Southeast Florida large (>2 meter) diseased coral colony intervention summary report

Florida Department of Environmental Protection
Coral Reef Conservation Program
&
Florida Fish and Wildlife Conservation Commission

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Final Summary Report

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List of Acronyms

ESA	Endangered Species Act
FDEP	Florida Department of Environmental Protection
FRT	Florida Coral Reef Tract
FWC	Florida Fish and Wildlife Conservation Commission
NOAA CRCP	National Oceanic and Atmospheric Administration Coral Reef Conservation Program
NSU	Nova Southeastern University
SE FL	Southeast Florida

1. PROJECT DESCRIPTION

a) Project Background

A coral disease event has devastated the Florida Reef Tract over the past four years. It has happened so quickly that many corals have perished before a response action could be taken. Reef managers are busy prioritizing actions to support all of their needs in this time of reef crisis. This now includes conducting disease intervention strategies to save the largest, oldest corals. In 2015, Nova Southeastern University (NSU) conducted a study documenting the condition of corals larger than two meters in diameter in southeast Florida (SE FL) (Walker and Klug 2015). That study found a total of 185 colonies, including 115 alive, of which 90 were *Orbicella faveolata* and two *Orbicella annularis*. Both species are listed as threatened under the Endangered Species Act (ESA). Some of the corals were over four meters in diameter and seemingly healthy. About 50% of the corals were either bleached or diseased with 15% of the 115 corals having both. One of these, confirmed at over 320 years old, lost 32 m² of live tissue in about 90 days and totally perished (Figure 1). The current condition of the other 114 corals (including 92 *Orbicella* spp.) after the disease event was unknown.

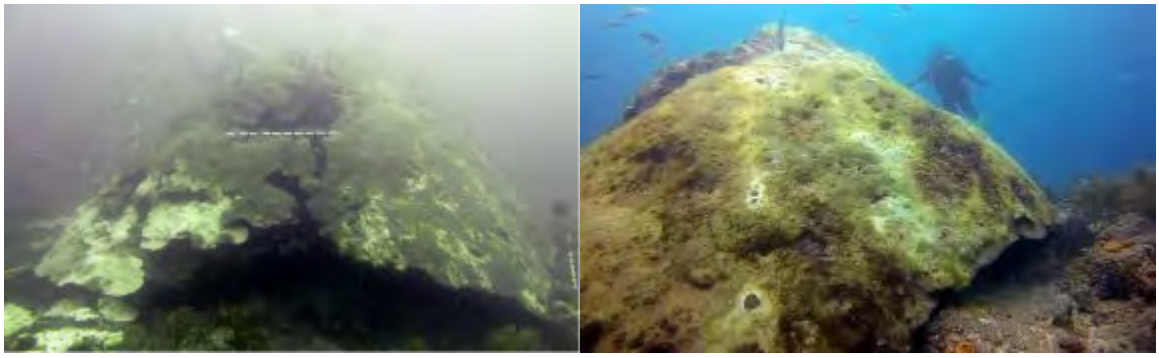

Figure 1. (Left) September 14, 2015 image of LC-008 dated to over 320 years old. This coral was about 90% alive with 10% bleaching and 1% disease. (Right) December 18, 2015 image by Courtney Keil, Broward County. Ken Banks, Broward County, found it was about 95% dead. In about 90 days, the coral had lost about 32 m² of live tissue.

The National Oceanic and Atmospheric Administration's Coral Reef Conservation Program (NOAA CRCP) funded an assessment in August 2017 to document the current condition of those corals to examine survivorship and document changes from the 2015 baseline survey. Hurricane Irma delayed the start of this project by physically creating conditions that precluded work (e.g. bad seas, poor visibility) and strained limited response capacity within a short timeframe to investigate the coral disease and hurricane reef impacts (PR B1FF46). As part of the hurricane impacts surveys, 10 large coral sites were visited on October 16, 2017. Three were healthy without bleaching or disease, two were partially bleached, two had disease just starting, one was 99% dead with some tiny remaining tissue with active disease, and two were completely dead (Figure 2). This indicated that there were still some large healthy corals and some that would benefit from disease intervention.

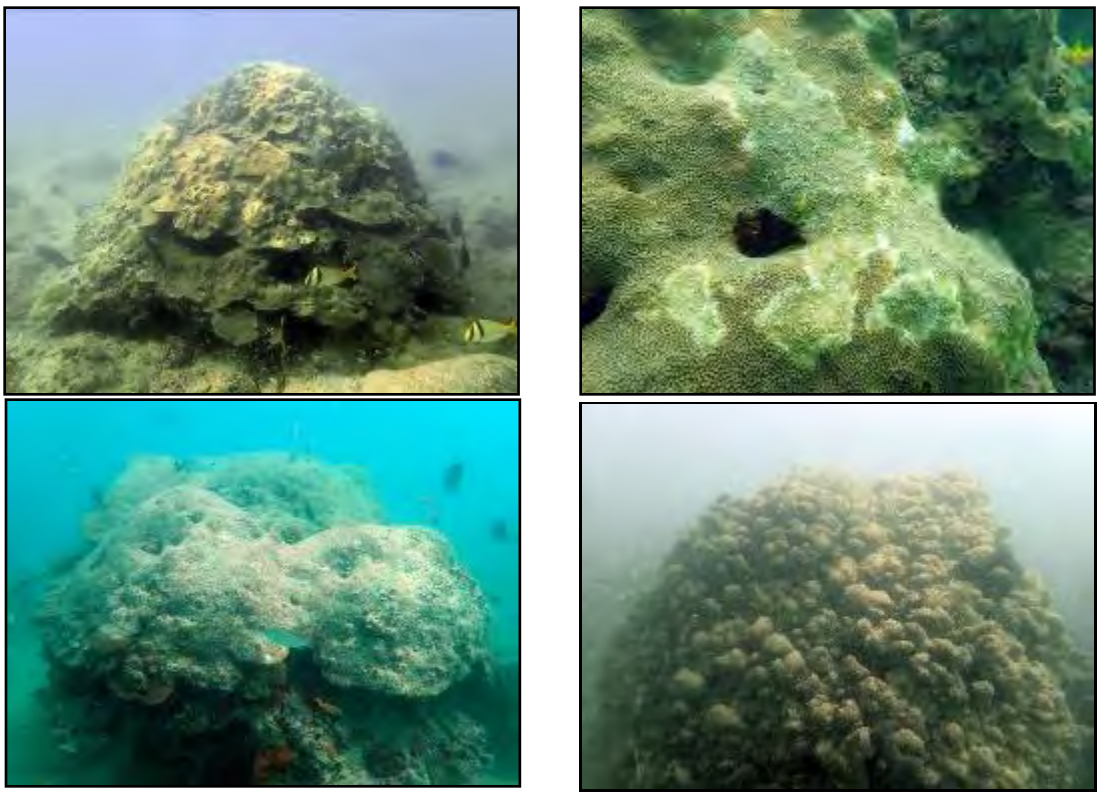

Figure 2. Examples of large corals visited on October 16, 2017; healthy coral (upper left), diseased coral (upper right), almost dead (lower left), and completely dead coral (lower right).

The Florida Fish and Wildlife Conservation Commission (FWC) and the Florida Department of Environmental Protection's Coral Reef Conservation Program (FDEP CRCP) funded efforts to restore the health of many of these sick colonies by covering the diseased tissues and arresting disease progression before the entire colony was lost.

These corals are the oldest living residents in SE FL and provide enormous ecological value. These corals are the main reef builders remaining in the region and have persisted in increasingly stressful locations for hundreds of years. That they are still alive in SE FL indicates they are tolerant to both cold and warm water, multiple bleaching events, high turbidity, and changes in water flow and water quality. Saving them would allow researchers the opportunity to perform reef restoration activities with resilient individuals, thus helping reef resilience in a warming climate. By conserving and restoring the quality and quantity of coral reef habitat, this project supports the Commission's mission of managing fish and wildlife resources for their long-term well-being and the benefit of people.

The project supports the following themes and goals of the Florida Fish and Wildlife Conservation Commission Agency Strategic Plan (2014-2019):

- Theme 1, Goal 1: Ensure the sustainability of Florida's fish and wildlife populations.
    - Strategy 1: Manage listed species such that they no longer meet Florida's listing criteria for endangered and threatened species.

    - Strategy 3: Anticipate and address fish and wildlife species' conservation needs in light of adaptation to long-term environmental changes.
- Theme 1, Goal 2: Ensure sufficient habitats exist to support health and diverse fish and wildlife populations.
    - Strategy 3: Manage habitats to sustain healthy and diverse fish and wildlife populations.
- Theme 2, Goal 1: Provide residents and visitors with quality fishing, hunting, boating and wildlife viewing opportunities that meet their needs and expectations while providing for the sustainability of those resources.
    - Strategy 2: Manage fish and wildlife populations to provide sustainable fishing, hunting, and wildlife-viewing opportunities.

This project also addresses a number of FDEP CRCP goals listed in their 2011-2016 Strategic Plan. Specifically, it supports CRCP Capacity Objective 1 Strategy 1.2 – Maintain existing CRCP services, programs, and partnerships for threatened and endangered reef species recovery planning and implementation; Objective 2 Strategy 2.2 – Continue to engage in resource management activities which support conservation and management of the Florida Reef Tract as a holistic system, Strategy 2.8 – Track locations and information for threatened, endangered, and unique coral colonies and masses off southeast Florida, and Strategy 2.9 – Expand recovery rate information for functional groups on southeast Florida reefs.

This project specifically addresses several items under NOAA CRCP priority 4, Local and Emerging Management Needs. Specifically, it addresses items 3a) Corals Listed under the Endangered Species Act-Florida, projects that map and build capacity for emergency sampling and genetic-banking of corals for imperiled genotypes – specifically threatened species; item 3b) Corals Listed under the Endangered Species Act-National, projects that support the recovery of key foundational corals (e.g., Acropora and Orbicella species) also listed as threatened under the ESA, by filling critical information gaps about their locations, habitats, early life history, and threat responses, specifically the major threats leading to their extinction risk: ocean warming, ocean acidification, diseases, trophic effects of reef fishing, and land-based sources of pollution; and item 4) Coral Disease –Florida, projects to increase jurisdictional understanding of the mechanisms and/or conditions that cause and promote coral diseases – including management recommendations for reducing outbreak potential.

b) Purpose

The purpose of this project is to perform disease intervention on previously-identified, large corals (including ESA-threatened-species) over two meters in diameter in SE FL identified with active disease. This includes restoring coral health by smothering diseased tissue, creating a "fire break" to arrest disease progression and covering the newly exposed skeleton with chlorinated epoxy. These activities are essential to save the largest, oldest, and most resilient corals in SE FL affected by disease.

2. METHODOLOGY

This work was conducted under the State of Florida Special Activity License SAL-18-2022-SRP which authorized cutting firebreaks in large (>2 meters) diseased corals of any species, and/or apply disease treatments to such corals.

Under the guidance of recommendations by the Florida Coral Disease Advisory Committee, initial treatments consisted of cutting firebreaks and applying peroxide toothpaste to the disease margins and firebreaks. It became immediately apparent this application was not sufficient to effectively treat the diseased coral. The toothpaste activated the coral to send out filaments and mucus, fish were picking at the paste, and the toothpaste did not adhere to lesions, especially on vertical surfaces. Due to these challenges, all subsequent treatments consisted of using chlorinated epoxy.

Chlorinated epoxy was created using the same ingredients (ZSPAR A-788 Splash Zone epoxy & Poolife™ TurboShock© powder), recipe, and application methodology as described in Aeby et al. (2015). "The marine epoxy was mixed with chlorine powder (calcium hypochlorite) (~15mL/ 50 mL epoxy), and then spread over the border of live tissue and bare skeleton (primary band). Another band of marine epoxy was applied to an area of healthy coral ca. two to five centimeters beyond the edge of the primary band as a "firebreak" or a second attempt to block disease progression if the primary band failed to halt disease progression (secondary band)" (Aeby et al. 2015). Firebreaks ranged in length, width, and depth depending on coral morphology and hardness. A typical firebreak was one to two centimeters wide and deep. Firebreaks were created by using a Nemo V2 underwater angle grinder and hammer and chisel. The disease area was first scored with chisel five centimeters away from the margin, and then a trench was created along the scored tissue.

Photos were taken before and after treatments using a 0.5-meter bar with a 3.9-centimeter-wide portion visible in the frame for scale. Images were taken from many angles along all treatment areas to allow for temporal visual comparisons and future image analysis. Treated colonies were initially monitored two to three days (or as soon as possible thereafter) after the first treatment to observe the effectiveness of the disease intervention methodologies. Treated colonies were also revisited and photographed about every two weeks after. Any continued progress of the disease margin was noted and additional treatments were applied as necessary.

3. RESULTS

Between December 19, 2017 and May 18, 2018, 244 colonies were visited and assessed for condition including size, amount of live tissue, bleaching, paling, and active disease (Figure 3). From these assessments, 23 corals were identified with disease and treated be-

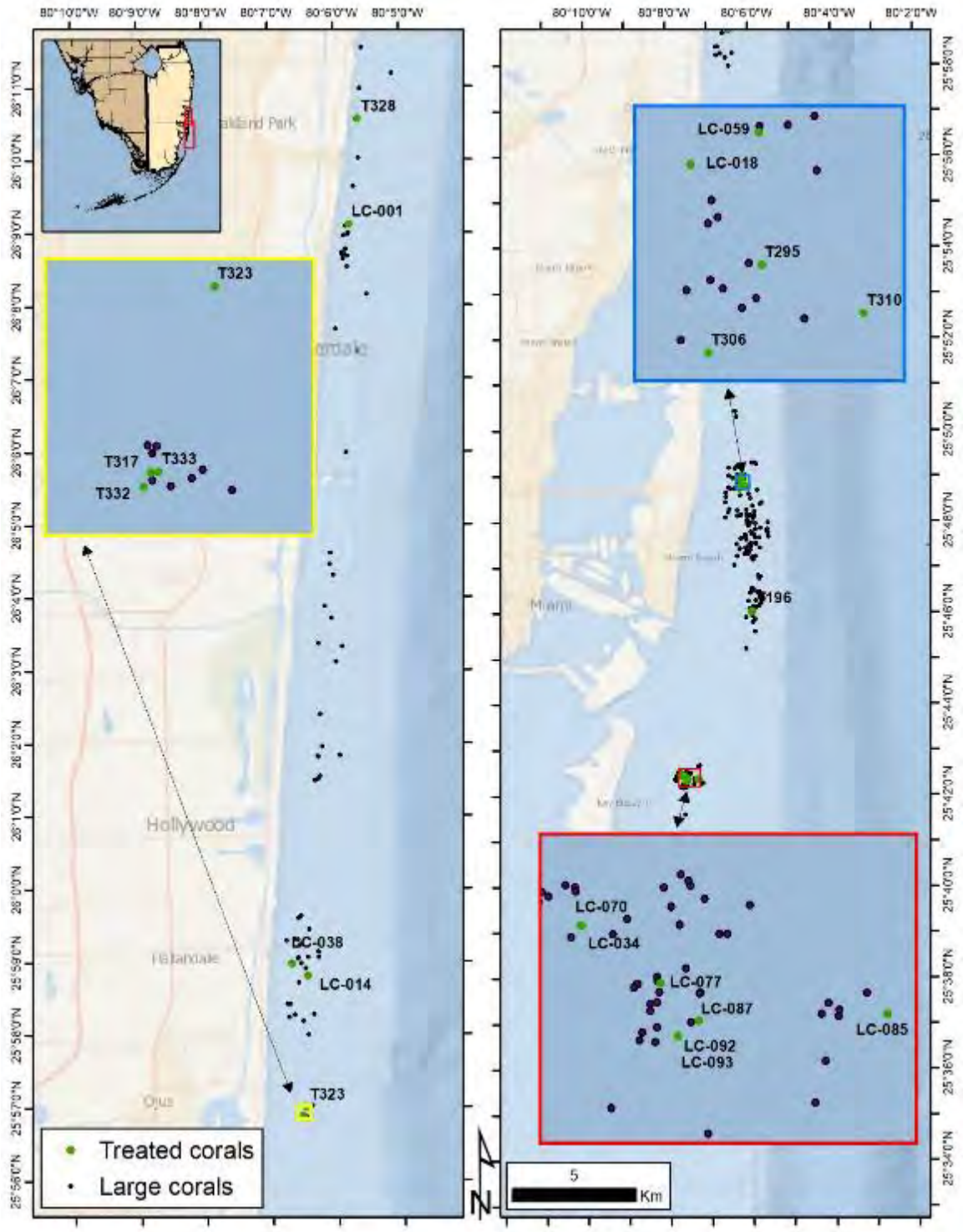

Figure 3. Southeast Florida large coral disease intervention map. Green sites are corals treated with chlorinated epoxy. Black sites are all other large coral locations (alive and dead).

tween April 25 and June 14, 2018: 16 *Orbicella faveolata*, 6 *Montastraea cavernosa*, and 1 *Siderastrea siderea* (Figure 4). Twelve of the treated corals were large corals previously surveyed in 2015 (LC sites). Eleven treated corals were new recon targets (T sites). Three

treated *M. cavernosa* corals were not >2 meters in diameter (T-328 and two next to T-317). T-328 was a healthy-looking colony (nearly 100% alive) near T-192 with recent infections at the bottom that presented a good opportunity to incorporate more treatments for this species. The two colonies next to T-317 were treated opportunistically and because they were <1 meter from T-317.

All corals were visited between two and seven times depending on treatment severity and timing (Figure 4) over 17 dive days (Table 1). The number of corals visited per day varied due to the activity performed at each coral. The average number of days between initial treatment and primary monitoring was 6.1 days (Table 2). The average treatment between the primary and second monitoring was 11.5 days. It was 13.9 days on average between the second and third monitoring and 10.8 days between third and fourth.

As of June 14, 2018, 86 active disease margins were treated and 119 firebreaks created (Table 3). In 36 cases, the disease progressed beyond the epoxy treatment on the margin resulting in a success rate of 58.1% on disease margins. In only three cases did the disease appear to cross the firebreak. This resulted in a 97.5% success rate for firebreak treatments.

Appendix 1 shows the majority of treatments and monitoring data throughout the project.

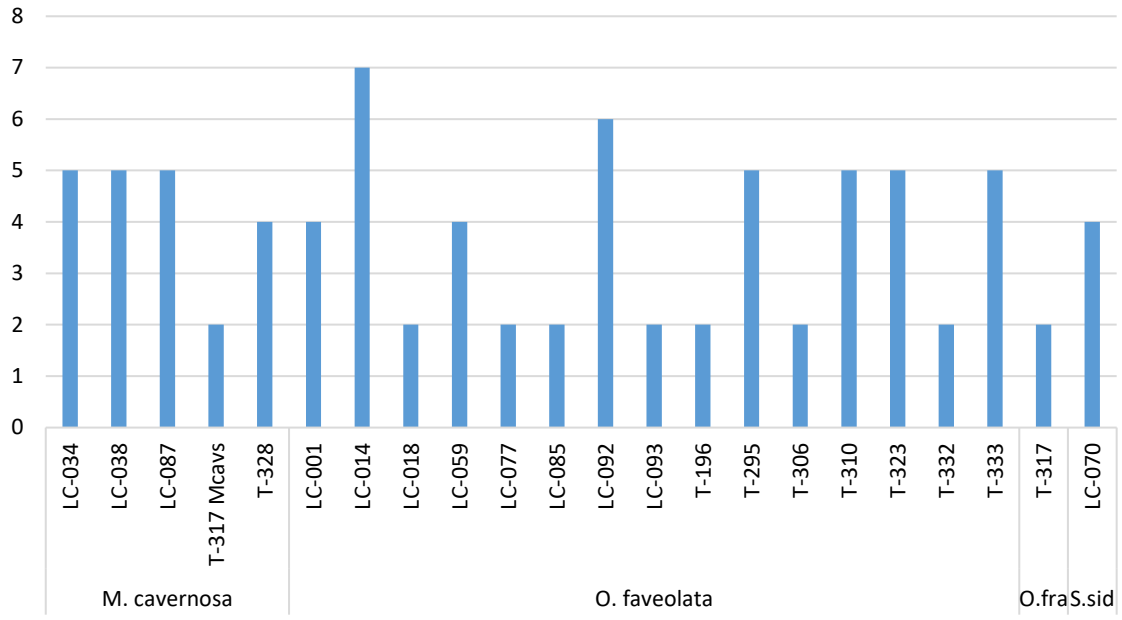

Figure 4. Graph showing the number of visits per treated coral including initial treatment and subsequent monitoring.

Table 1. Dates of disease intervention activities and the corals visited.

