ELKHORN CORAL FRAGMENT STABILIZATION PROTOCOL: AN EVALUATION OF 2 METHODS

Dana E. Williams
Assistant Scientist, University of Miami Rosenstiel School of Marine & Atmospheric Science dwilliams@rsmas.miami.edu

Margaret W. Miller
Ecologist, NOAA National Marine Fisheries, margaret.w.miller@noaa.gov

NOAA FISHERIES PROTECTED RESOURCES AND BIODIVERSITY REPORT NO. PRBD-07/08-09

ACKNOWLEDGEMENTS

Funding for this project was made available from the National Park Service South Florida and Caribbean Cooperative Ecosystems Study Unit (Task order #J5250060018) hosted by the University of Miami RSMAS. Leveraged support was also provided by NOAA's Coral Reef Conservation Program.

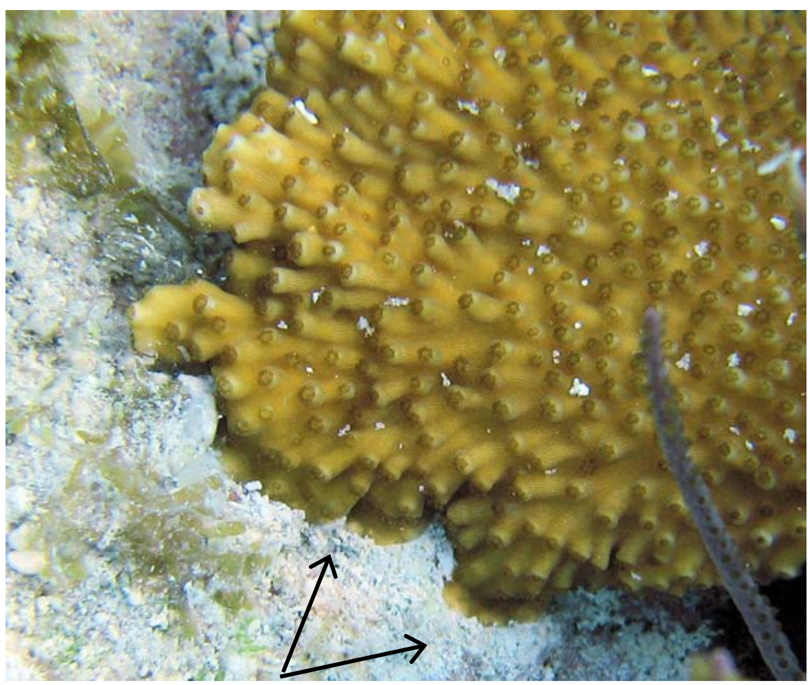
TABLE OF CONTENTS

APPLICATION

The following protocol is intended to guide the salvage and restoration of small (<50cm) fragments from *Acropora palmata* colonies. The guidelines here are based on the results of an in situ field experiment comparing 2 different attachment methods. Additional methods have been used in the past (see Bruckner 2002 Appendix I) Both methods evaluated here performed well and resulted in higher survival and increased tissue growth over fragments that were left loose. Both methods will be detailed in these instructions along with some factors that should be considered when choosing which method will be used.

As with all activities involving coral, any plans to manipulate *Acropora* fragments **MUST** be specifically permitted by the applicable state and federal resource management agencies. Both *A. palmata* (Elkhorn coral) and *A. cervicornis* (Staghorn coral) are listed as Threatened species under the U.S. Endangered Species Act and disturbing them, even in an attempt to restore them, without express permission is a violation of federal law in US waters.

THE LIFE OF A FRAGMENT



After physical disturbance, the fragment will land on the substrate. If left un-disturbed on suitable substrate, polyps in contact with the substrate will begin to form attachments in as little as a week. However, natural water motion will often continue to move the fragment, and each time the fragment is moved the attachment process is arrested. The water motion and frequent movement may also result in abrasion and fragments often end up piled in small depressions on the reef or wedged under other structures. Once they are buried or significantly shaded they are doomed to lose substantial amounts or all of their live tissue.

