, sharks and even turtles have been seen on, in and under the tables and domes. Document these!

Biodiversity: invertebrates

Many critters recruit to the corals, and the structures! Crabs, worms, sponges, gorgonians, even other stony coral species. Try to document this!

U/W Temperature (loggers)*

We use model U22-001. You can purchase a protective sleeve or use ziplocks. You must also have shuttle to upload data. Set for every hour, upload every year.

*http://www.onsetcomp.com/products/data-loggers/u22-001

Materials

- large plastic containers
- small bailer/container for transferring water
- extra weights
- hammers, chisels, scissors, knife
- tags
- cement (Portland II)
- **extra fresh water for mixing cement**
- large ziplocks
- heavy gloves
- wire brushes
- container for mixing cement
- hammers
- cement nails (3-4")
- slates and pencils

Site selection criteria

1. Evidence of acroporids (dead and alive)
2. Low macro-algae cover
3. Crustose coralline cover
4. Presence of diadema
5. Presence of parrotfish/surgeon fish
6. Solid/fixed substrate (not rubble-can use domes on rubble)
7. No-Take (replenishment) zone status)
8. Accessibility (logistics for long-term monitoring)

Out-planting the corals

Three out-planting methodologies include using cement, pegging (nailing) ropes into substrate and tightly wedging fragments into crevices in dead reefs (Bowden-Kerby and Carne 2012). Corals are harvested from the nurseries and transported in large containers, with seawater flushing them constantly, to the out-plant sub-site. Ideal weather and sea conditions are overcast, cool and calm waters, both for the transporting and the cement work. ***Corals are currently only harvested and out-planted outside of the hurricane season (December-May)*** to minimize stress and maximize survival rates. However we plan to explore expanding this time frame by out-planting at deeper depths. Wire brushes are used to remove turf algae from stable but dead coral heads for out-planting corals. Only Portland II cement is mixed with **fresh** water on the boat. This technique/recipe can only be learned by experience. Out-planted fragments are counted and recorded by species, genet, sub-site, date, etc.

Evidence of *A. cervicornis*

Presence of diadema and crustose coralline algae

Evidence of *A. palmata*, presence of parrotfish, low macro-algae cover and crustose coralline.

Harvesting/trimming corals

We find a heavy tool like a hammer or chisel is best to knock the branches from ropes, making a clean break, vs. any cutting tools.

Removing the cookies

A knife works best, as there is often other growth around the cookies.

Transporting corals

Cool, calm overcast (or shaded in the boat) days are best. We transport in seawater and add more continuously to keep them cool.

Photo: Stephanie Wandke

Transferring corals

Large containers of corals and water are quite heavy; lift bags (underwater) or more than one set of hands is necessary.

Photo: Stephanie Wandke

Substrate preparation

Even large dead corals are sometimes loose, make sure where you plant will not be shifted in the next storm. Wire brushes remove turf algae.

Out-planting with cement

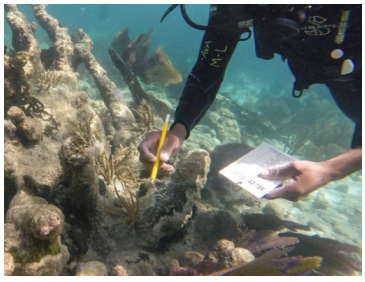
We use a 'porcupine' or 'rosette' method, putting many fragments of same genet in a cement mound. Large ziplocks are used to dispense just the right amount of cement.

Cable ties

Large, heavy fragments may not need cement, only cable ties to prevent any shifting. Acroporids quickly grow over the plastic ties.

Nailing ropes

Ropes can be pegged onto certain (not all) substrate with 3-4" cement nails. Older ropes or brand new ones, the key is not to allow any shifting (peg in many places).



Counting out-planted corals

Each person counts their own out-plants. Over time you and your team will get more efficient and faster. We went from ~ 400 to > 2000 corals a day (also depend son number of people of course).

Monitoring your out-planted corals

Frequency

Ideally, monthly, (combined with nursery monitoring). At least the first six months. Special attention to spawning (if funded) and bleaching months (mandatory).

Materials

Camera (software, laptop and especially external hard drive)
Slates, pencils
Extra cable ties

Photo-Mosaics

The use of photo-mosaics is a new method FoH uses to track percentage of coral cover increased over time. There are six plots in use at LBCNP for this method. The cameras are expensive, the protocol time consuming, and the analyses performed by the U of Miami who developed it come with a large service fee. Separate funding would need to be sourced to implement this method at new sites.

How do we define success of restoration efforts?

Survivorship: to track this, you must know how many corals you out-planted and where, and follow them over time. You may track survival by species, genet, site, age, out-plant method, etc.