Date	Corals visited
4/25/2018	LC-014 T-319 T-323
4/26/2018	LC-014 LC-059 T-310 T-319 T-323
4/27/2018	LC-014 LC-038 LC-059 T-295 T-310 T-319 T-323
5/7/2018	LC-027 LC-070 LC-071 LC-074 LC-089 LC-092 LC-110
5/8/2018	LC-001 LC-002 LC-004B LC-014 LC-038 T-192 T-319 T-323
5/10/2018	LC-021 LC-031 LC-038 LC-059 T-233 T-295 T-296 T-310 T-316 T-317
5/11/2018	LC-001 LC-034 LC-070 LC-089 LC-092 T-196 T-215 T-216 T-222 T-233
5/16/2018	T-263 T-285 T-286 T-287 T-288 T-289 T-290 T-291 T-293 T-295 T-301
5/24/2018	LC-001 LC-014 LC-034 LC-038 LC-059 LC-070 LC-087 LC-092 T-192 T-295 T-310 T-317 T-323 T-329
6/1/2018	LC-014 T-310 T317 T-322 T-323
6/4/2018	LC-028 LC-062 LC-066 LC-067 LC-075 LC-077 LC-079 LC-080 LC-084 LC-085 LC-087 LC-090 LC-092 LC-093 LC-098 LC-101 LC-103 LC-110 LC-114
6/5/2018	LC-013 LC-015 LC-016 LC-018 LC-024 LC-58 LC-59 T-196 T-233 T-240 T-284 T-306 T-322 T-327
6/7/2018	LC-077 LC-085 LC-093 T-330 T-331
6/8/2018	LC-007 LC-014 LC-018 T-196 T-306
6/11/2018	LC-034 LC-038 LC-059 LC-070 T-295 T-310 T-317 T-323 T-332 T-333
6/12/2018	LC-007 LC-014 LC-018 LC-077 LC-085 LC-092 LC-093 T-196 T-306
6/14/2018	LC-001 LC-002 LC-004B LC-005 LC-034 LC-055 LC-056 T-328

Table 2. Statistics on monitoring frequency.

Average number of days between Treatment and Primary Monitor	6.1
Average number of days between Primary Monitor and Secondary Monitor	11.5
Average number of days between Secondary Monitor and Third Monitor	13.9
Average number of days between Third and Fourth Monitor	10.8

Table 3. Frequency of treatment success.

Total active margins treated	86
Total progressions past margin	36
Percent of treatments that progressed passed margin	41.9%
Total firebreaks (any trench made separating tissue)	119
Total progressions past firebreak	3
Percent of treatments that progressed past firebreak	2.5%

4. DISCUSSION

This study achieved its goals to restore coral health by smothering diseased tissue and creating a firebreak which arrested disease progression. These activities undoubtedly saved large portions of live tissue and in some cases, the entire coral from full mortality, especially in colonies like T310 (Appendix 1, page 99), which was over 90% alive but had rapid disease progression and required multiple extensive treatments.

The peroxide toothpaste was not an effective treatment and should not be used in further efforts.

The chlorinated epoxy was effective in varying levels (58.1% frequency on disease margins and 97.5% on firebreaks); however, since we did not treat any corals with non-chlorinated epoxy, we do not know if the chlorine conferred additional benefits. In some cases the chlorine may have hindered the epoxy from setting properly. The epoxy is particularly difficult to measure into discrete volumes due to its viscosity and it is likely that the ratios of the two epoxy parts to the chlorine were not always adequate to stop disease progression. The epoxy's viscosity also contributed to a significant amount of waste because it stuck to everything. Aeby et al. (2015) found "that treatment was more effective if the epoxy was mixed with chlorine powder." Since it did not add much to the cost or time and did not adversely affect the coral other than the tissue to which it was applied, we recommend continuing to use the chlorine. We did not observe corals growing back over the epoxy as Aeby et al. (2015) reported, however our monitoring period may have been too short to observe this phenomenon and it may still occur.

Using epoxy on disease margins was not as effective as originally hoped. It is difficult to gauge if this treatment is worth applying in future efforts. It did arrest the disease

progression in 50 out of 86 treatments. If analyzed, the images may show that this saved a significant portion of live tissue between the marring and the firebreak. However, the epoxy is expensive and mixing it underwater takes between 5 and 10 minutes so treating all the disease margins does have associated costs of slowing the operation and using more materials. The epoxy was much less effective on *M. cavernosa* and should likely not be used on disease margins for this species in the future. *Montastrea cavernosa* has much larger, thicker, and smoother polyps that prevented the epoxy from adhering to the live tissue sections of the disease margin. This allowed the disease to continue and caused the epoxy to peel off in some cases. The epoxy was more effective on the disease margins of *Orbicella* spp. and *S. siderea* and may be a viable treatment for these species.

The firebreak was very effective in almost all cases (116 of 119). If designed well, the firebreak can save large amounts of live tissue and is worth continuing in future efforts. We did not test different depths or widths of firebreaks, but a one centimeter wide and deep firebreak was sufficient in most cases. The few cases that it did not contain the disease were on *M. cavernosa* which are noticeably denser and more difficult to create a deep firebreak.

The Nemo angle grinder was the best tool for creating firebreaks and enabled the success of our project. Using a hammer and chisel can work, but the process was time consuming and exhausting for field crews. In most cases, the angle grinder allowed a one or two meter long firebreak to be created in just a few minutes with much less effort. The angle grinder is not effective in all cases due to varying coral morphologies, requiring additional work with a hammer and chisel to ensure a complete firebreak and to prevent unnecessary damage to healthy portions of the colony. We recommend using a diamond blade on denser corals; while thinner, these blades can better cut the denser coral.

In many cases (mostly *O. faveolata*), the live tissue between the treated disease margin and firebreak remained visually healthy and intact after treatment. This indicates that perhaps five centimeters is too far away from the disease margin in these cases. Reducing the distance between the firebreak and the disease margin would save more tissue. We recommend that this distance be reevaluated to see if there are circumstances where it can be reduced.

Several corals were re-infected in new places during subsequent monitoring periods, which led to retreatment. In some cases, it was a small spot and in others it was rather large areas or many small spots. Several corals became visibly more stressed during the monitoring with increasing paled and bleached areas and new disease outbreaks (e.g. LC-092 on page 67). More investigation is needed to quantify and analyze these occurrences in space and time with other potential stress factors like proximity to inlets and the onset of rainy season.

Although there has been considerable loss in colony density and richness at the highest coral sites and the population demographics have changed, there are still many corals that are seemingly yet unaffected by the disease or have exhibited resilience (Walker 2017). Even though the majority of the large coral population has been hit hard in SE FL, there

are still corals worth monitoring closely and employing disease intervention techniques on if necessary. Catching the disease early before it spreads across large portions of the colony will save significant amounts of tissue and may leave the coral more resistant to fighting off new infections. In May 2018 we prioritized the large coral database by roughly estimating their remaining live tissue using percent mortality and colony size. This resulted in 50 corals with more than four square meters of live tissue remaining and colonies with <10% mortality (Figure 5). All of these colonies were revisited in early June where some were discovered to have very recent infection sites. These corals were treated during the writing of this report and could not be incorporated herein. We recommend the priority corals be monitored monthly and treated if necessary. Monitoring monthly will also give a better understanding of how their condition changes temporally. We have seen many of them bleach and recover, however the frequency, timing, and cause of the bleaching is unknown.

It is important that actions are taken to curtail this disease quickly so that the remaining population can stabilize and recovery and restoration efforts can begin. There should be continued focus on the remaining corals because they are apparently resistant to the disease and perhaps better acclimated to the stressful conditions over the past several decades. Below are a series of recommendations for future focus on the large corals in SE Florida.

5. RECOMMENDATIONS

Recommendation 1*: Continue ongoing efforts to determine the disease agent/etiology and investigate how to prevent its spread and/or treat corals to resist the disease.* FDEP CRCP and FWC are conducting workshops and phone calls to coordinate many coral and disease experts with managers. These efforts should continue.

Recommendation 2*: Monitor and treat large priority corals monthly.* The largest corals have the highest reproductive capacity and therefore provide the most benefit to save. Most of these are the threatened species *Orbicella faveolata*, one of the main reef-building species in our region. Fifty colonies have been identified as worthy of regular monitoring. These corals should be visited monthly to monitor their condition and, if disease outbreaks occur, be targeted for disease intervention efforts.

Recommendation 3*: Conduct restoration efforts to aid in coral population recovery.* Once the disease has passed and prevalence is low again, coral restoration efforts should be conducted to improve the probabilities of reproductive success and regain coral diversity and density in the system. We recommend collecting gametes from the large corals, fertilizing them in the near future, and rearing them in a land-based nursery to save the genetic diversity of these resistant colonies. These corals should be grown out for several years and then outplanted strategically to help regrow tissue on recently dead large colonies.

Recommendation 4*: Consider treating a subset of large corals with antibiotic paste.* Several colonies seemingly had systemic infection that might benefit from the treatment of antibiotics to help it fight the disease.

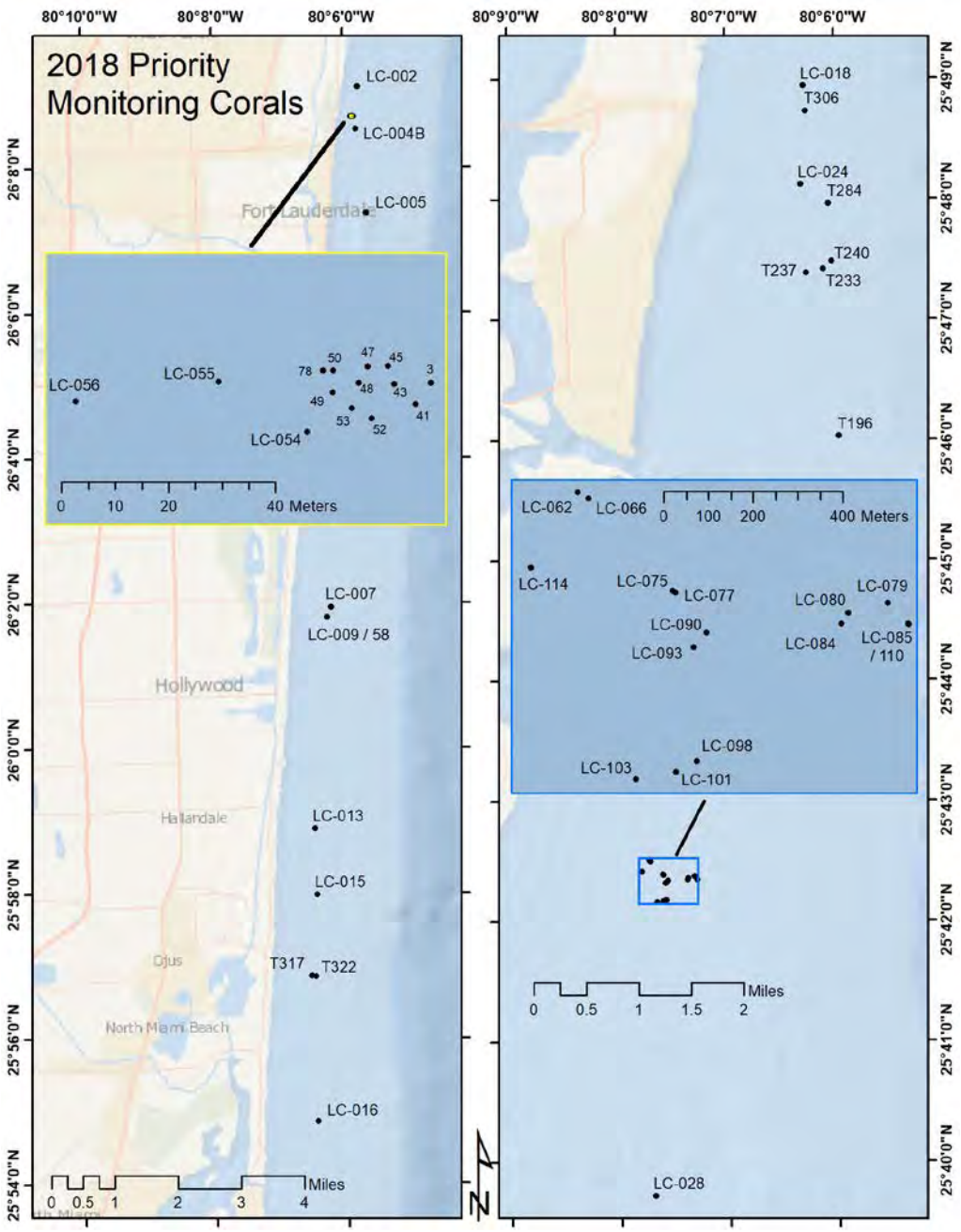

Figure 5. Map of the recommended priority monitoring colonies.

6. REFERENCES

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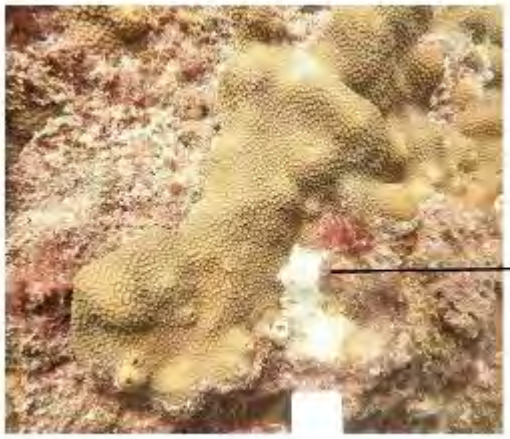
7. APPENDIX 1

LC-001

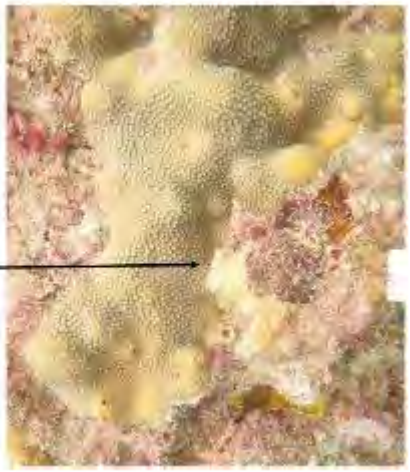
May 8, 2018-Treatment

May 11, 2018- 1st Monitor

May 11, 2018- 1st Monitor



May 24, 2018-Secondary Monitor



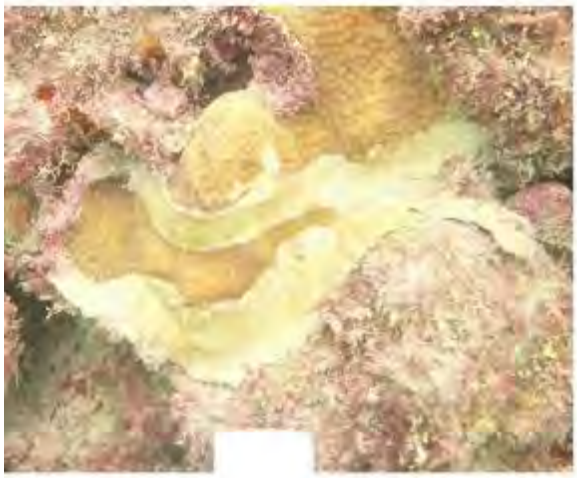
May 8, 2018-Treatment

May 11, 2018-1st Monitor

May 11, 2018-1st Monitor

May 24, 2018-Secondary Monitor

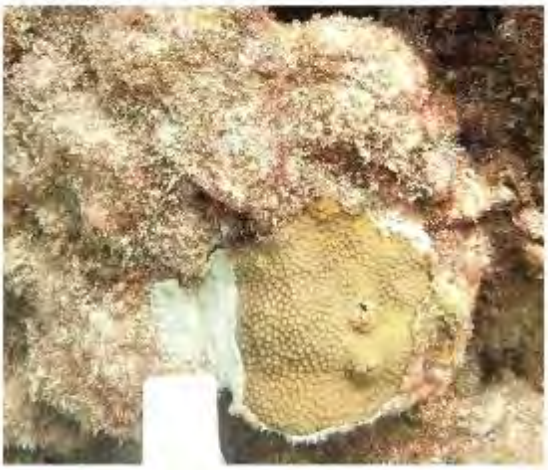
May 24, 2018 Secondary Monitor



June 14, 2018- Monitor- Passed firebreak

May 8, 2018-Treatment

May 11, 2018-1st Monitor



May 11, 2018-1st Monitor

May 24, 2018-Secondary Monitor

May 24, 2018-Secondary Monitor

June 14, 2018- Monitor

May 11, 2018-Treatment

May 24, 2018-1st Monitor

May 24, 2018 1st Monitor

June 14, 2018 Monitor

May 24, 2018-Secondary Monitor- New disease/bleach spots

LC-018

June 5, 2018-Priority Re-Check

June 5, 2018-Priority Re-Check

June 8, 2018- Treatment

June 8, 2018- Treatment

June 12, 2018- Monitor

June 8, 2018- Treatment

June 12, 2018- Monitor

June 8, 2018- Treatment

June 12, 2018- Monitor

June 8, 2018- Treatment

June 12, 2018- Monitor

June 8, 2018- Treatment

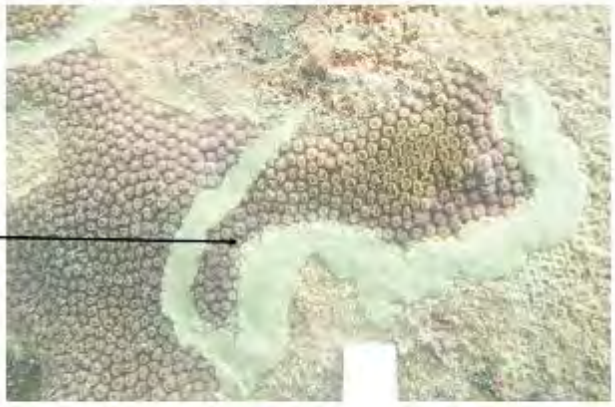
June 12, 2018- Monitor

LC-034

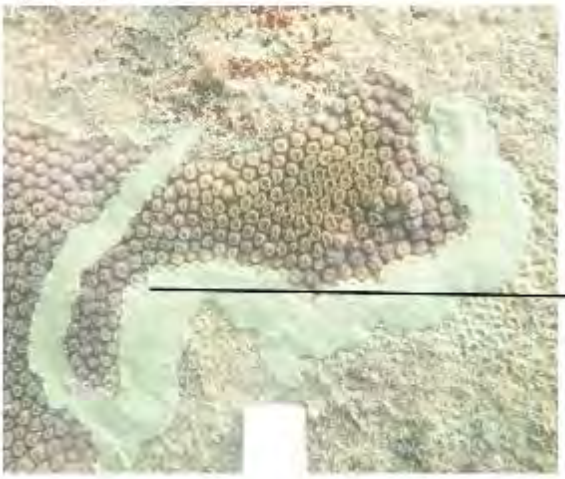
March 1, 2018 Initial Visit

May 7, 2018-Treatment

May 11, 2018-1st Check



May 11, 2018-1st Check



May 24, 2018-Secondary Monitor

May 24, 2018-Secondary Monitor

June 11, 2018- Monitor- disease either passed FB or started a new margin

May 7, 2018-Treatment (no pics of epoxy filled)

May 11, 2018-1st Check

May 11, 2018-1st Check

May 24, 2018- Secondary Monitor

May 24, 2018- Secondary Monitor

June 11, 2018- Monitor

May 7, 2018-Treatment (no pics of epoxy filled)

May 11, 2018-1st Check


May 24, 2018- Secondary Monitor
May 11, 2018-1st Check


May 24, 2018- Secondary Monitor


June 11, 2018- Monitor

June 11, 2018- Monitor- New active margins

June 11, 2018- Monitor - New active margins

June 14, 2018- Treatment

June 11, 2018- Monitor- New active margins

June 14, 2018- Treatment

June 11, 2018- Monitor- New active margins

June 14, 2018- Treatment


LC-038
March 20, 2018-1st Visit
April 27, 2018- 1st Disease Assessment and Limited Treatment
May 8, 2018- Finish Treatment- Progressing disease margin due to "old" epoxy?
- FB and re-applied chl. epoxy
May 10, 2018-1st Monitor
No progression after re-application

May 10, 2018-1st Monitor
No progression after re-application

May 24, 2018-Secondary Monitor
Progression after re-application

May 24, 2018-Secondary Monitor
Progression past margin after re-application

June 11, 2018-Monitor

March 20, 2018-1st Visit

April 27, 2018- 1st Disease Assessment and Chiseled FB- no epoxy

May 8, 2018- Finish Treatment

May 10, 2018- 1st Monitor

May 10, 2018- 1st Monitor

May 24, 2018- Secondary Monitor- Progressed epoxy covered passed margin

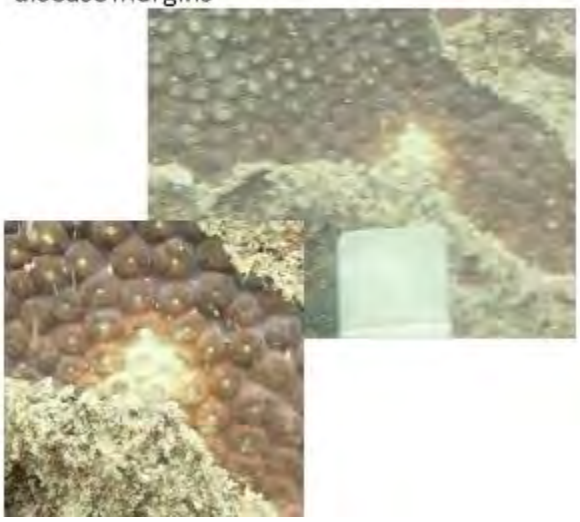
May 24, 2018- Secondary Monitor- Progressed epoxy covered passed margin