The time window where fragments can be effectively rescued depends on the conditions; rough seas following a storm will result in continual abrasion however it may also prevent the fragments from being buried and keep them in a sort of fragment limbo. Once the fragments are in stable piles where there does not appear to be live tissue that is buried, restoration is not likely to improve the outcome.

POST-DISTURBANCE ASSESSMENT

Following a reported disturbance to *A. palmata,* a basic assessment should be performed to determine if restoration is needed and to determine which method will be most appropriate. At the site you will want to note the approximate 'age' of the disturbance (i.e. grounding that occurred 2 days ago or a storm that passed 2 weeks ago). Are the fragments loose, buried or beginning to attach naturally? If it has been more than 2 weeks, fragments should be visually inspected carefully before touching them to determine if they are attached. Even a delicate touch can disrupt the process. If they are delicately attached and there is no imminent threat (i.e. approaching storm) they can be left alone as they have a good chance at successfully attaching on their own.

If your assessment reveals loose, unstable fragments and a restoration effort is possible, the site should be assessed to plan the restoration.

1) Estimate the number of fragments that can be restored
    a) If there are large numbers then this should be scaled conservatively based on available time, personnel and materials.
    b) Use a conservative estimate that a team of 3 people can effectively stabilize 15 to 20 fragments in an hour.
2) Evaluate the substrate for suitable placement of fragments. These observations will dictate the type of stabilization method to be used and the necessary materials.
    a) Are there structures or holes that are amenable to cable-tie attachment?
    b) Is the substrate relatively clean or mostly covered in sand?
3) If the actual restoration can be done within a day or so it may be appropriate to begin selecting the fragments that will be restored. If it will not be possible to return for several days it is best to leave the fragments undisturbed unless they are in the sand or other unsuitable setting. Gathering the fragments to be stabilized will help determine the amount and type of materials that will be needed.

Site characteristics

When planning to stabilize fragments it is helpful to assess the site to determine if it is suitable for restoration. Taking note of the following attributes will help determine the appropriate stabilization method if any.

- How old is the disturbance?
- How many fragments are present?
- How many can be restored?
  - Depends on resources and condition of the fragments
- What are the substrate characteristics?
  - Attachment points (standing dead skeleton, holes in the reef substrate) are needed to use cable-ties
  - Stable substrate is needed (avoid sandy or unconsolidated rubble bottom)
  - Excessive sedimentation may interfere with attachment or smother fragments
- What are the water conditions (energy regime)
  - Calm conditions are needed to stabilize fragments
  - Divers should be experienced in working in high surge conditions!
- What are the permitting requirements
  - In US waters a permit from the federal and state agencies managing the impacted area
  - Outside of US waters, local regulations generally require permits too

Suitable fragment sizes

- Fragment size will dictate the appropriate method of stabilization.
  - Fragments smaller than 50cm should be targeted for these methods.
  - Larger fragments have naturally higher survivorship and are difficult to handle using the methods presented here (see Bruckner 2002 Appendix I for other options).
- Fragments with large dead portions may be chiseled down to a smaller size (by breaking away the dead portion) to facilitate stabilization and natural tissue contact with the substrate.

Note that continuous live portions of large fragments should not be divided to make the fragment more amenable to the methods described here. Ultimately, larger areas of continuous live tissue will be less vulnerable to complete mortality than smaller areas of live tissue.