Growth: Once an acroporid is > 6 months, it is very difficult to measure their growth. If there was baseline PIT* data on your site, that may be useful but not completely accurate for growth. Easiest would be to select representative individual corals for long-term growth rates measurements. See sidebar on photo-mosaics.

Bleaching/Disease: We want to know which genets perform better over time (are more resilient or resistant to bleaching and/or disease events). You must keep track of which genets are out-planted, where, for this crucial data.

Predation: It's a snail-eat-coral (and fire worms!) world out there and although natural, can be unbalanced. For this reason we actively remove the coral eating snails and fire worms when encountered. You will learn to identify coral predators, the safest way to remove them, and whether or not extra permits are required in your area for this activity.

Biodiversity: Hundreds of fish and invertebrates are coral-associates. Baseline fish surveys on unrestored sites can be compared to restored sites. FoH is working on international collaboration for protocols to measure biodiversity of the smaller coral-associated invertebrates.

Spawning: Natural sexual reproduction of out-planted corals is an end goal! However, spawning occurs at night, and during variable small windows around the full moons of July-September. This monitoring requires extra funds because of the complicated logistics. FoH has documented all three nursery-grown acroporids spawning after five years on site. We have reason to believe they may spawn as early as two years after out-planting. Ask your instructor/trainer for more info.

*PIT=point intercept transects used in AGRRA and MBRS surveys

Survivorship

This is easy to track with discrete colonies/units like the elkhorn cookies, harder with many staghorn branches. This photo shows ~80% survival of all the out-planted branches, in one 'rosette'.

Bleaching

Keeping track of which corals bleach and which do not is crucial data!

Photo: Mariko Wallen

Disease

Disease, bleaching and predation can be difficult to distinguish. Disease typically has a sharp line between live and dead tissue (unlike bleaching) and often starts from the base up.

Predation-Snails

Coral eating snails look just like dead reef-they can often be found by their predation scar, dead and/or newly dead (white) tissue (center of photo). Two large snails are on the edge of the dead/live tissue in the photo.

Predation-Snails-Identification

There are lots of different snails out there! Only the coral-eating snails have an orange operculum (their 'foot'). Pictured are adults, they can also be very small, and there is almost never just one, but they are often hard to see/reach under branches.

Predation-Fire worm

Typically fire worms are nocturnal, but sometimes found in the day. They may prefer staghorn, but eat all three acroporids. DO NOT touch fire worms! You need a tool to remove them (we use salad tongs).

Predation-Fire worm

Fire worm scars on staghorn are easy to recognize: they start from the tip of the branch and go down. Either bright white (newly eaten) or algae covered tips are evidence of fire worm predation on staghorn.

Biodiversity-fish surveys?

Fish surveys to date have been modified around the photo-mosaic plots-but this is not the only way to measure biodiversity. Have an idea? Want to know more? Ask your instructor/trainer.

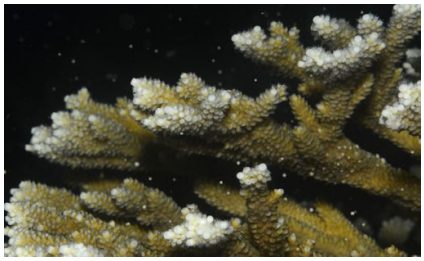


Photo: Annelise Hagan

Spawning?

Spawning occurs in a short, variable window at night, after the full moon (July-September). It requires additional equipment and experience to monitor and FoH is pursuing affordable ways to use remote cameras.

Concluding remarks and useful websites

This manual was designed for use in conjunction with a three-four day hands-on training workshop and accompanied training videos. At least for the next five years, Fragments of Hope members will supervise all mapping of acroporids and selection of new nursery and replenishment sites. Participants, like you, are selected for their experience and enthusiasm. It is hoped that by offering this training course at least once a year over the next five years, we will have teams of trained coastal community members to assist with the 19 nurseries in southern Belize, and at least 12 more planned for SWCMR and Turneffe Atoll. It is anticipated that participants will gain experience and knowledge by working with us, and be able to monitor nurseries and outplants without direct supervision (at the minimum), and eventually take over ownership and responsibility for nurseries in their home/work areas.

Keep in mind that the information shared is the result of many trials and errors over ~ 10 years, but that there is always room for improvements and modifications. Please always keep communication lines open! Via e-mail: lisasinbelize@gmail.com, phone 623-6122, the Facebook page or the website. Methods and sample data sheets on specific protocols (like TLE, AGRRA, fish surveys) are provided separately.

Websites:

www.fragmentsofhope.org

http://frrp.org/FRRP%20documents/Coral_Guide_111811_r1.pdf

http://www.coris.noaa.gov/activities/elkhorn_recovery_plan/

http://www.coralrestoration.org

http://www.seascapecarib.com

http://www.agrra.org

Notes