June 11, 2018-Monitor- Progressed until firebreak

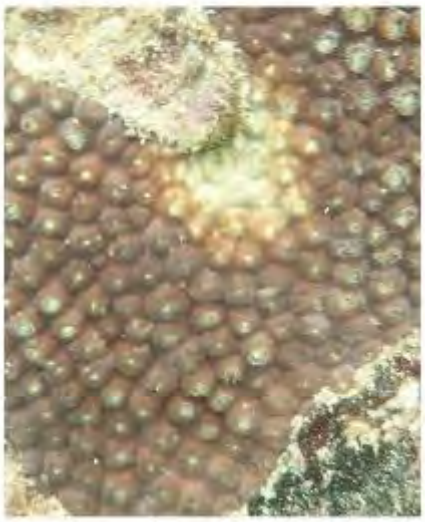
June 11, 2018-Monitor- New active disease margins

June 11, 2018-Monitor- New active disease margins

June 11, 2018-Monitor- New active disease margins



June 11, 2018-Monitor- New active disease margins

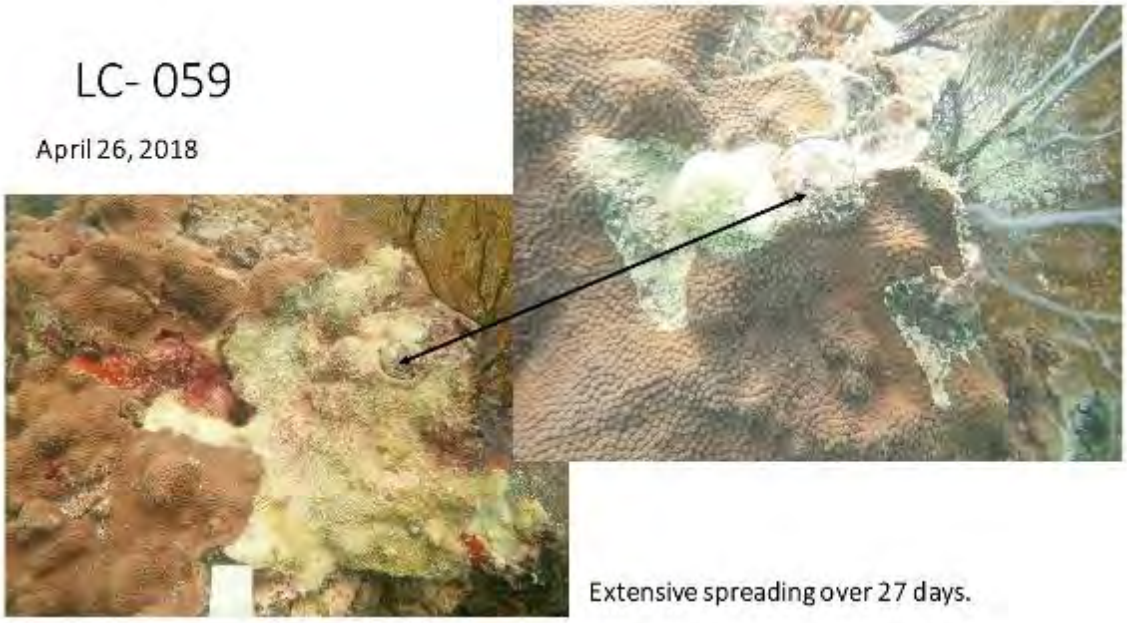


LC- 059

March 16, 2018- Initial Visit

LC- 059

April 26, 2018



Extensive spreading over 27 days.

April 26, 2018 - Treatment

May 10, 2018 – Secondary Monitor

May 10, 2018 – Secondary Monitor

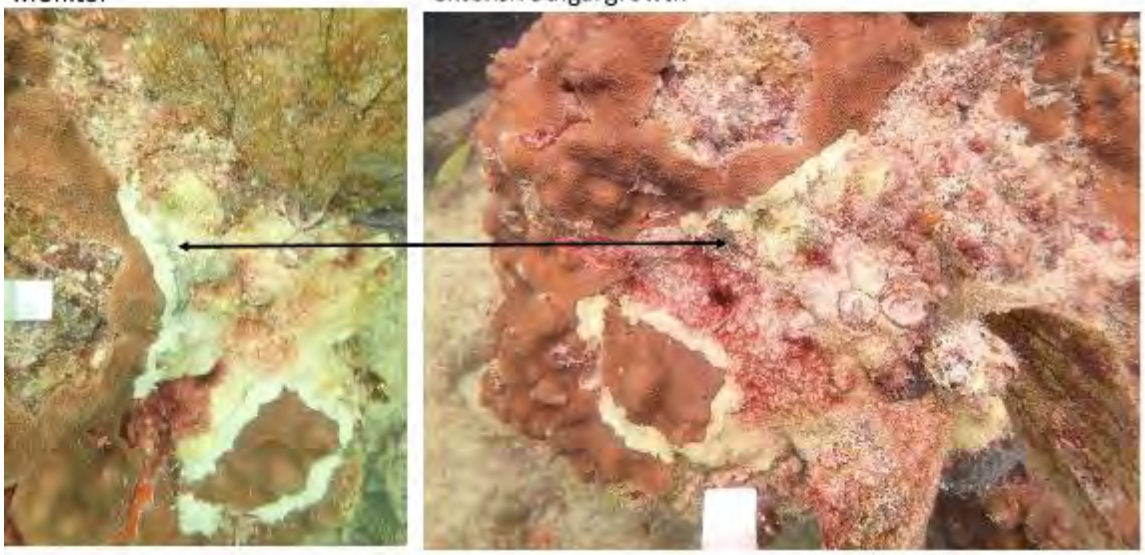
May 24, 2018 – Monitor

May 24, 2018 –Monitor

June 11, 2018 –Monitor

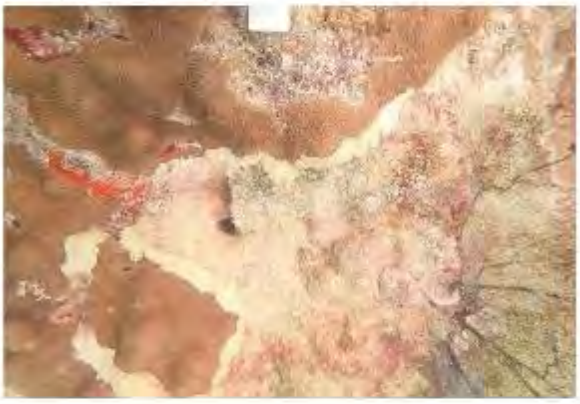
April 27, 2018 – Secondary Monitor

May 10, 2018 – Secondary Monitor- extensive algal growth



May 10, 2018 – Secondary Monitor

May 24, 2018 – Secondary Monitor

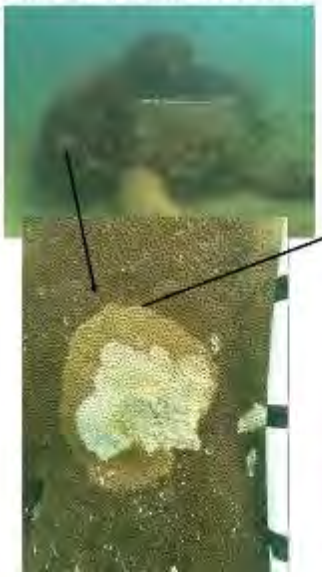


May 24, 2018 – Secondary Monitor

June 11, 2018 –Monitor

LC-070

March 1, 2018- First Visit



May 7, 2018- Treatment

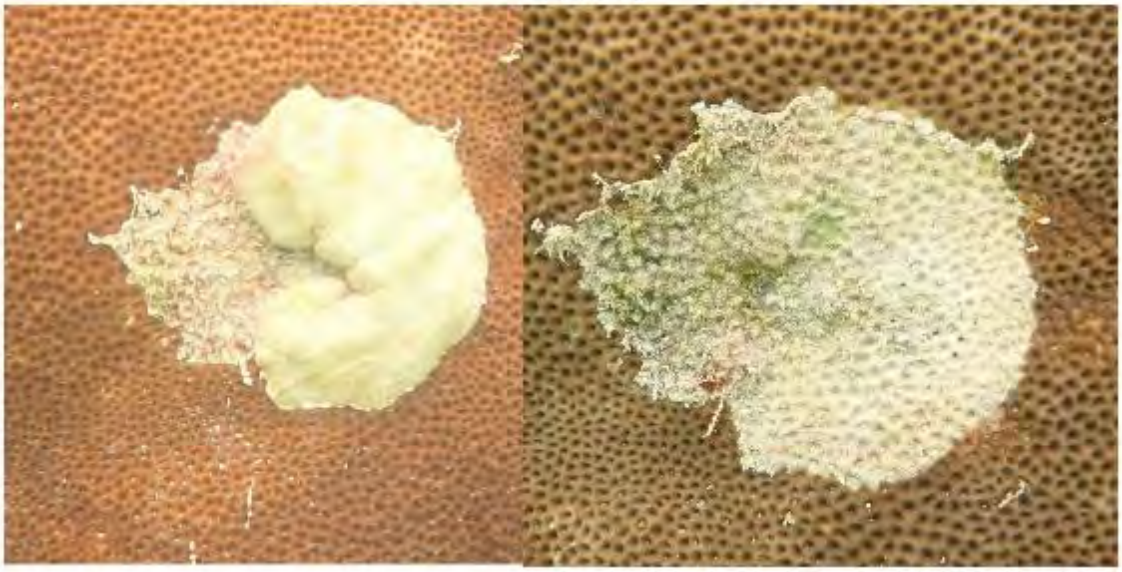
May 11, 2018- 1st Monitor

May 11, 2018- 1st Monitor

May 24, 2018- Secondary Monitor

May 24, 2018- Secondary Monitor

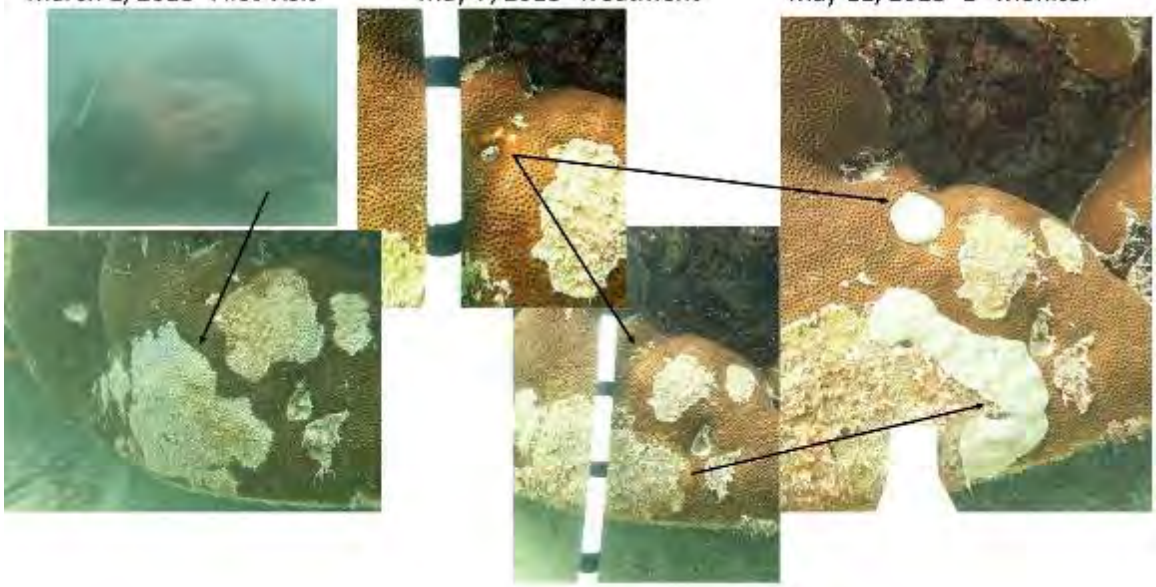
June 11, 2018- Monitor-epoxy came off no spreading