COMPARISON OF METHODS

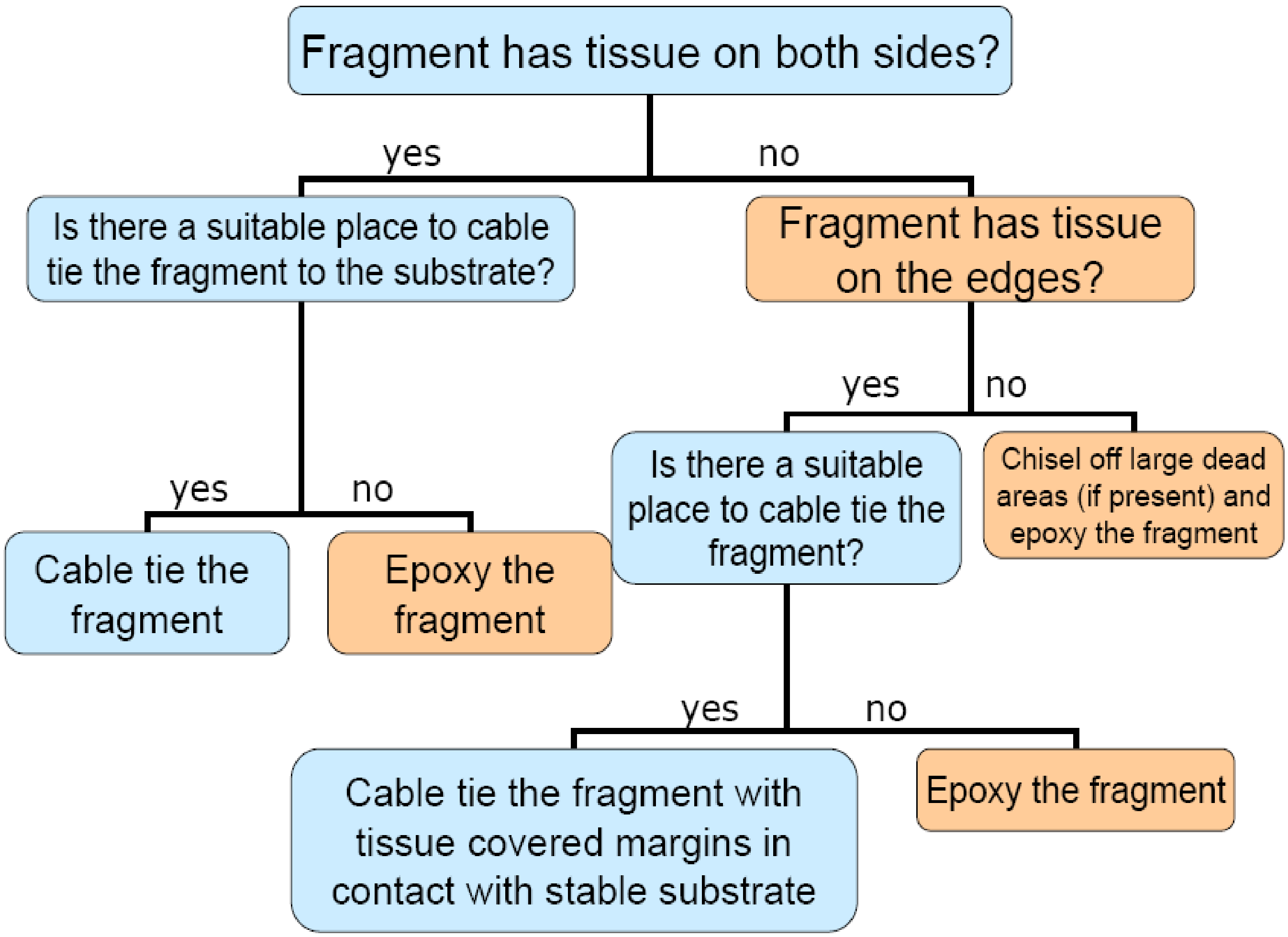
Both methods of fragment stabilization presented here can be used to restore fragments, however there are costs and benefits of each method. In general there is no right or wrong method and having multiple methods at your disposal will maximize the efficiency and success of the restoration effort. The table below was constructed as a guideline to assist in choosing the most suitable method.

Feature	Epoxy	Cable-tie
Cost ($ per fragment)	$ 4.00	$0.05
Time (min) per fragment	10	5
Purchase price	$32 per 2qt*	$25/1000
Cost effective	Less	More
Ease of method	Less	More
Access to materials	Less	More
General suitability	More	Less
Performance	More	Less
Failure rate	equal	equal
Low Maintenance	more	less

* can be purchased in 40qt kit ($400) to reduce cost to $2.50 per fragment, however it should be used within a few months of opening.

Selecting the appropriate method

If both methods are available then the decision tree below will assist in selecting the method best for individual fragments.