March 1, 2018- First Visit

May 7, 2018- Treatment

May 11, 2018- 1st Monitor



May 11, 2018- 1st Monitor

May 24, 2018- Secondary Monitor

May 24, 2018- Secondary Monitor

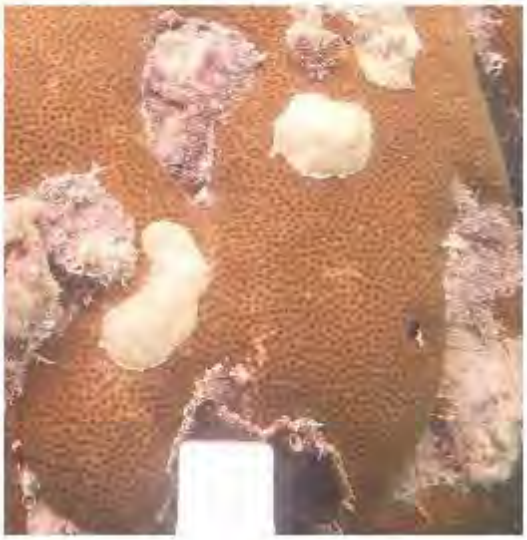
June 11, 2018- Monitor

May 7, 2018- Treatment

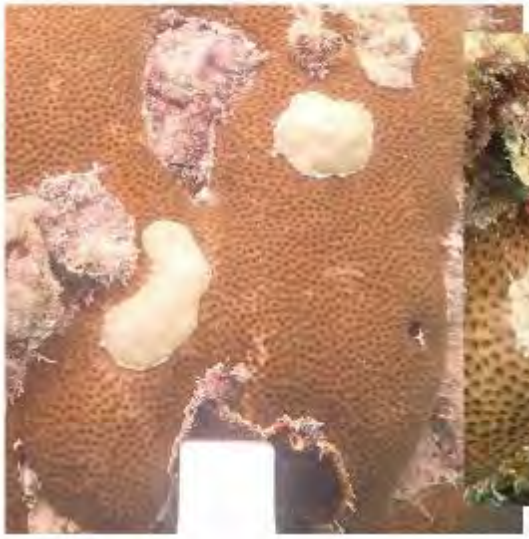
May 11, 2018- 1st Monitor

May 11, 2018- 1st Monitor

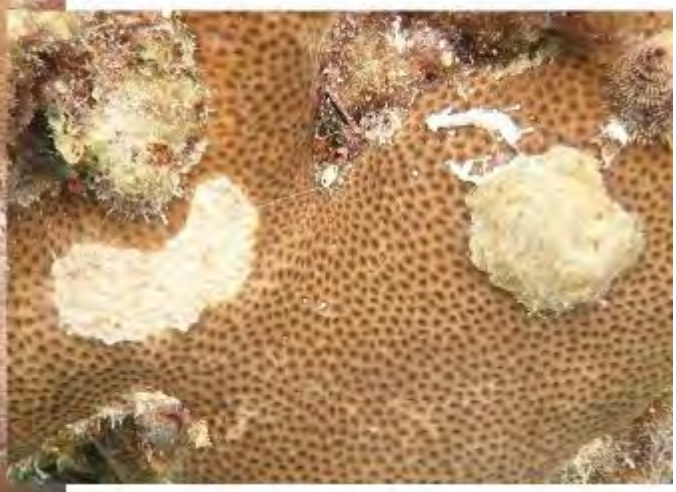
May 24, 2018- Secondary Monitor



May 24, 2018- Secondary Monitor



June 11, 2018- Monitor-epoxy came off no spreading



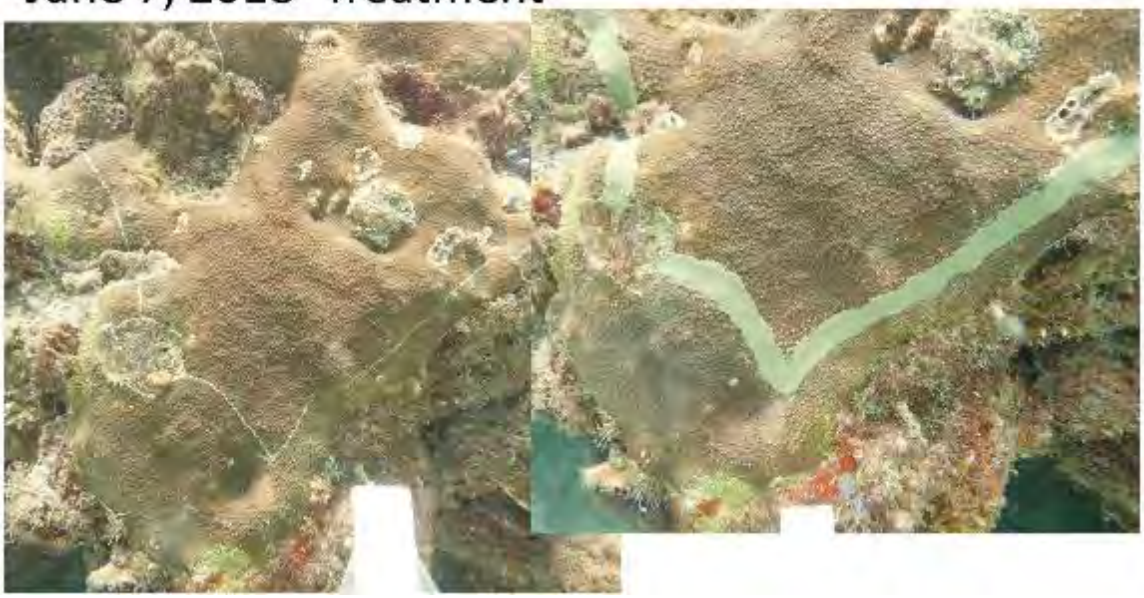
LC-077

June 7, 2018- Treatment

June 7, 2018- Treatment

June 12, 2018- Monitor

June 7, 2018- Treatment



June 7, 2018- Treatment

June 12, 2018- Monitor

June 7, 2018- Treatment

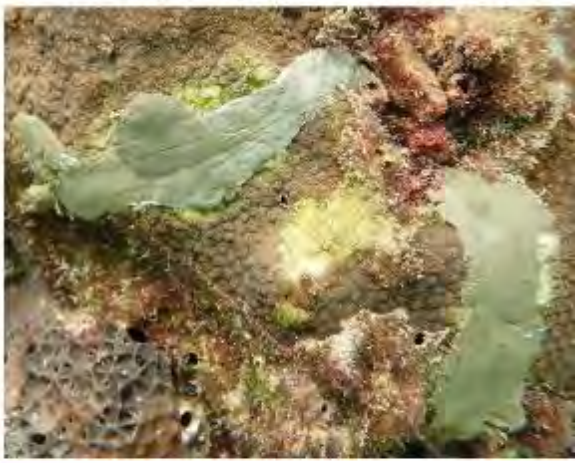
June 7, 2018- Treatment

June 12, 2018- Monitor

June 7, 2018- Treatment

June 7, 2018- Treatment

June 12, 2018- Monitor



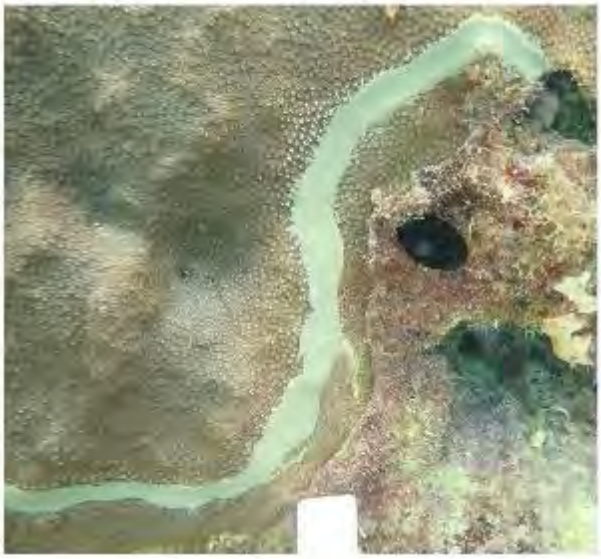
June 7, 2018- Treatment

June 7, 2018- Treatment

June 12, 2018- Monitor

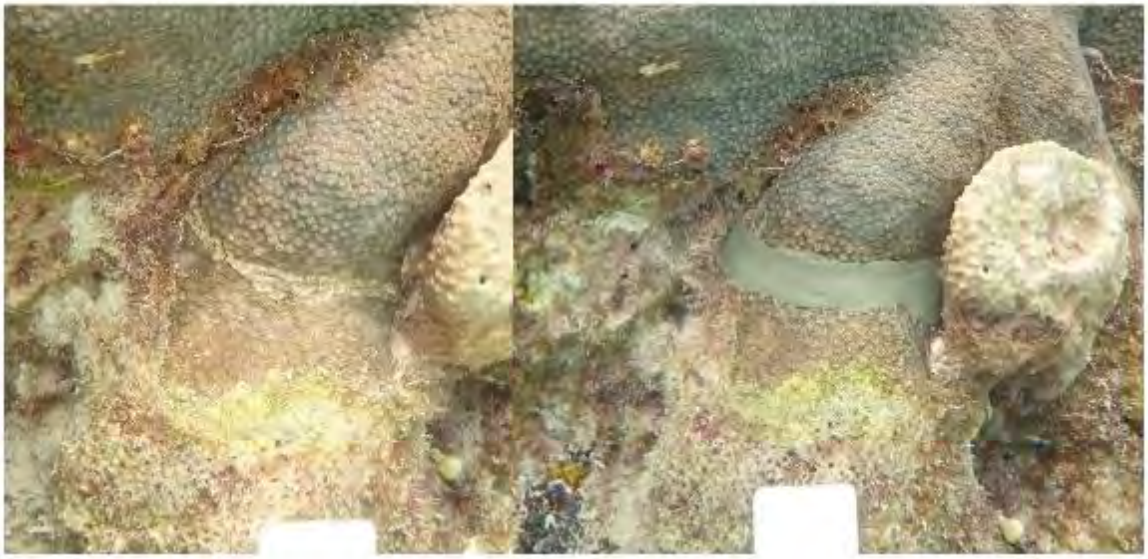
June 7, 2018- Treatment

June 7, 2018- Treatment



June 12, 2018- Monitor

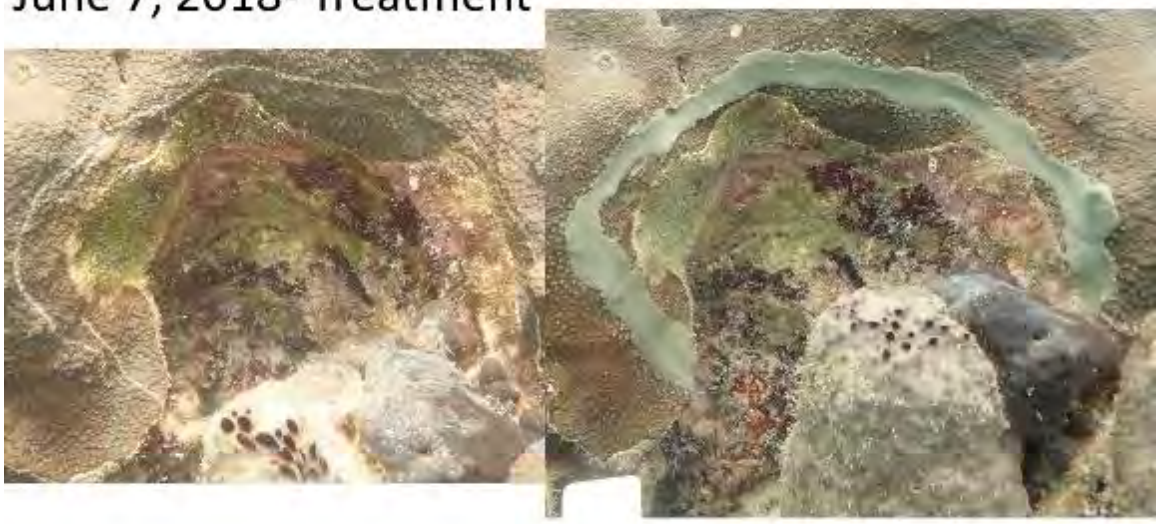
June 7, 2018- Treatment



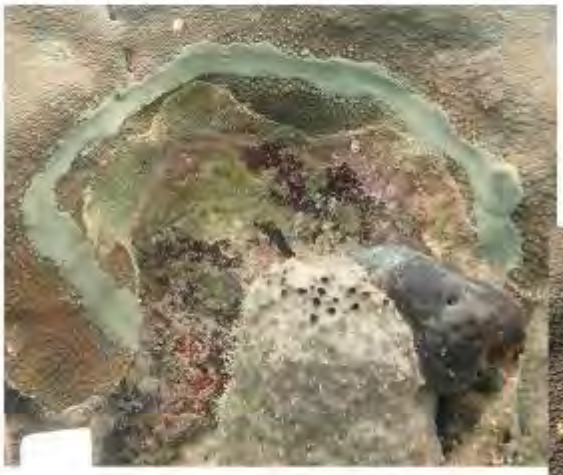
June 7, 2018- Treatment

June 12, 2018- Monitor

June 7, 2018- Treatment



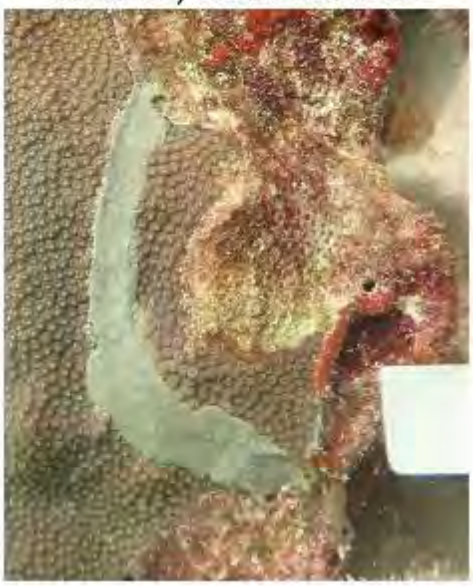
June 7, 2018- Treatment



June 12, 2018- Monitor

June 7, 2018- Treatment

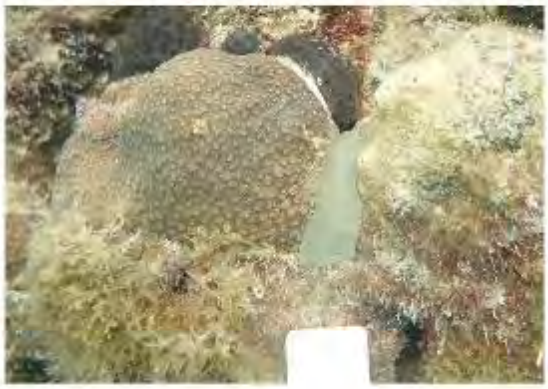
June 12, 2018- Monitor



June 7, 2018- Treatment

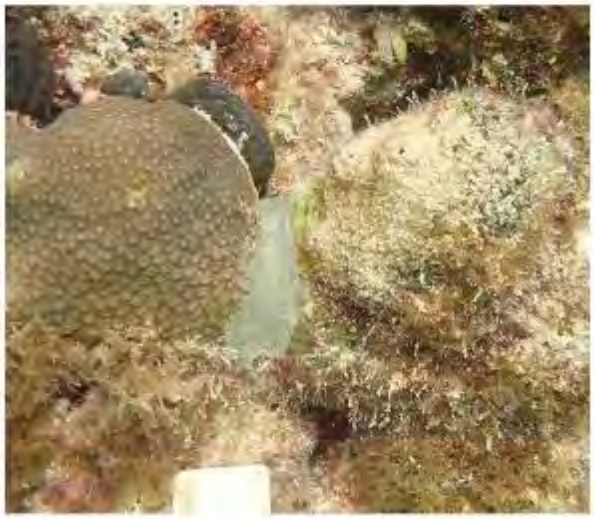
June 12, 2018- Monitor

June 7, 2018- Treatment



June 12, 2018- Monitor

June 7, 2018- Treatment

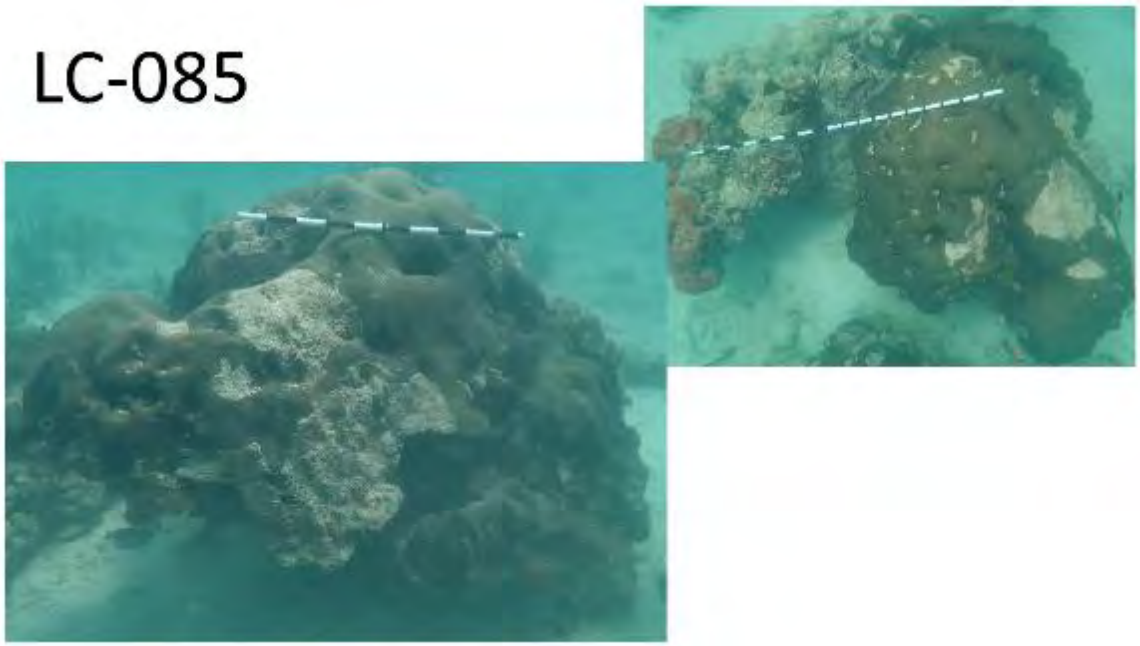


June 7, 2018- Treatment

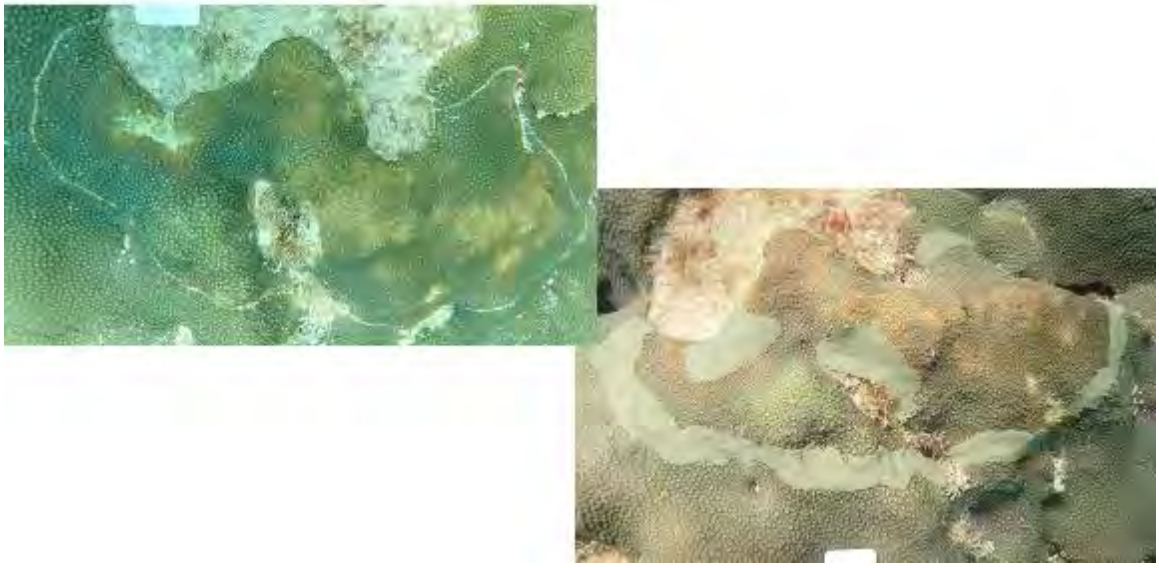
June 7, 2018- Treatment

June 12, 2018- Monitor

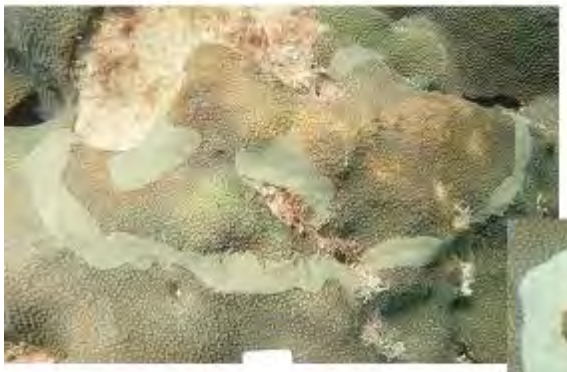
LC-085



June 7, 2018- Treatment



June 7, 2018- Treatment



June 12, 2018- Monitor

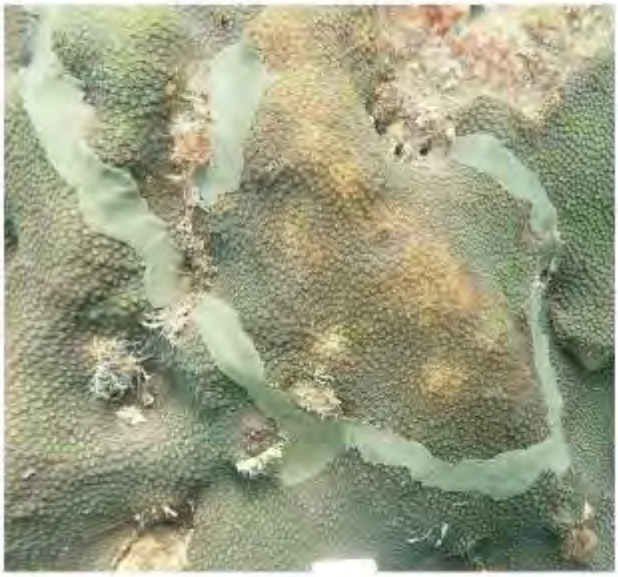
June 7, 2018- Treatment

June 7, 2018- Treatment

June 12, 2018- Monitor

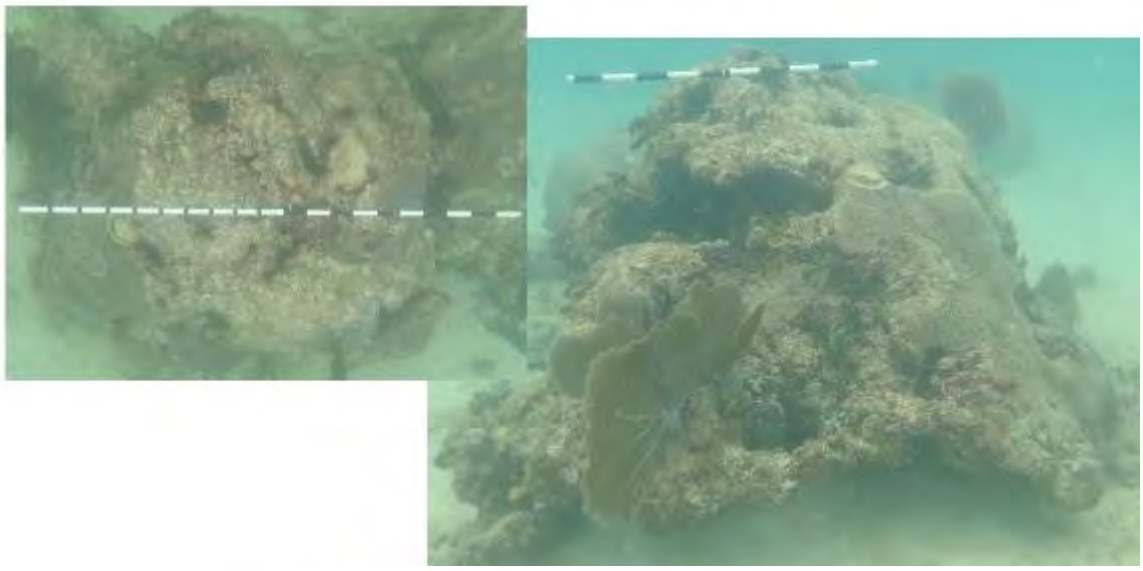
June 7, 2018- Treatment

June 7, 2018- Treatment



June 12, 2018- Monitor

LC-087

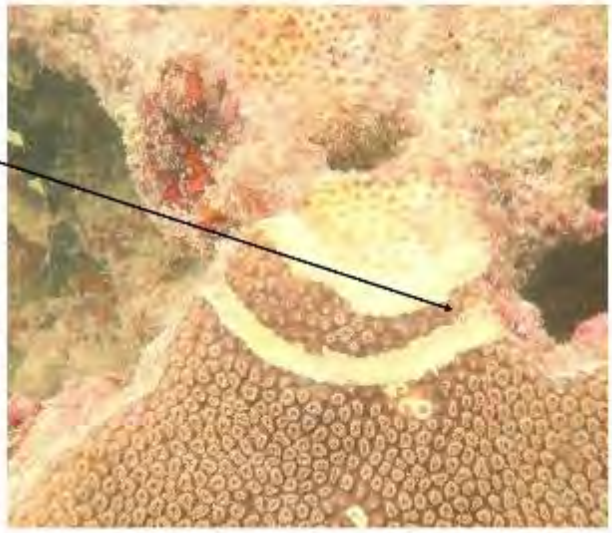


May 7, 2018- Treatment

May 11, 2018-1st Monitor

May 11, 2018-1st Monitor

May 24, 2018-Secondary Monitor



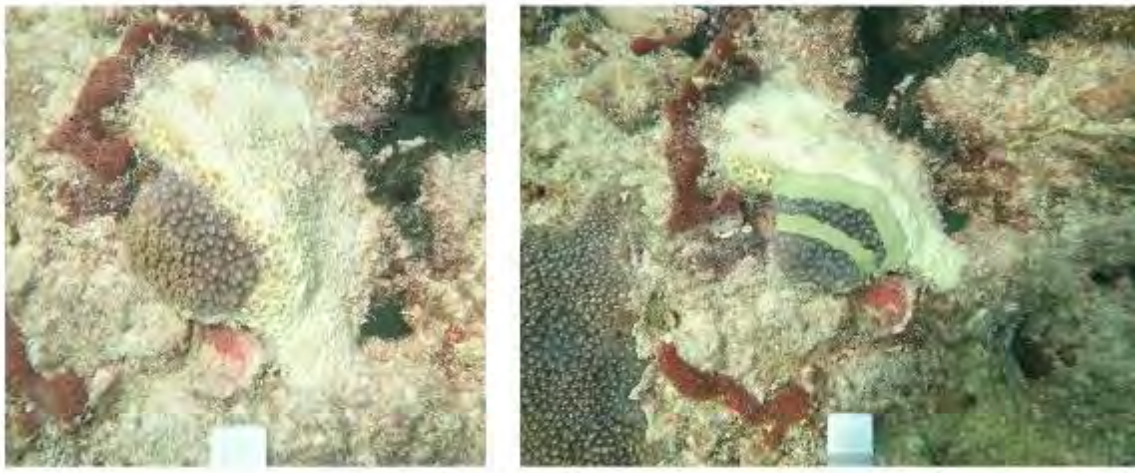
May 24, 2018-Secondary Monitor

June 4, 2018- Monitor

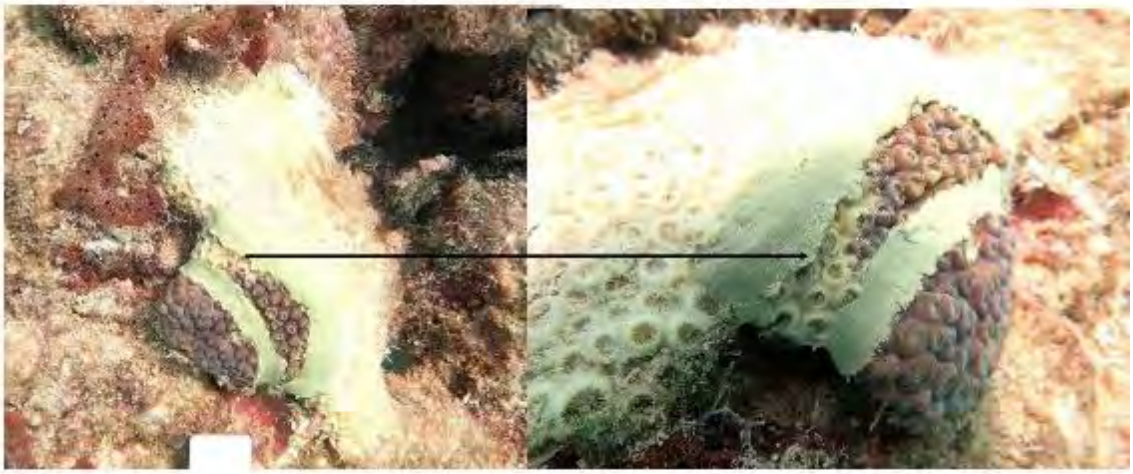
June 4, 2018- Monitor

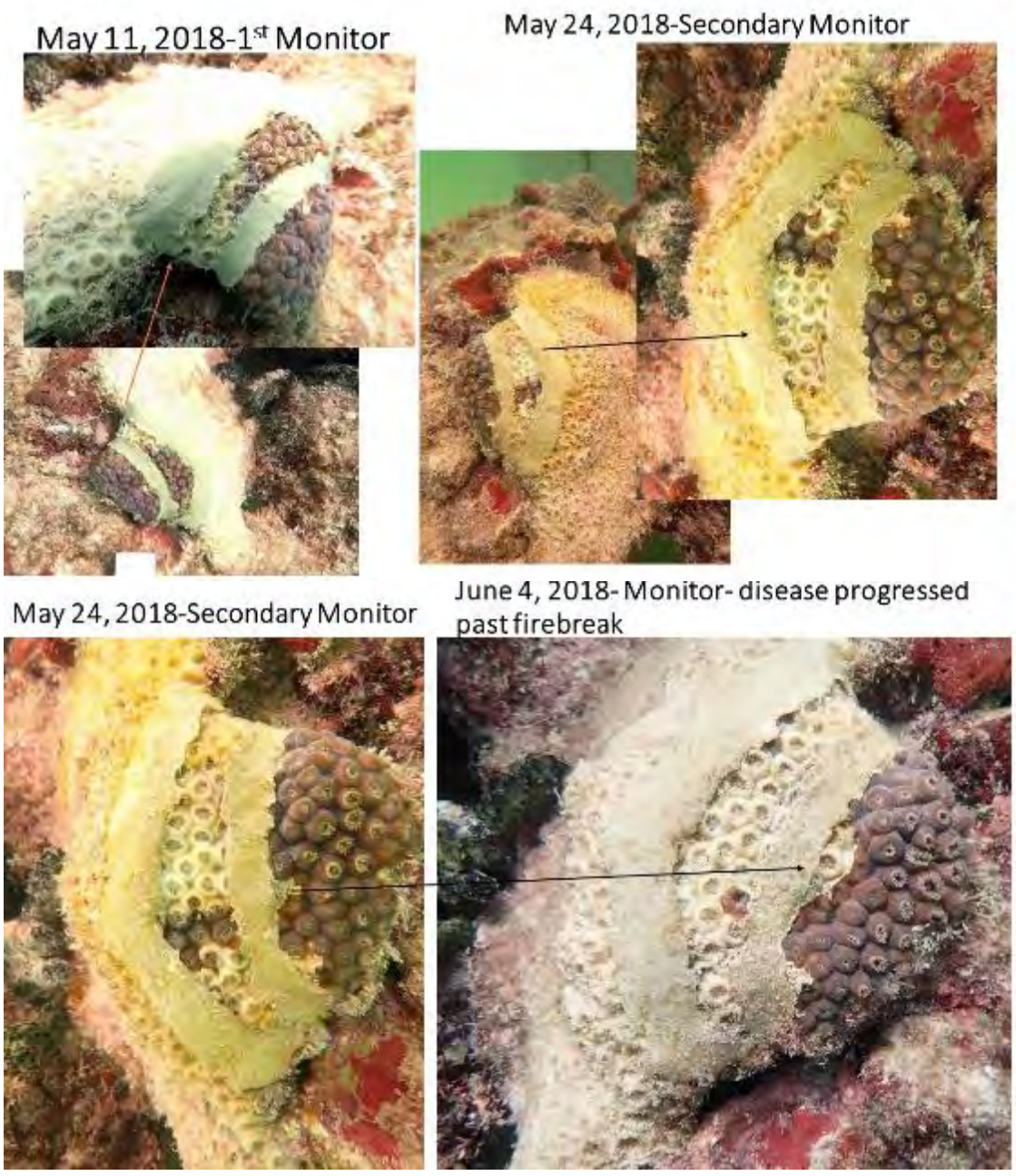
June 11, 2018- Monitor- no progression after 7 days

May 7, 2018- Treatment



May 11, 2018-1st Monitor




May 11, 2018-1st Monitor
May 24, 2018-Secondary Monitor
May 24, 2018-Secondary Monitor
June 4, 2018- Monitor- disease progressed past firebreak

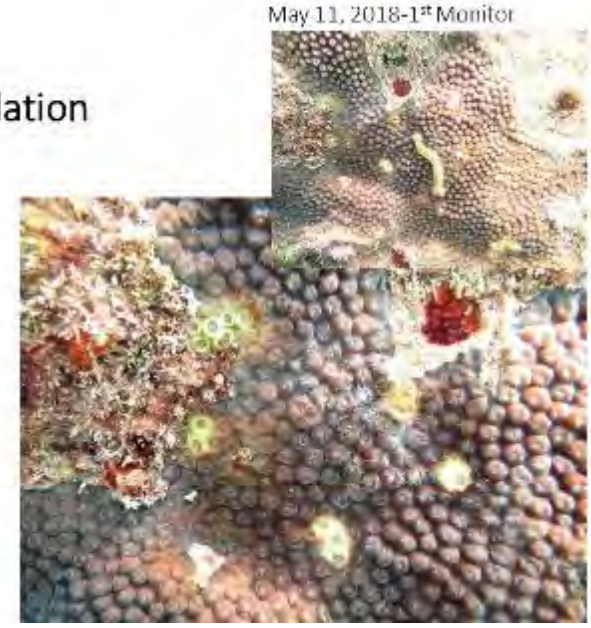
June 4, 2018- Monitor- disease progressed past firebreak

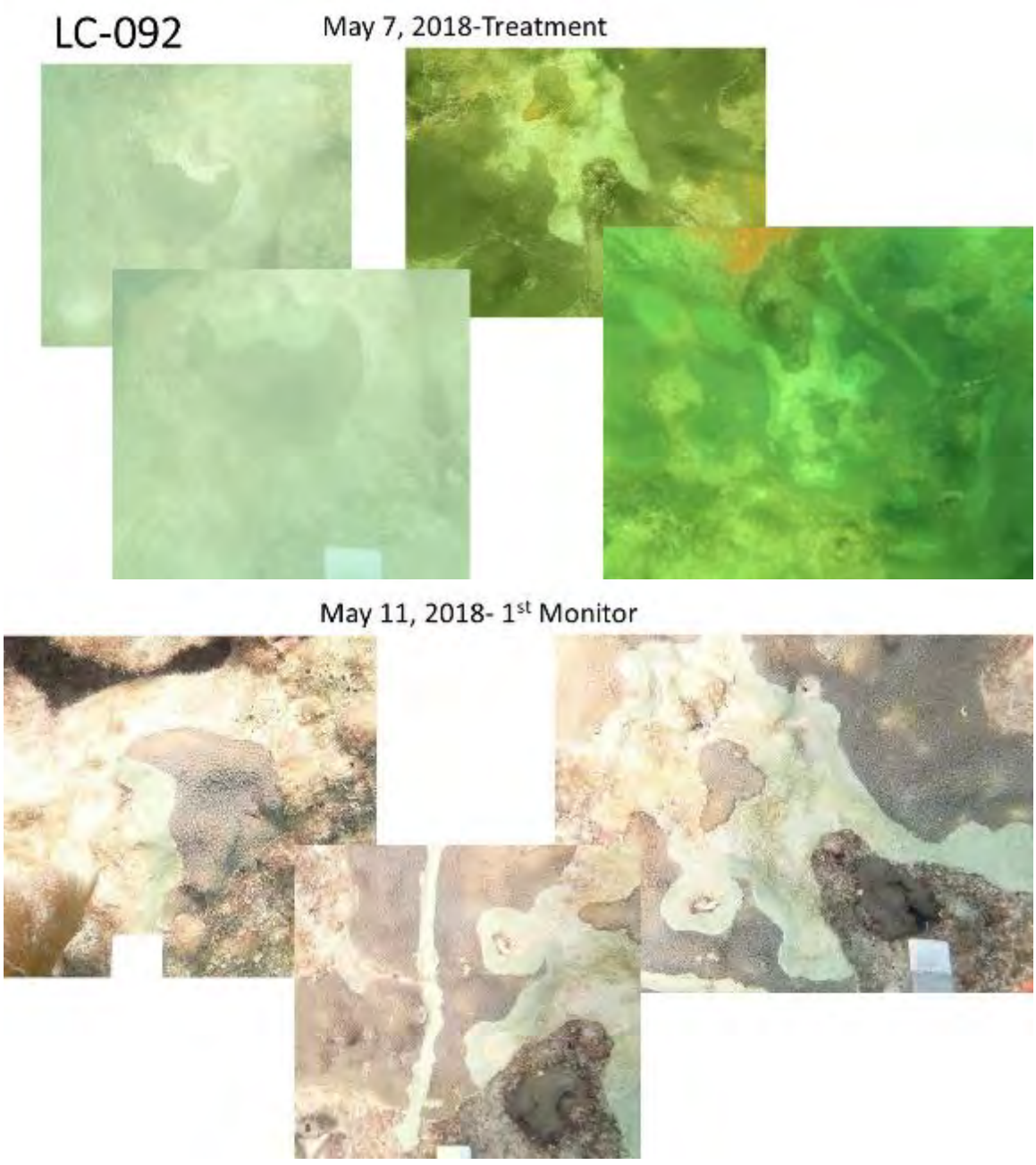
June 11, 2018- Monitor- no progression after 7 days

May 7, 2018- Treatment

herm. predation

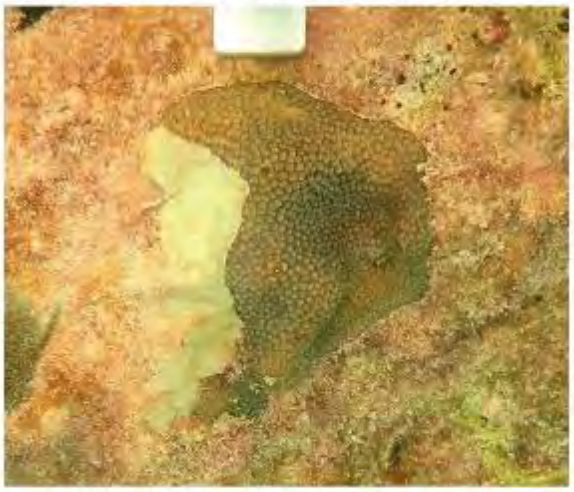
May 11, 2018-1st Monitor




LC-092
May 7, 2018-Treatment
May 11, 2018- 1st Monitor

May 11, 2018- 1st Monitor

May 24, 2018- Secondary Monitor



May 24, 2018- Secondary Monitor

June 4, 2018-Monitor- past epoxy margin

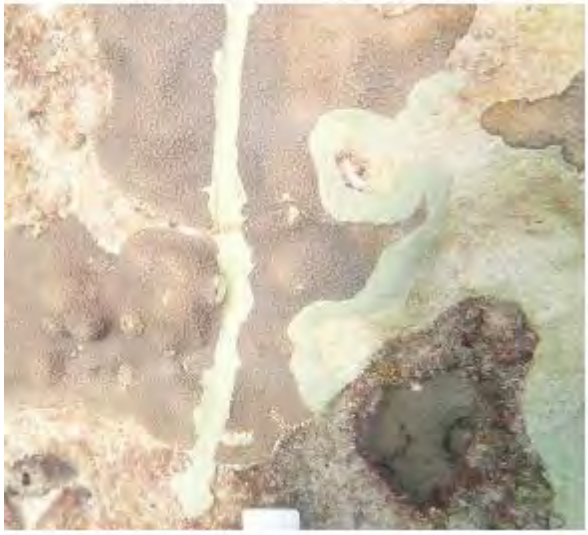
June 4, 2018-Monitor

June 7, 2018-Monitor

June 7, 2018-Monitor

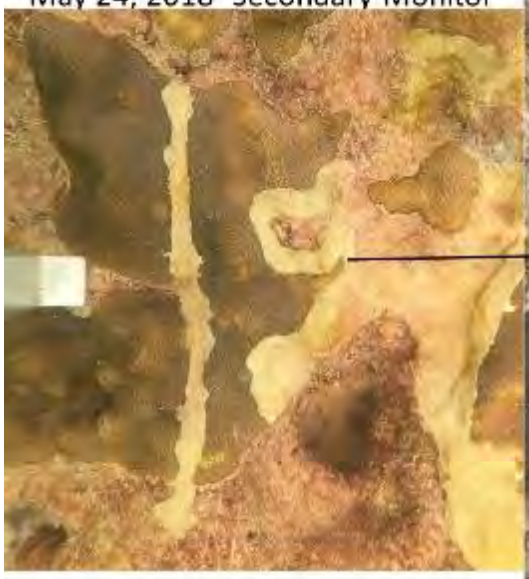
June 12, 2018-Monitor

May 11, 2018- 1st Monitor



May 24, 2018- Secondary Monitor

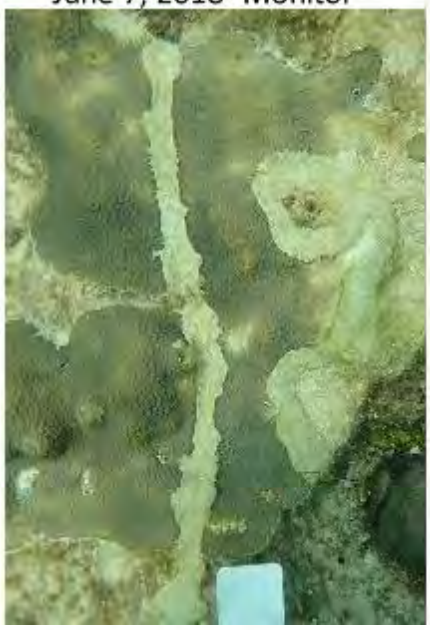
May 24, 2018- Secondary Monitor



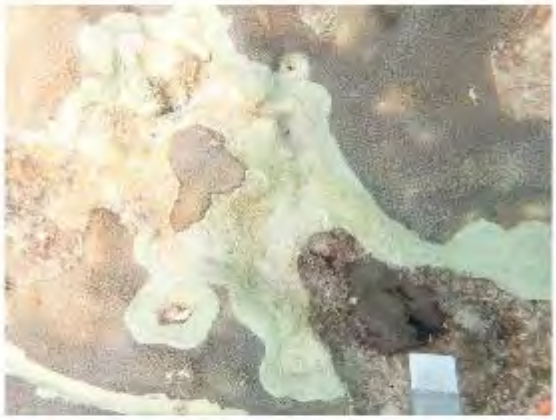
June 4, 2018- Monitor- past epoxy margin