Materials

General items

A. Hand held GPS in Water-proof case
B. Camera in U/W housing
C. Slate & pencil
D. Trays (wire basket)
E. Brushes
F. Hammer & chisel
G. Scissors

Cable-tie stabilization method

H. Cable ties
I. Small mesh bag
J. Snippers
K. Pliers
L. Trash receptacle

Epoxy stabilization method

M. All-fix® epoxy
N. Latex Gloves
O. Heavy duty putty knife

Material uses:

- The GPS is needed to accurately record the location of restoration activities which often take place in areas that are not directly accessible by boats. A handheld GPS in a waterproof case **(A)** allows a snorkeler to swim to the restoration site and mark the center or outline the area.

- A slate and pencil **(C)** can be extremely helpful for recording basic data and communicating with the other divers. A clipboard and underwater paper are shown in the photo instead of a slate, either can be used but paper will result in a permanent record that can be referenced in the future.

- Baskets **(D)** are helpful for collecting the fragments to be reattached. The example shown is plastic coated metal and 20" across. It is ideal for this purpose because it does not float yet it is light weight. When this basket is full of *A. palmata* fragments it is very heavy so larger sized baskets should be avoided.

- The hammer and chisel **(F)** are used to remove dead portions of fragments so that only live material is being attached. This should ONLY be done on the day that the fragments are being attached since the smaller fragment will be much more vulnerable while it is loose.

- When choosing cable ties it is best to have a variety of sizes and choose 'organic' colors **(H)** that will be less conspicuous in the weeks before they are covered with tissue. Cable ties are more manageable when bundled in groups of ~20, the bundles can be carried in nylon or fine mesh pouches **(I)** (will tangle in wider mesh). These pouches will not float if weighted down with tools (snippers, chisel, pliers etc.) or attached to the wire basket. A second pouch **(L)** can be used for the trash (cut cable ties) that invariably results from using cable ties.

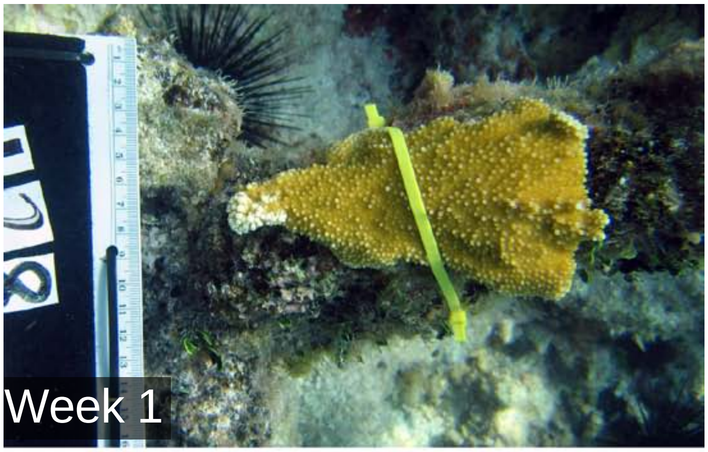
- The brushes shown are extremely buoyant and must be attached either to the diver or the basket at all times. Either a retractor or a string with clip should be attached.

- If epoxy it to be used, each part **(M)** can be scooped out by hand but it is helpful to use a strong (rigid) metal putty knife **(O)**.

CABLE-TIE STABILIZATION OF FRAGMENTS

1) Select spot
   a) Find a spot on the substrate or solid structure that can be used to wrap the cable tie. Standing dead *Acropora* can be used, however if it appears highly bio-eroded it is best to avoid branches that may easily break off. When searching for these attachment spots it is helpful to use a cable tie to find holes and test the strength of the structure (wrap cable tie around and pull).
   b) Avoid areas with sponges, tunicates and other sessile biota.
2) Clean with brush
   a) Use a scrub brush to clear sediment and fleshy macroalgae from the selected area. Crustose coralline algae (pink cement) and turf algae will not interfere with the process and do not need to be removed.
3) Fit fragment to contours- maximize contact points
   a) Set the fragment on the cleaned spot and adjust the position to maximize its stability and contact (especially live portions of the fragment).
4) Wrap the cable tie around the fragment and tighten until the fragment can not be moved.
   a) Pliers can be used to grasp the tail of the cable tie for tightening.
   b) Leave the extra tail of the cable-tie in place for the follow up check.
5) Follow-up
   a) After the initial setup fragments may settle slightly resulting in some 'wiggle room' or even very loose cable ties. It is advisable to return to the site 4 or 5 days after the initial setup to check the integrity of the attachments.
   b) If the fragments are loose it is best to tighten them where they are rather than to remove the cable tie and start over since it has likely settled to a more stable position. Use pliers to pull the cable ties tight if needed, at this point the tails can be cut off with snippers or scissors.
   c) It is extremely helpful to have a trash receptacle or other small container to hold the cut pieces!

Cable- tie stabilization time series



Week 1- The fragment has been stabilized on a standing dead *A. palmata* structure.

Week 7- The cable has been partially overgrown by live tissue.

Week 24- The cable tie has been completely overgrown by live *A. palmata* tissue and, live tissue has also begun to connect with the substrate (not visible in photo).

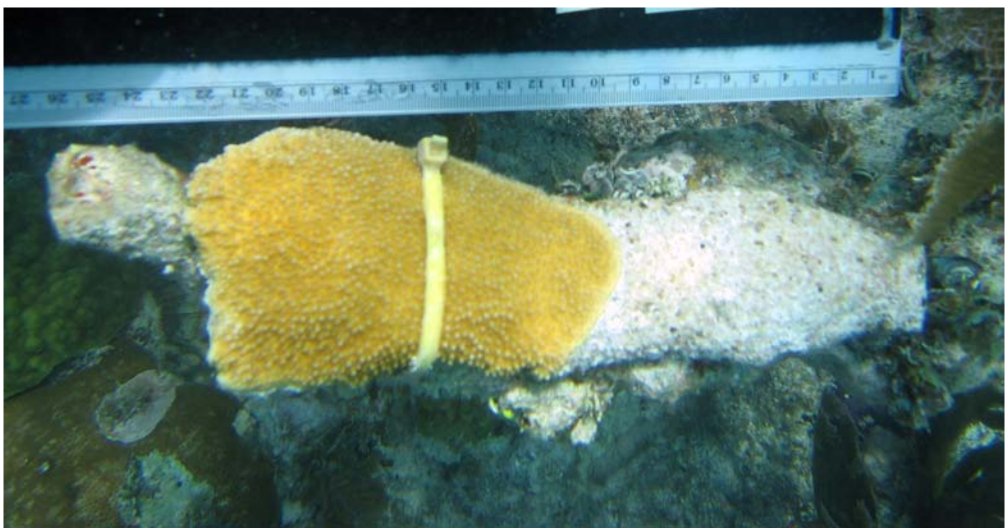
Week 44- The fragment has strongly fused with the substrate.

Example: optimal use of cable- tie method

The image below shows an example of an optimal use of cable ties to stabilize a fragment (same fragment from different angles).

A. Cable tie is passed through a natural hole in the substrate (not visible in photo)
B. secured around the fragment at a central narrow point
C. Fragment is in a naturally stable position /orientation (i.e. could rest there with no support from the cable tie
D. Live tissue is in contact with the substrate

Example: acceptable use of cable-tie method



The image at left shows an example of an acceptable use of cable ties to stabilize a fragment.