June 4, 2018- Monitor- past epoxy margin

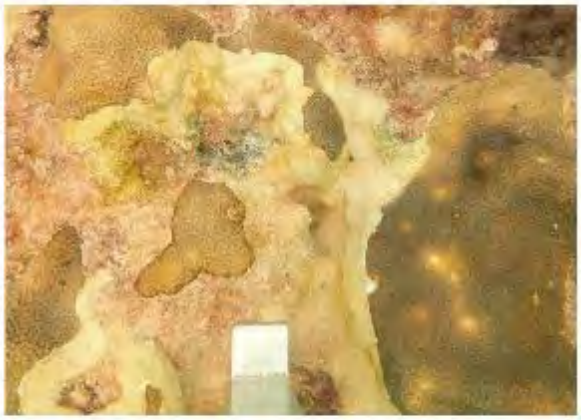
June 7, 2018- Monitor



May 11, 2018- 1st Monitor

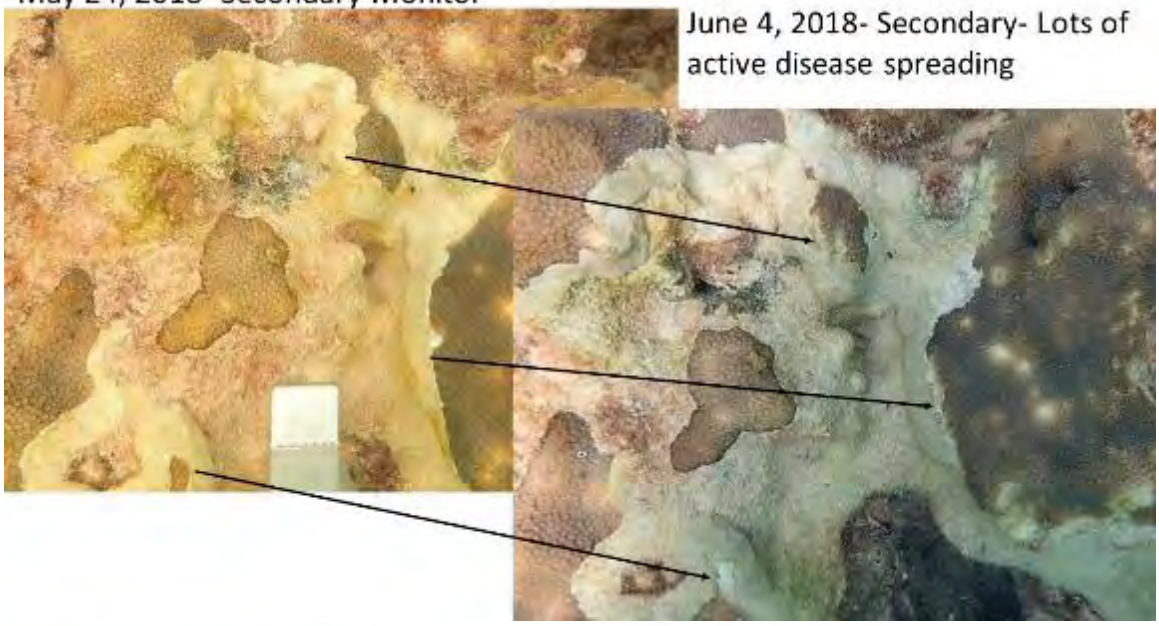


May 24, 2018- Secondary Monitor



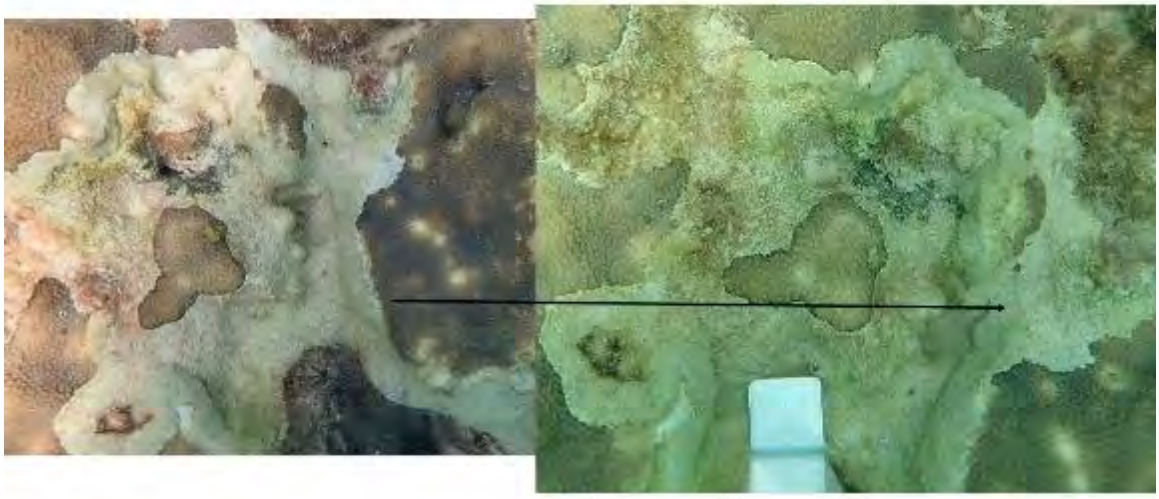
May 24, 2018- Secondary Monitor

June 4, 2018- Secondary- Lots of active disease spreading

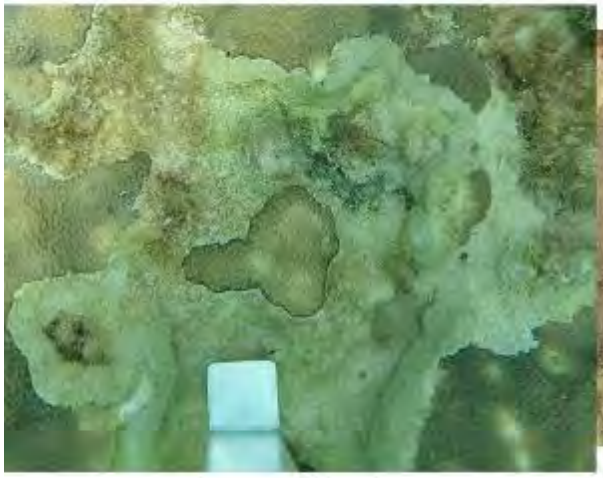


June 4, 2018- Secondary monitor

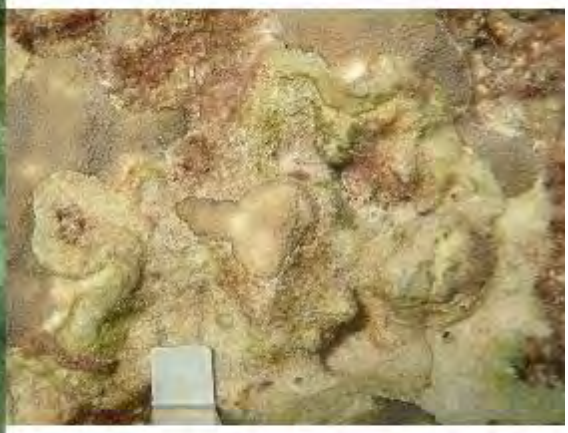
June 7, 2018- Monitor



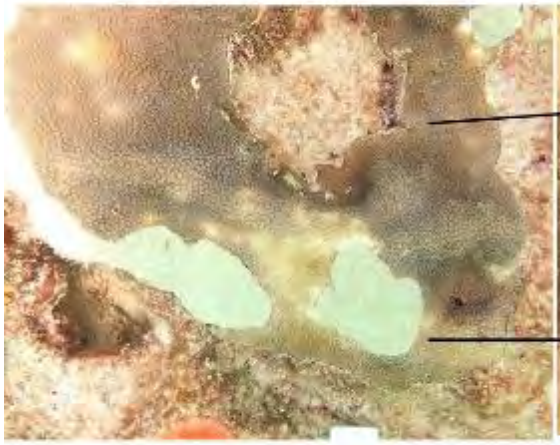
June 7, 2018- Monitor



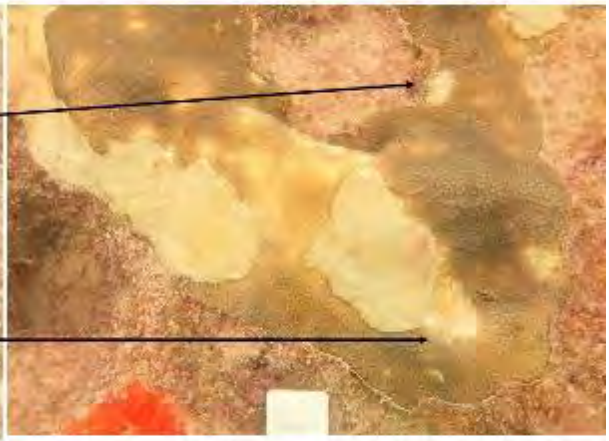
June 12, 2018-Monitor

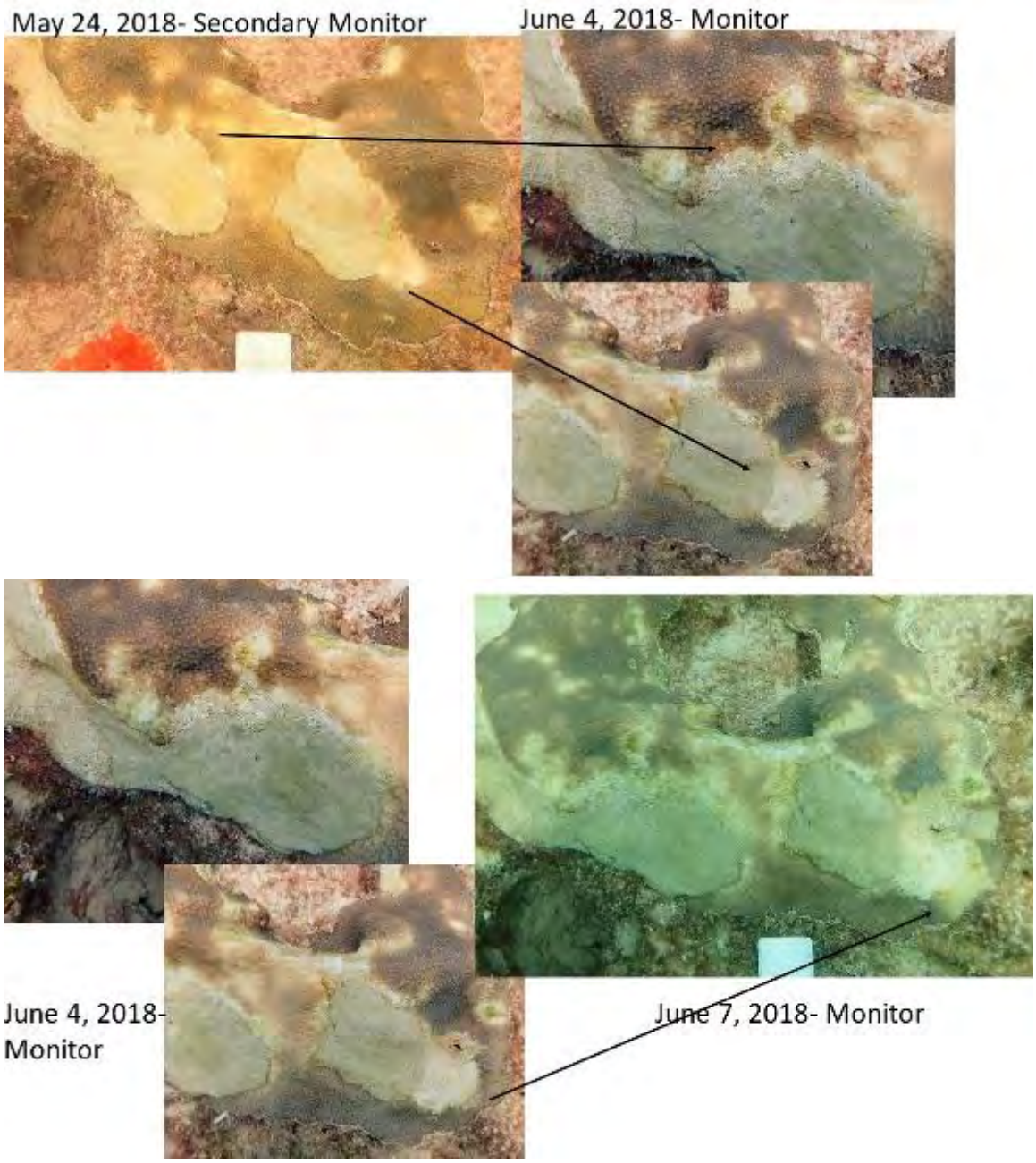


May 11, 2018- 1st Monitor



May 24, 2018- Secondary Monitor



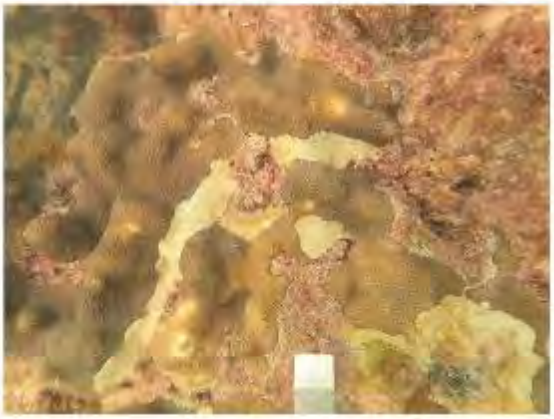

May 24, 2018- Secondary Monitor
June 4, 2018- Monitor
June 4, 2018- Monitor
June 7, 2018- Monitor

June 7, 2018- Monitor

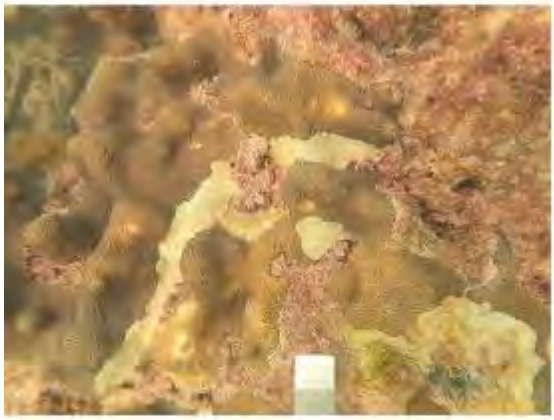
June 12, 2018-Monitor

May 11, 2018- 1st Monitor

May 24, 2018- Secondary Monitor



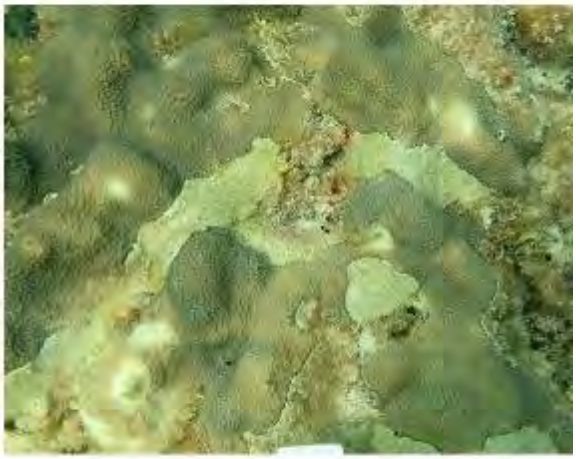
May 24, 2018- Secondary Monitor



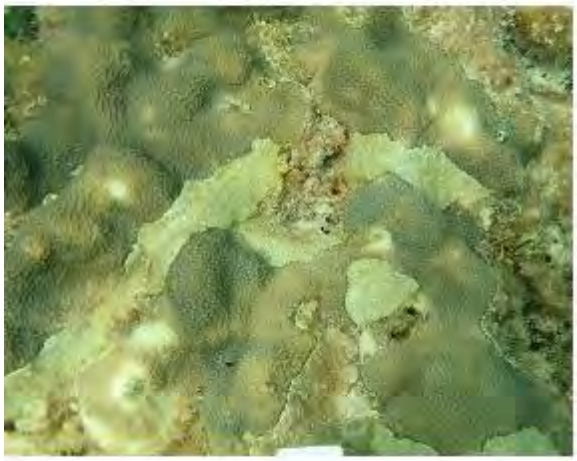
June 4, 2018- Monitor

June 4, 2018- Monitor

June 7, 2018- Monitor



June 7, 2018- Monitor



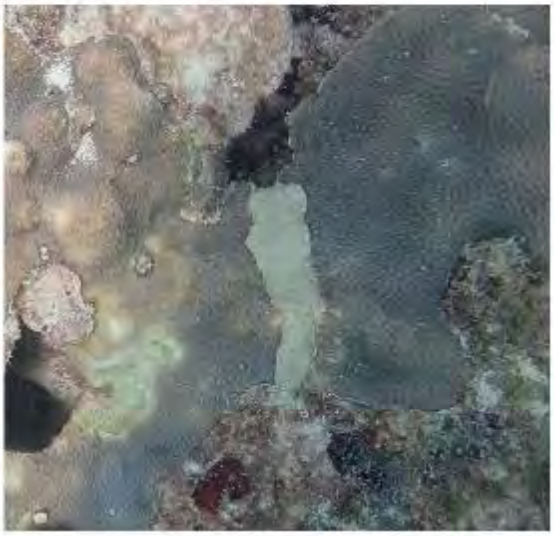
June 12, 2018-Monitor

May 11, 2018- 1st Monitor

May 24, 2018- Secondary Monitor

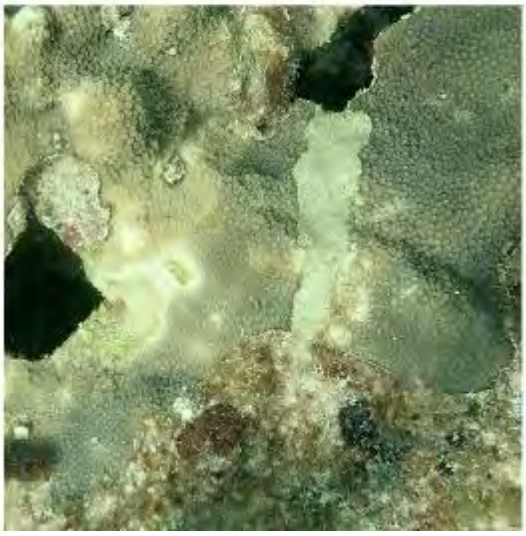
May 24, 2018- Secondary Monitor

June 4, 2018- Monitor

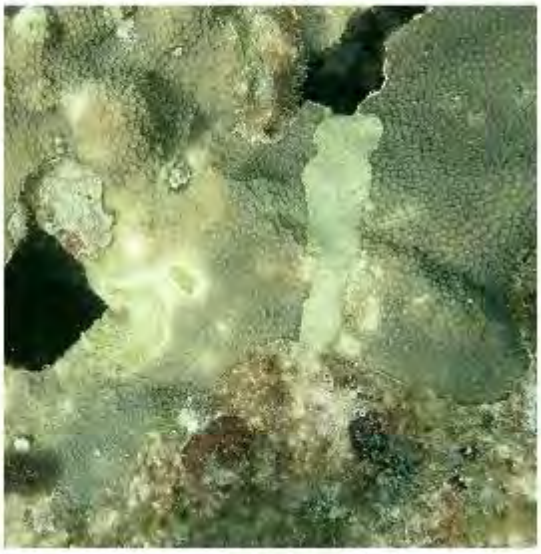


June 4, 2018- Monitor

June 7, 2018- Monitor



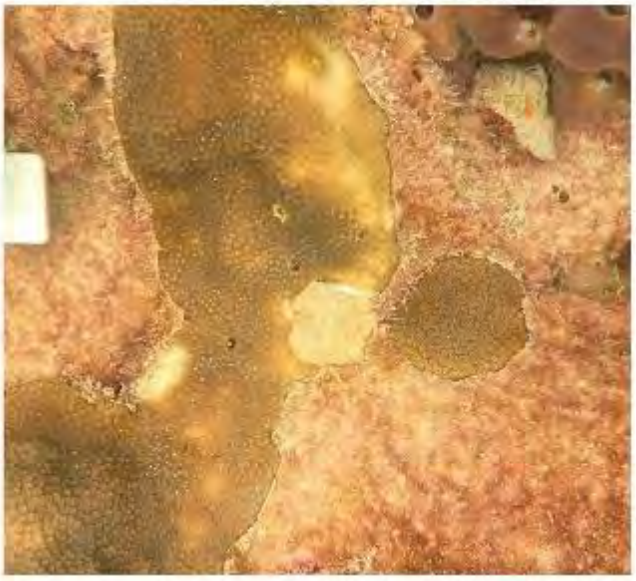
June 7, 2018- Monitor



June 12, 2018-Monitor

May 11, 2018- 1st Monitor

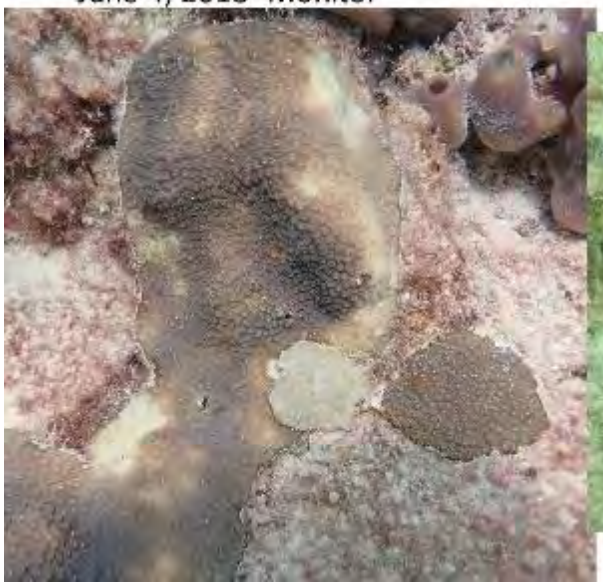
May 24, 2018- Secondary Monitor



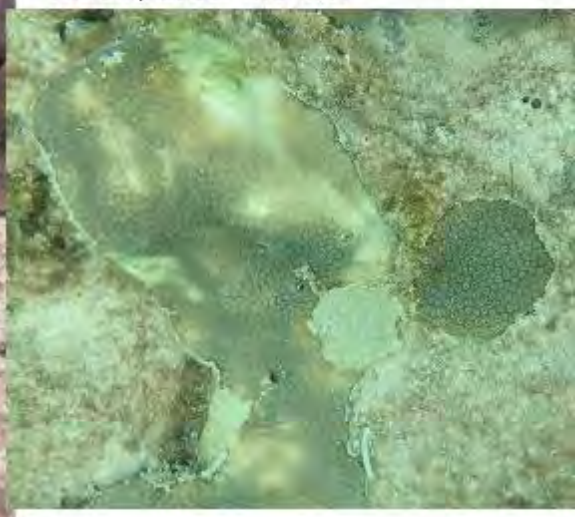
May 24, 2018- Secondary Monitor

June 4, 2018- Monitor

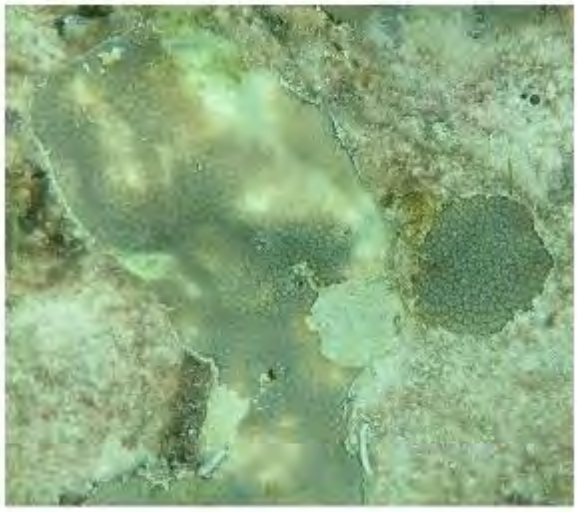
June 4, 2018- Monitor



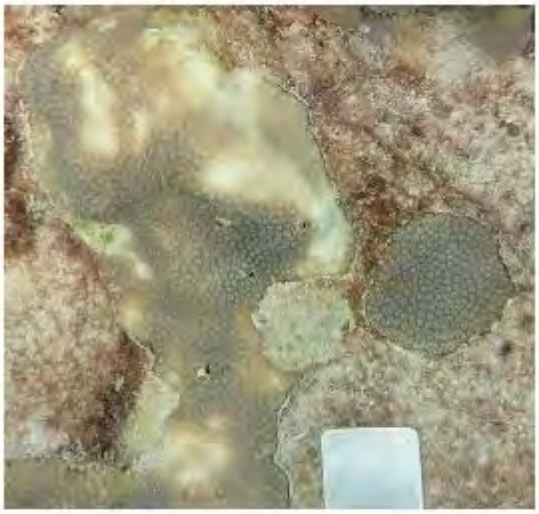
June 7, 2018- Monitor



June 7, 2018- Monitor

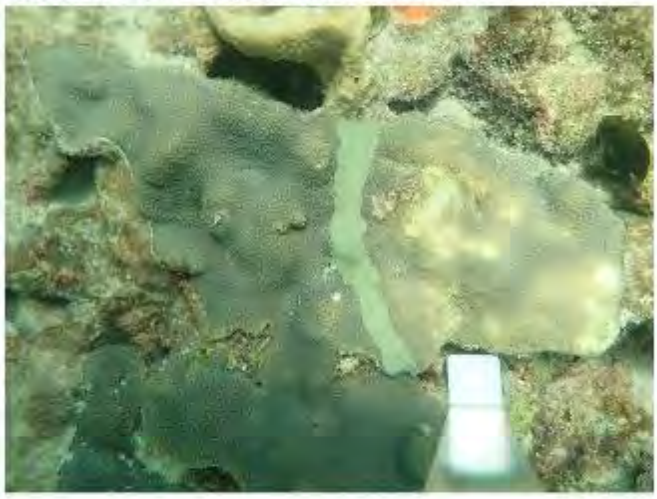


June 12, 2018-Monitor



May 24, 2018- Secondary Monitor-
Additional Disease Spots

June 7, 2018- Additional Treatment



June 12, 2018-Monitor

LC-093

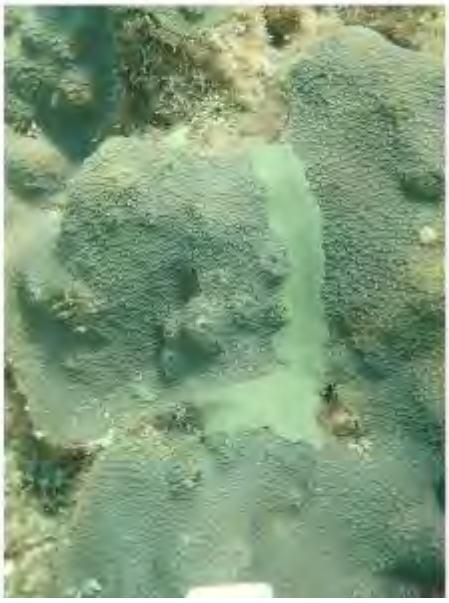
June 7, 2018- Treatment

June 12, 2018- Monitor

June 7, 2018- Treatment

June 12, 2018- Monitor

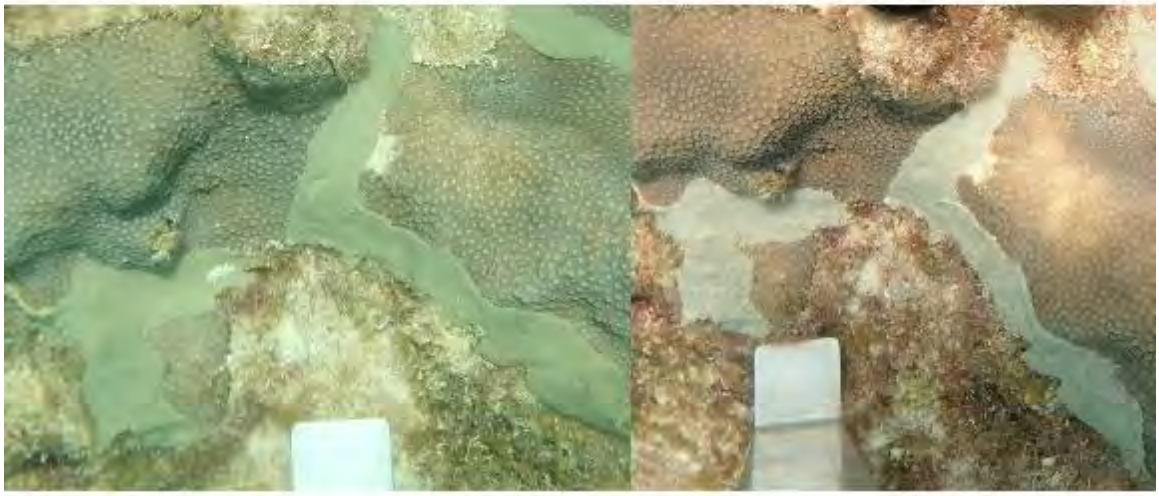
June 7, 2018- Treatment



June 12, 2018- Monitor

June 7, 2018- Treatment

June 12, 2018- Monitor



June 7, 2018- Treatment

June 12, 2018- Monitor

June 12, 2018- Monitor- New active margins

June 12, 2018- Monitor- New active margins

June 12, 2018- Monitor- New active margins

LC-196

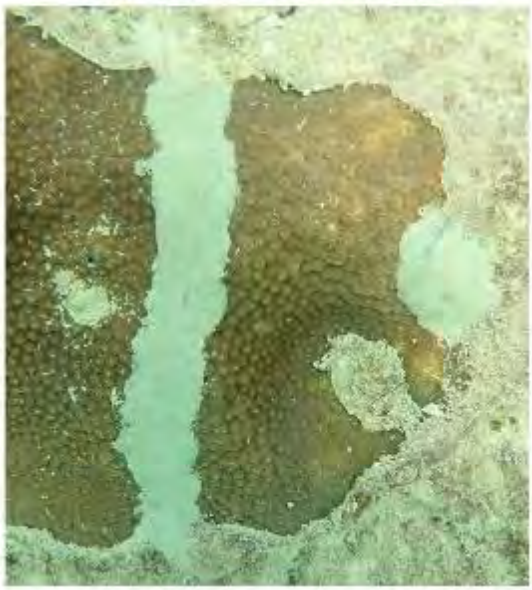
June 5, 2018-Priority Re-Check

June 5, 2018-Priority Re-Check

June 8, 2018- Treatment

June 8, 2018- Treatment

June 12, 2018- Treatment



T-295 April 27, 2018-Treatment

April 27, 2018-Treatment

May 10, 2018- 1st Monitor

May 10, 2018- 1st Monitor

May 16, 2018- 2nd Monitor

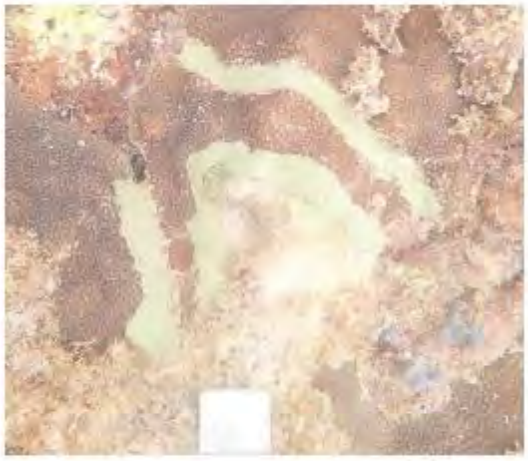
May 16, 2018- Secondary Monitor

May 24, 2018- Monitor

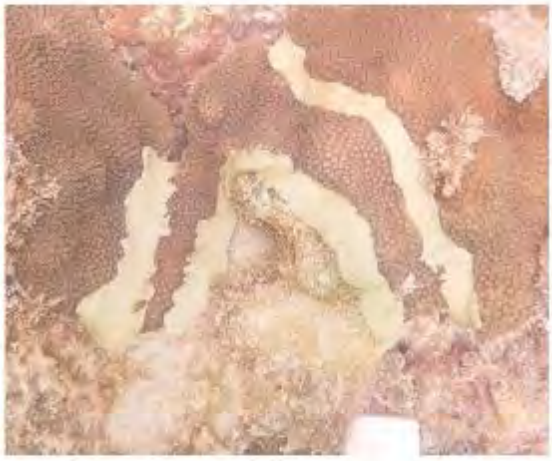
May 24, 2018- Secondary Monitor

June 11, 2018- Monitor

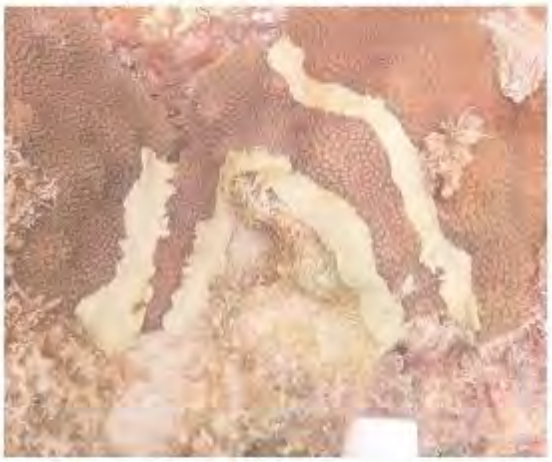
April 27, 2018-Treatment



May 10, 2018- 1st Monitor



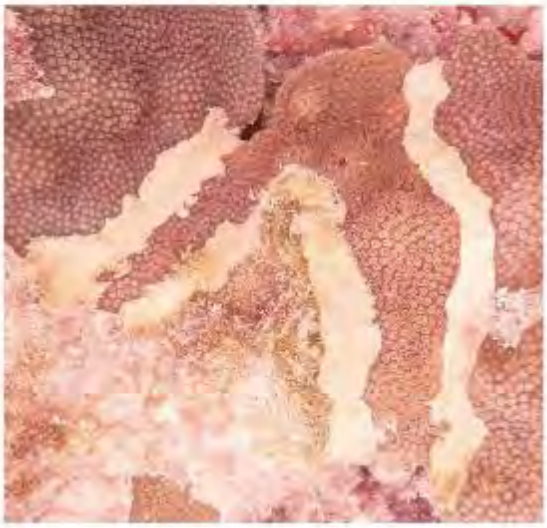
May 10, 2018- 1st Monitor



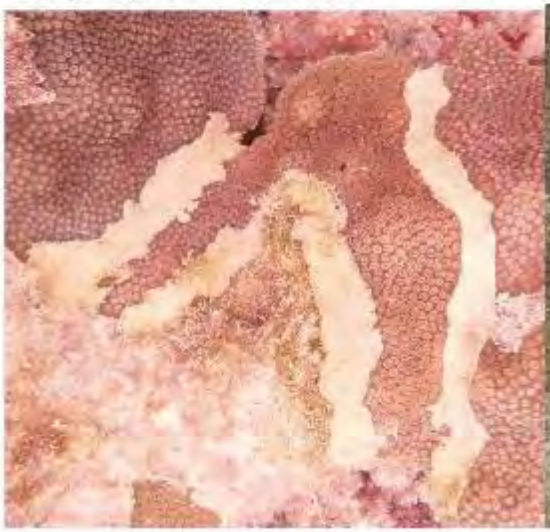
May 16, 2018- 2nd Monitor

May 16, 2018- 2nd Monitor

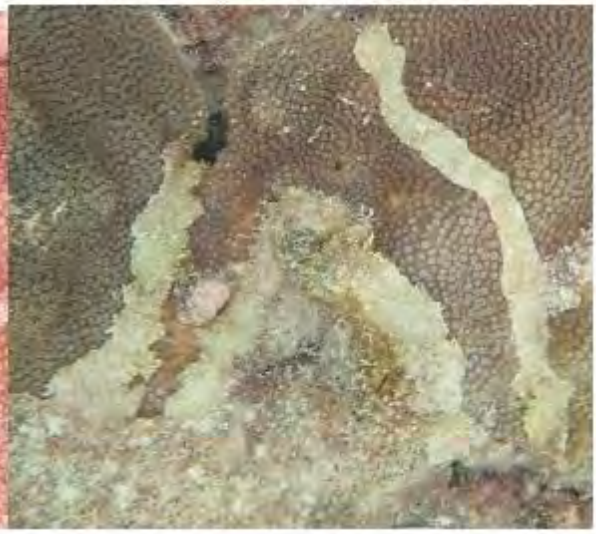
May 24, 2018- Monitor



May 24, 2018- Monitor



June 11, 2018- Monitor



April 27, 2018-Treatment

May 10, 2018- 1st Monitor

May 10, 2018- 1st Monitor

May 16, 2018- 2nd Monitor

May 16, 2018- 2nd Monitor

May 24, 2018- Monitor

May 24, 2018- Monitor

June 11, 2018- Monitor

April 27, 2018-Treatment

May 10, 2018- 1st Monitor


May 16, 2018- 2nd Monitor
May 24, 2018- Monitor
May 24, 2018- Monitor
June 11, 2018- Monitor