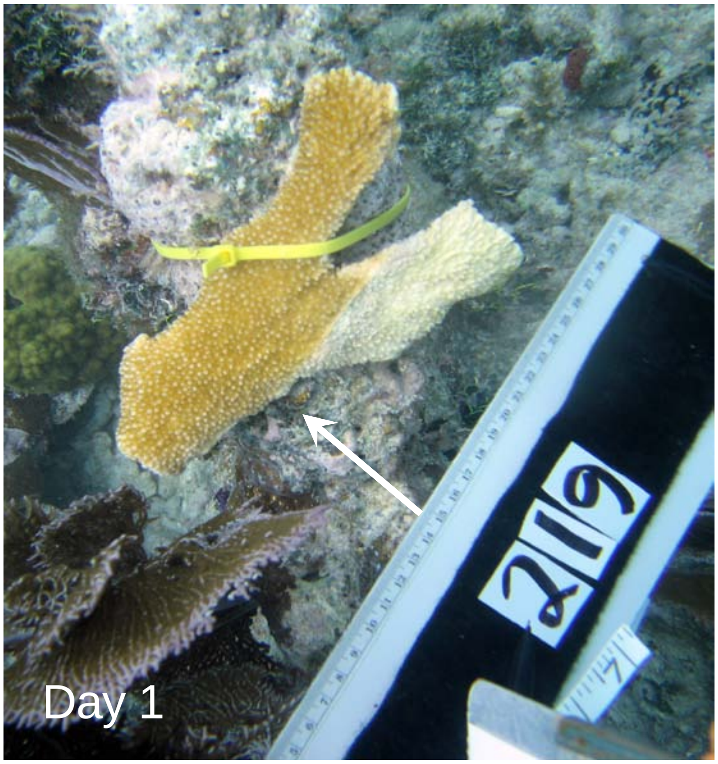
A. Cable tie is wrapped around a dead but upright *Acropora* branch

B. Fragment is in a naturally stable position /orientation (i.e. could rest there with no support from the cable tie

C. Not secured around the fragment's narrow point

D. Note that the right side of the fragment could have been chiseled off prior to being stabilized

Example: suboptimal use of cable- tie method



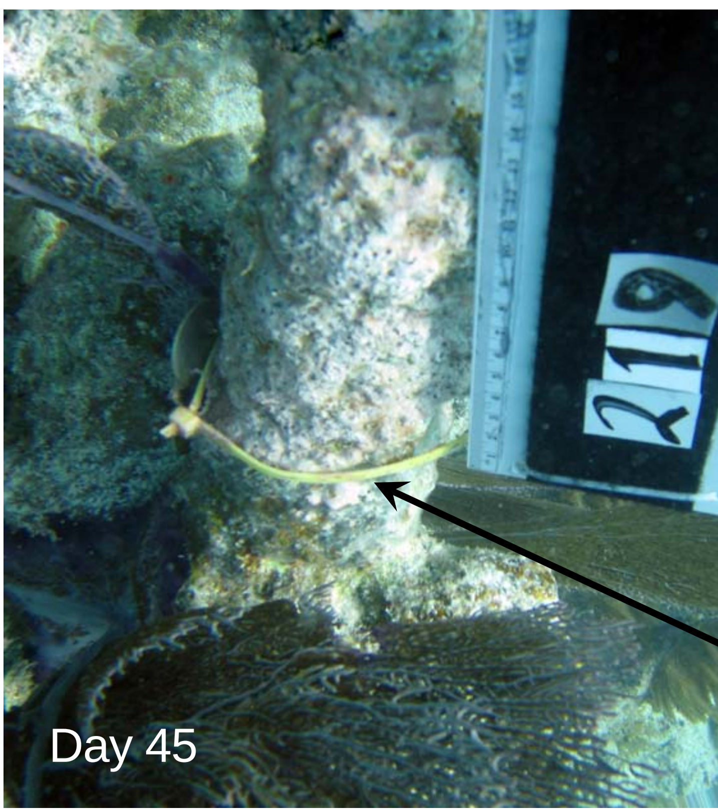
The image at left shows an example of suboptimal use of cable ties to stabilize a fragment.

A. Cable tie is wrapped around a dead *Acropora* branch, live tissue is in contact with the substrate

B. However the fragment is not in a naturally stable position /orientation and is not secured at a narrow point

C. The fragment should have been rotated counter clockwise and attached at the point indicated by the arrow

D. Additionally the fragment would have been more stable if placed in a more horizontal orientation



Note that by day 45 (bottom photo) the fragment has slipped out of the cable tie.

Epoxy Stabilization of Fragments

1) Select spot- free of sponges, tunicates and other sessile biota

2) Clean with brush

3) Fit fragment to substrate contours

    a) The fit is less important than in the cable tie method but is still best to place the fragment in the intended orientation to determine the amount and placement of the epoxy.

4) Mix epoxy and shape into balls

    a) The amount of epoxy needed varies with the fragment size, shape and fit to the substrate.

    b) Once the ball is flattened (see next step) the epoxy ‘patty’ should be about ½″ to ¾″ thick and the diameter should be 2-3″ or 2/3 of the width of the fragment (which ever is greater).

5) Place ball on substrate and cover with fragment and press into place.

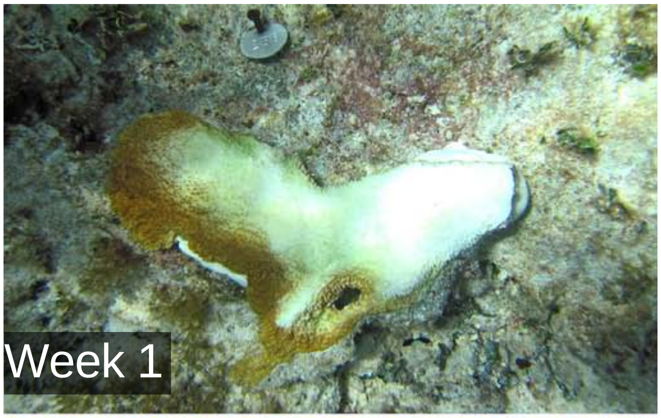
    a) The ball of epoxy will flatten into a patty.

    b) The epoxy will set in an hour and be fully cured (according to mfr specs) in 24 to 48 hours.

Bulk method

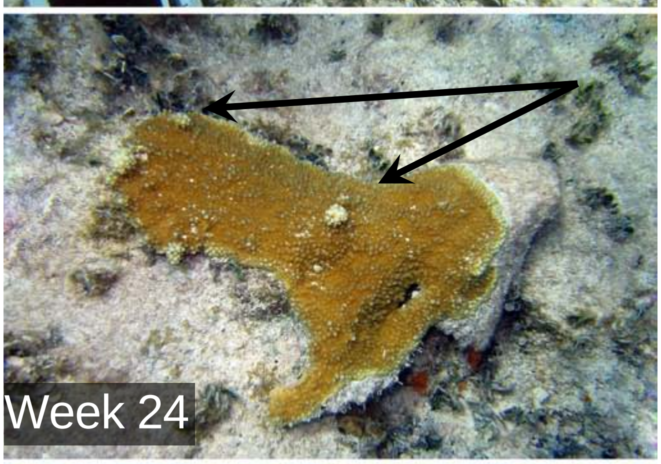
Although the epoxy can be mixed entirely in the water, it is more efficient if it is done by a 3rd person on the boat and a 4th person is used to shuttle the mixed epoxy to the divers. Since it is mixed by hand it can only be made in 1-2 cup sized batches at a time and each batch takes approximately 5 minutes to mix. After mixing it is workable for approx 30 minutes, but the sooner it is used the better the ‘grip’ on the fragment. Prior to any mixing, the substrate and fragments should be prepared (first 3 steps above completed) for several fragments so that the epoxy can be used immediately after it is mixed.

Epoxy stabilization time series

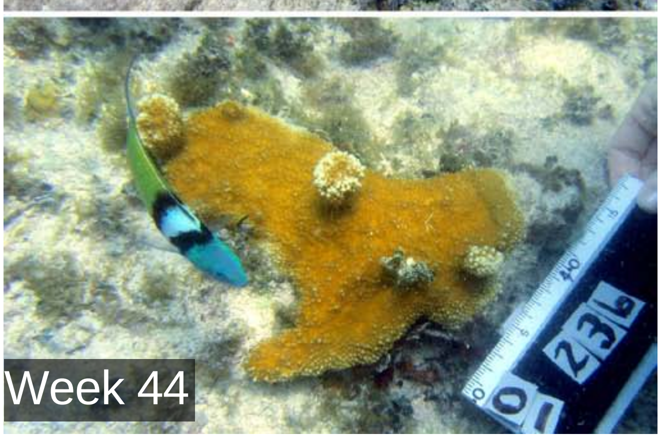


Week 1- The fragment has been stabilized on the substrate using epoxy. The fragment was originally found overturned leaving the live tissue bleached.

Week 7- The tissue has begun to regain its natural color, though the far right end did not recover and has been colonized by algae.



Week 24- The live tissue has fully regained its natural color and sprouted 'proto-branches'.

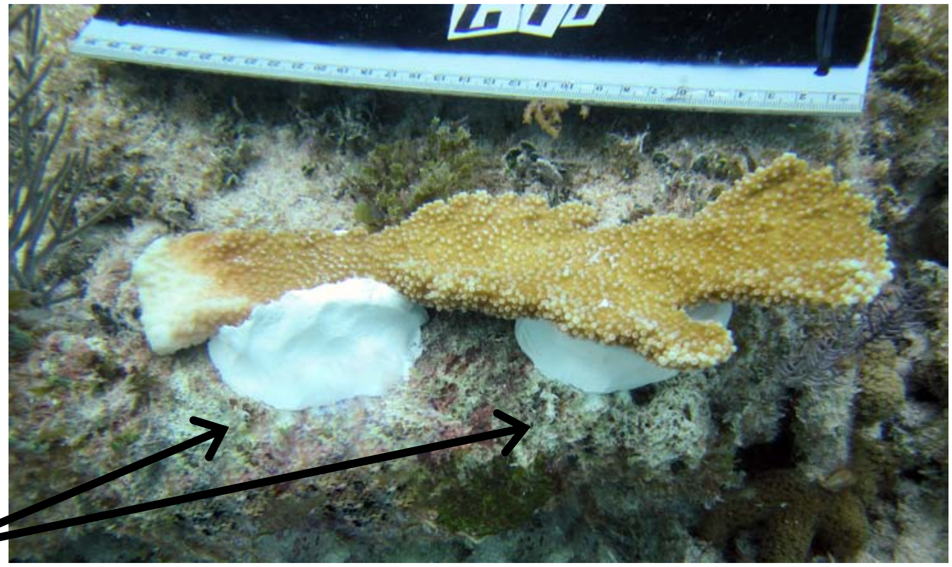


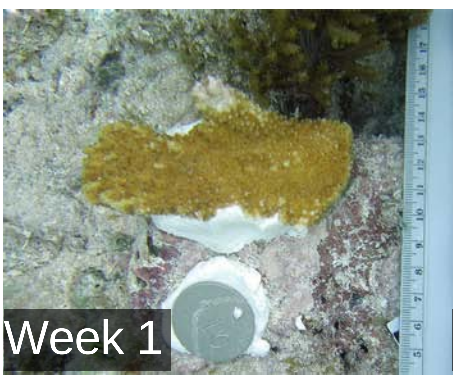
Week 44- The branches continued their growth and the fragment remains stable.

Example: optimal use of epoxy method

These images show examples of **optimal** use of epoxy to stabilize a fragment

- Fragment is in a naturally stable position /orientation
- Epoxy was used in 2 places due to the long slender shape of the fragment





Week 1- Fragment is in a naturally stable position /orientation. Epoxy placed in direct contact with live tissue when there is no other choice

Week 6- Epoxy is colonized by turf and crustose coralline algae by 6 weeks and has become relatively inconspicuous. Live tissue is beginning to overgrow the epoxy

Week 27- Epoxy is readily overgrown by live tissue in 6 months

RECORD KEEPING

Even if follow-up surveys are not planned it is important to record the details of the restoration effort:

- Location of the restored fragments:
  - if possible a GPS waypoint should be taken at the surface over the restored fragments. If they are distributed over a relatively large area consider taking multiple points at the perimeter.
- If the fragments were moved from the general area of the disturbance a waypoint marking the general area where they were found should also be collected.
  - NOTE: Moving fragments between reefs is somewhat controversial at the moment due to potential transfer of pathogens and or disruption of the local population's genetic structure. This type of activity should be carefully considered and explicitly discussed with area managers before being undertaken. Detailed records are particularly important in this scenario.
- Number of fragments and method of stabilization.
- Photographs of the completed restoration should also be taken if possible.