T-306

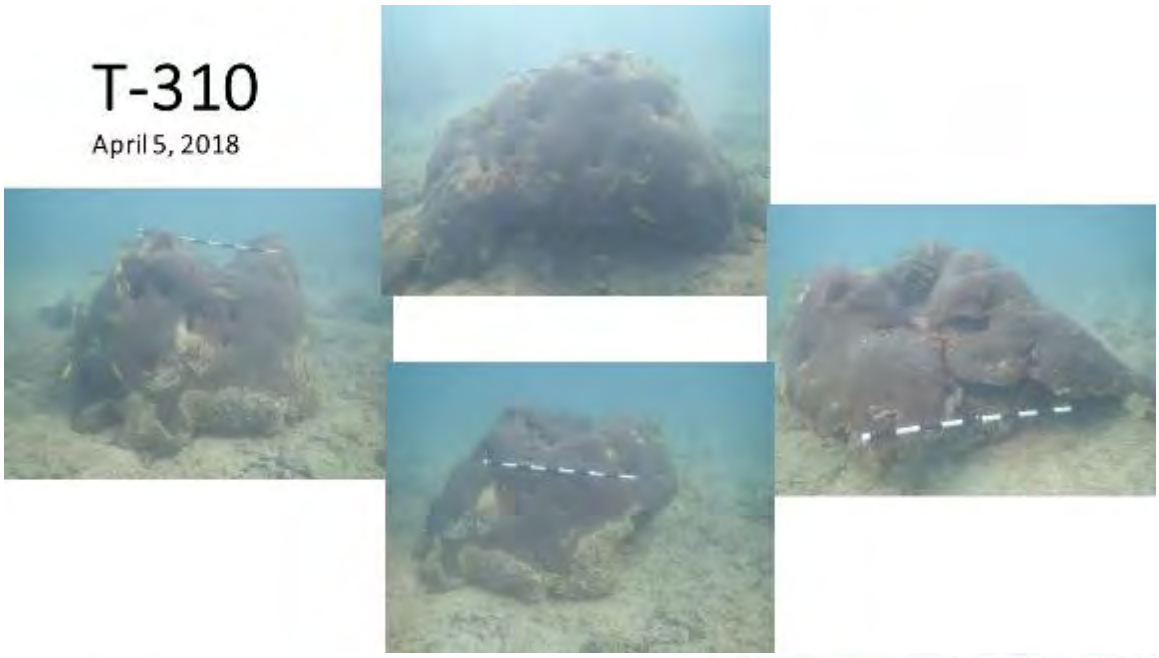
June 5, 2018-Priority Re-Check

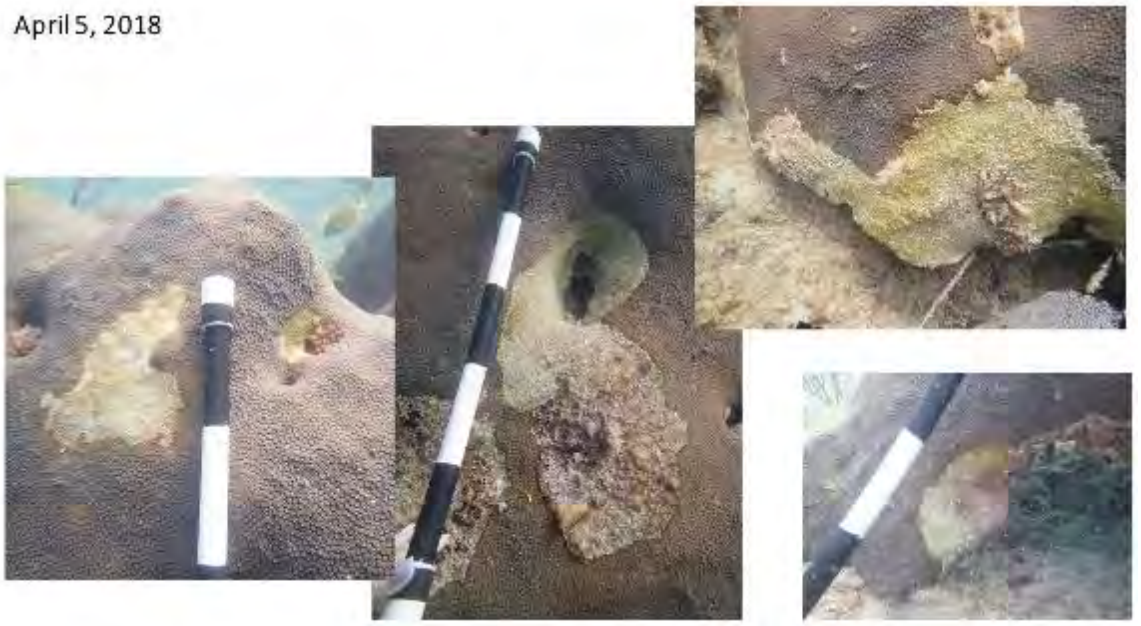
June 5, 2018-Priority Re-Check

June 8, 2018-Treatment

June 8, 2018-Treatment

June 12, 2018-Treatment- white polyps outside FB may be from reaction to epoxy


T-310
April 5, 2018


April 5, 2018

April 5, 2018-
First Visit

April 27, 2018

April 27, 2018- Treatment

May 10, 2018- Primary Monitor

May 10, 2018- Primary Monitor

May 24, 2018- Secondary Monitor

May 24, 2018- Secondary Monitor

June 1, 2018- Monitor

June 1, 2018- Monitor

June 11, 2018- Monitor

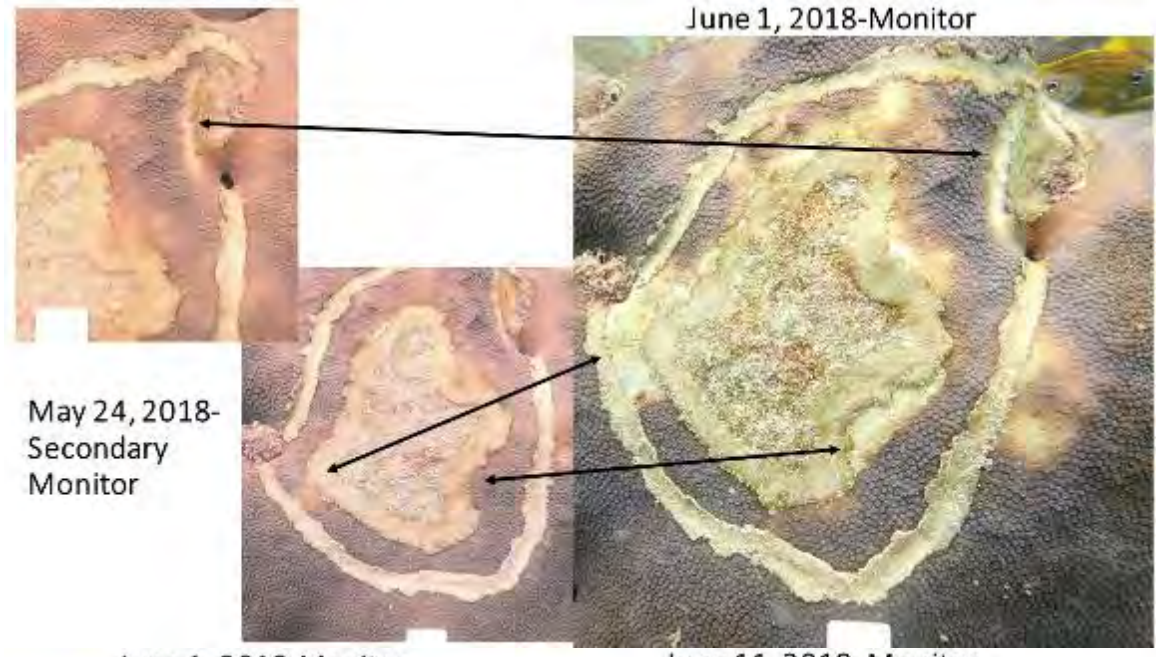
April 5, 2018- Primary Visit

April 27, 2018- Treatment

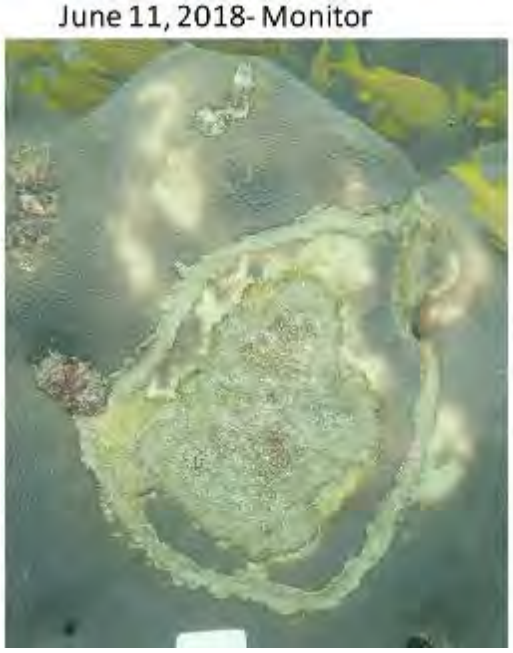
April 27, 2018 -Treatment

May 10, 2018- Primary Monitor

May 10, 2018- Primary Monitor


June 1, 2018-Monitor
May 24, 2018-
Secondary
Monitor


June 1, 2018-Monitor


June 11, 2018- Monitor

April 5, 2018- 1st Visit

April 27, 2018- Treatment

April 27, 2018- Treatment

May 10, 2018 -1st Monitoring

May 10, 2018 -1st Monitoring

May 24, 2018 -1st Monitoring

May 24, 2018 -Secondary Monitoring

June 1, 2018 -Monitor

June 1, 2018 -Monitor

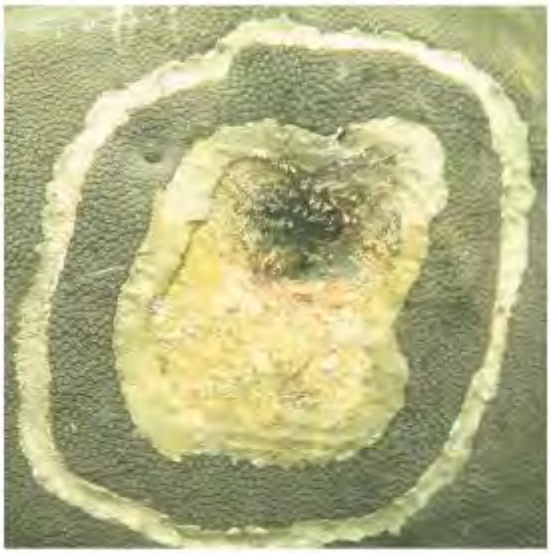
June 11, 2018- Monitor

April 5, 2018- First Visit

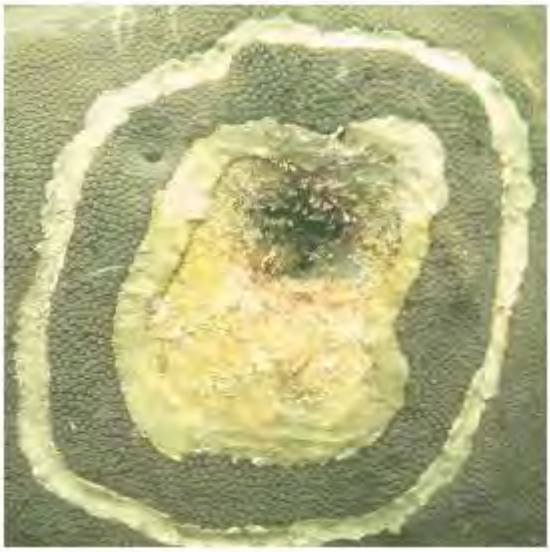
April 27, 2018- Treatment

April 27, 2018- Treatment

May 10, 2018 - 1st Monitoring



May 10, 2018 - 1st Monitoring



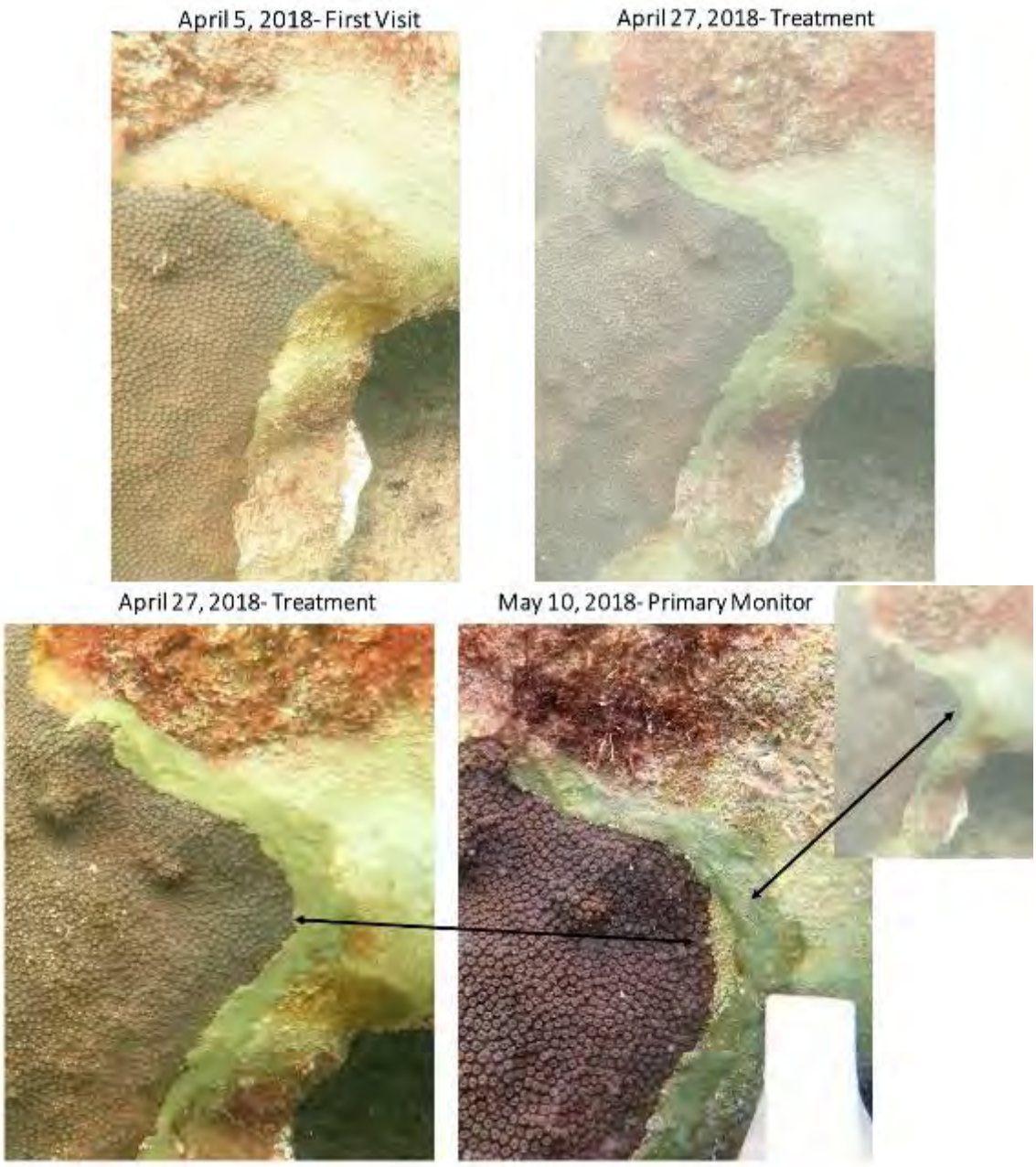
May 24, 2018 – Secondary Monitor

May 24, 2018 – Secondary Monitor

June 1, 2018 –Monitor- Progressed passed covered margin

June 1, 2018 –Monitor- Progressed passed covered margin

June 11, 2018- Monitor


April 5, 2018- First Visit
April 27, 2018- Treatment
April 27, 2018- Treatment
May 10, 2018- Primary Monitor

May 10, 2018- Primary Monitor

May 24, 2018- Secondary Monitor

May 24, 2018- Secondary Monitor

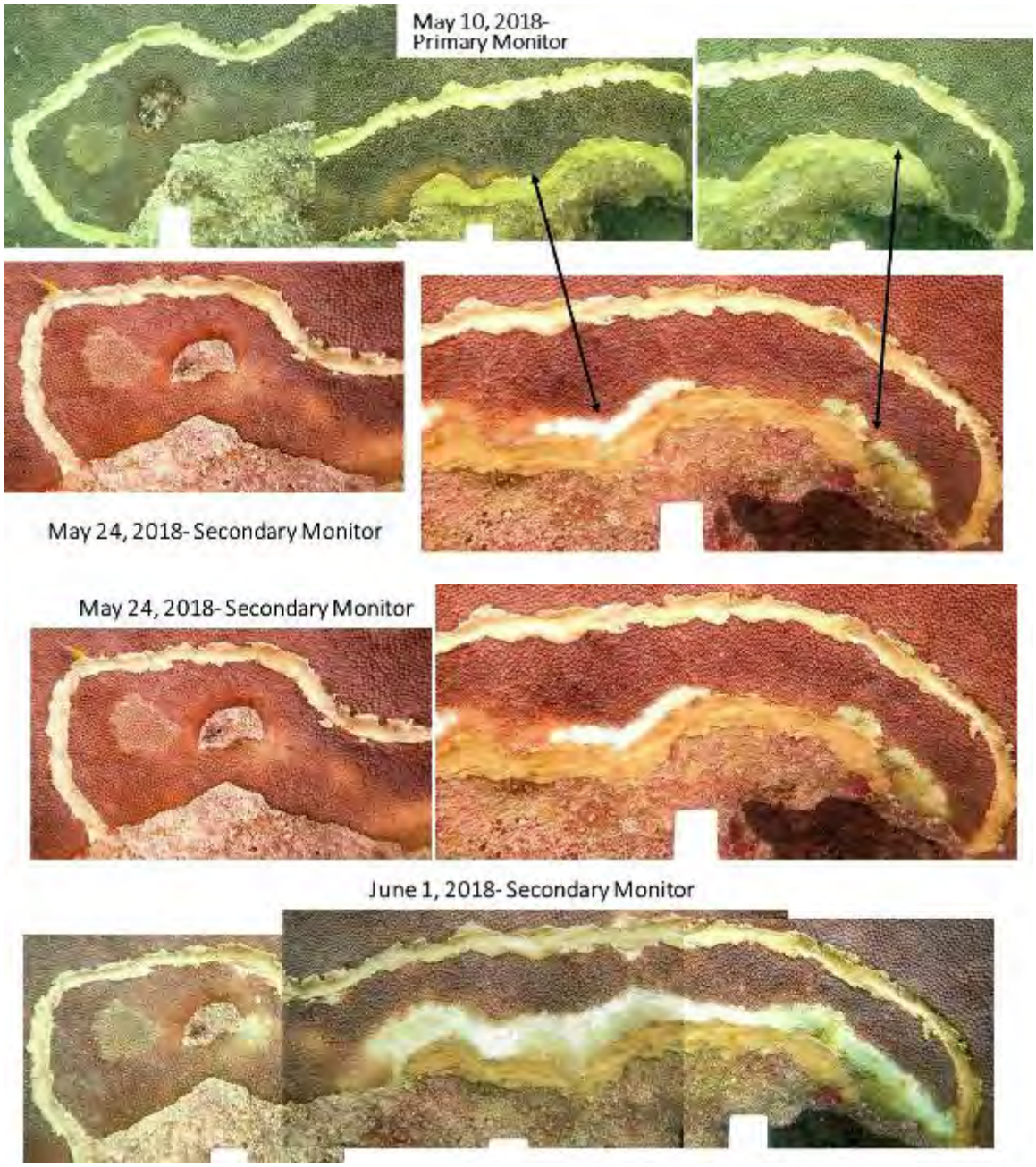
June 1, 2018- Monitor

June 1, 2018- Monitor

June 11, 2018- Monitor

April 27, 2018- Treatment

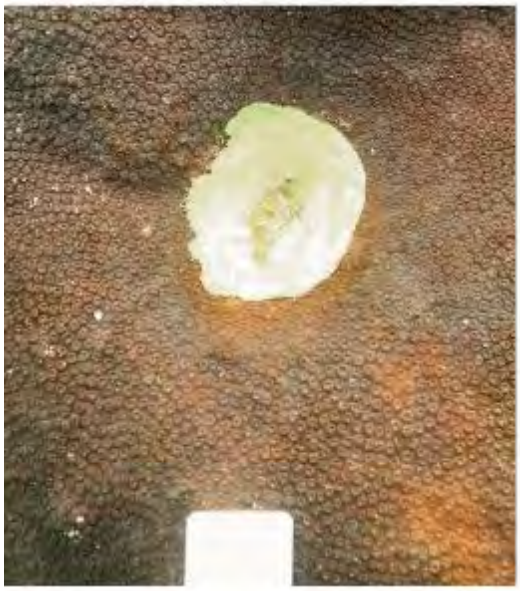
May 10, 2018- Primary Monitor


May 10, 2018-
Primary Monitor
May 24, 2018- Secondary Monitor
May 24, 2018- Secondary Monitor
June 1, 2018- Secondary Monitor

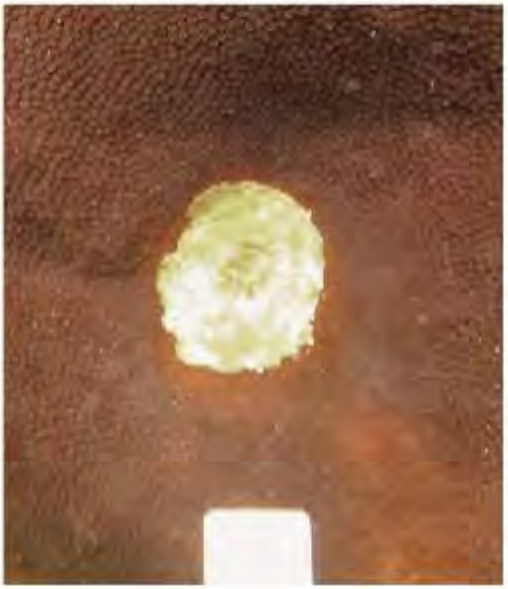
June 1, 2018- Secondary Monitor

June 11, 2018- Monitor

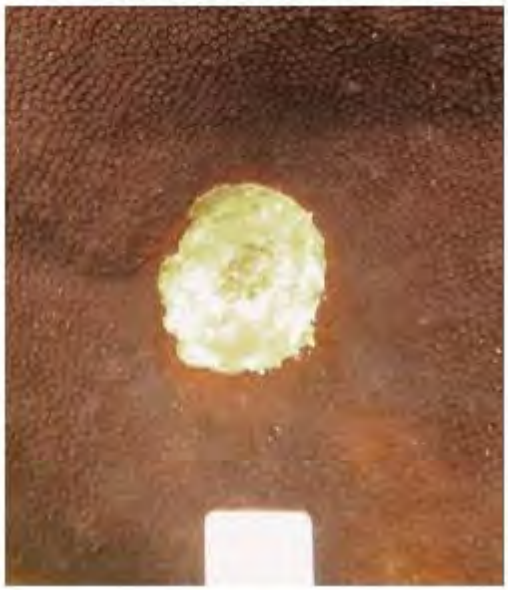
April 27, 2018- Treatment



May 10, 2018- Primary Monitor



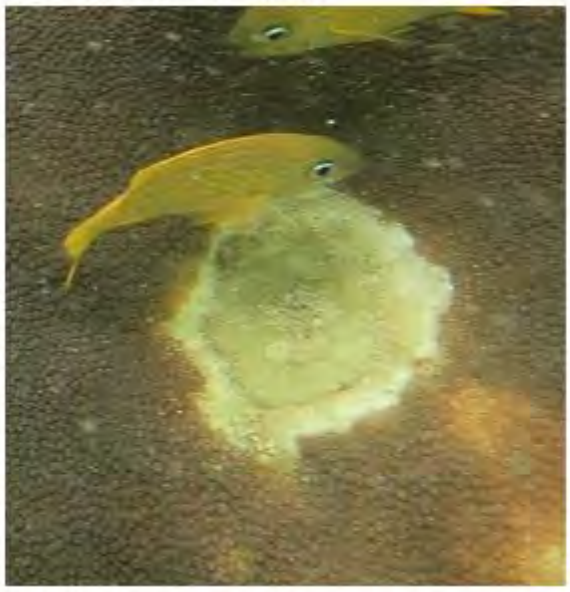
May 10, 2018- Primary Monitor



May 24, 2018- Secondary Monitor

May 24, 2018- Secondary Monitor

June 1, 2018- Monitor



June 1, 2018- Monitor

June 1, 2018- Addition of FB and more epoxy on disease margin

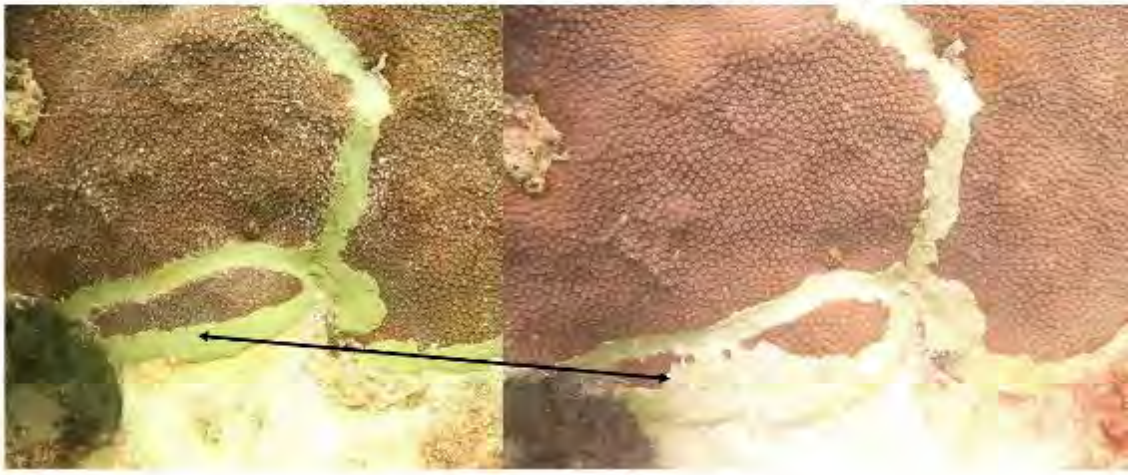
June 1, 2018- Addition of FB

June 1, 2018- Addition of FB

June 11, 2018- Monitor

April 27, 2018- Treatment

May 10, 2018- Primary Monitor



May 10, 2018- Primary Monitor

May 24, 2018- Secondary Monitor

May 24, 2018- Secondary Monitor

June 1, 2018- Monitor

June 1, 2018- Monitor

June 1, 2018 Addition of FB and more epoxy on margin

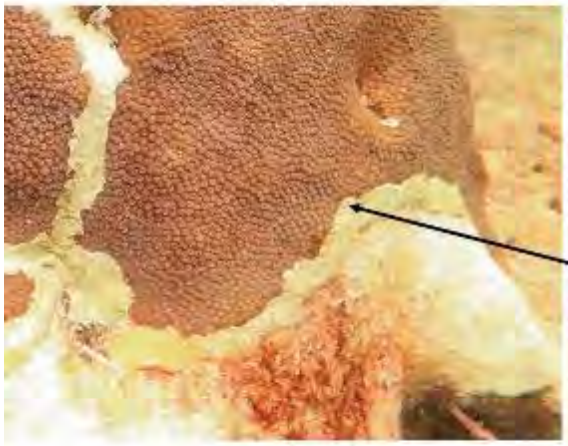
June 1, 2018- Addition of FB and more epoxy on margin

June 11, 2018- Monitor

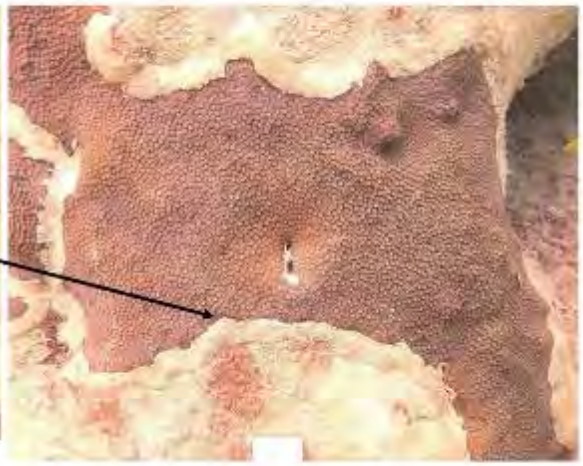
April 27, 2018- Treatment

May 10, 2018- Primary Monitor

May 10, 2018- Primary Monitor

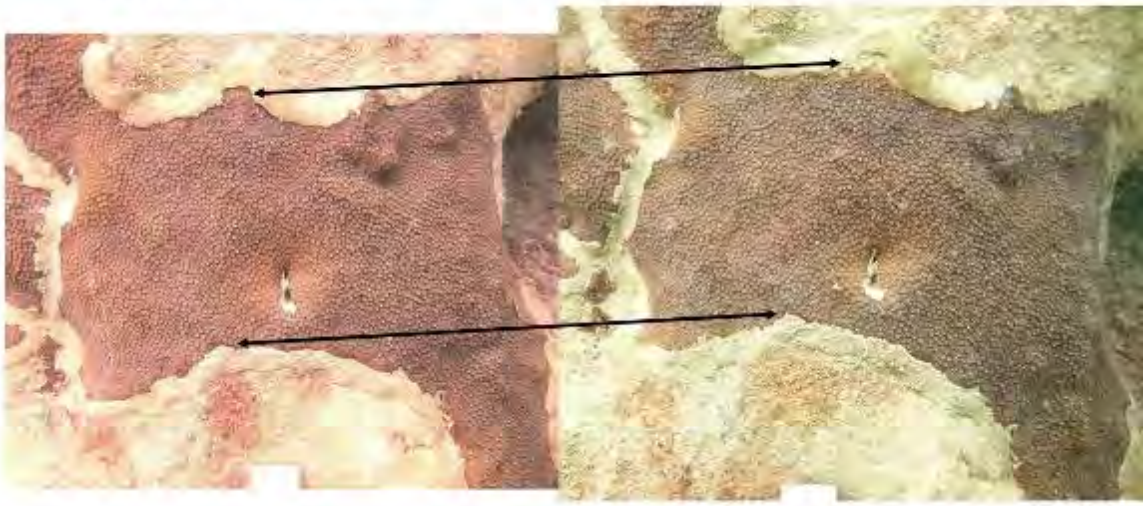


May 24, 2018- Secondary Monitor



May 24, 2018- Secondary Monitor

June 1, 2018- Monitor



June 1, 2018- Monitor

June 11, 2018- Monitor

April 27, 2018- Treatment

May 10, 2018- Primary Monitor

May 10, 2018- Primary Monitor

May 24, 2018- Secondary Monitor

May 24, 2018- Secondary Monitor

June 1, 2018- Monitor

June 1, 2018- Monitor

June 1, 2018- Added FB without covering margin

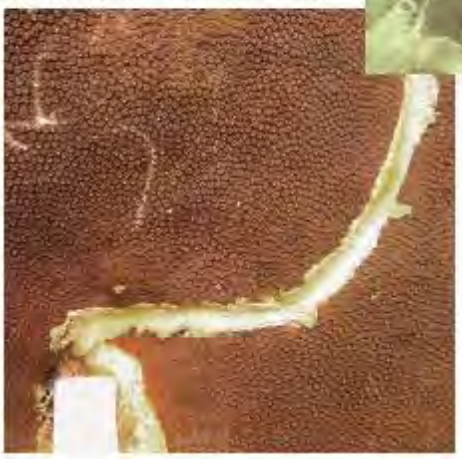
June 1, 2018- Added FB without covering margin

June 11, 2018- Monitor

April 27, 2018- Treatment

May 10, 2018- Primary Monitor

May 10, 2018- Primary Monitor



May 24, 2018- Secondary Monitor

May 24, 2018- Secondary Monitor

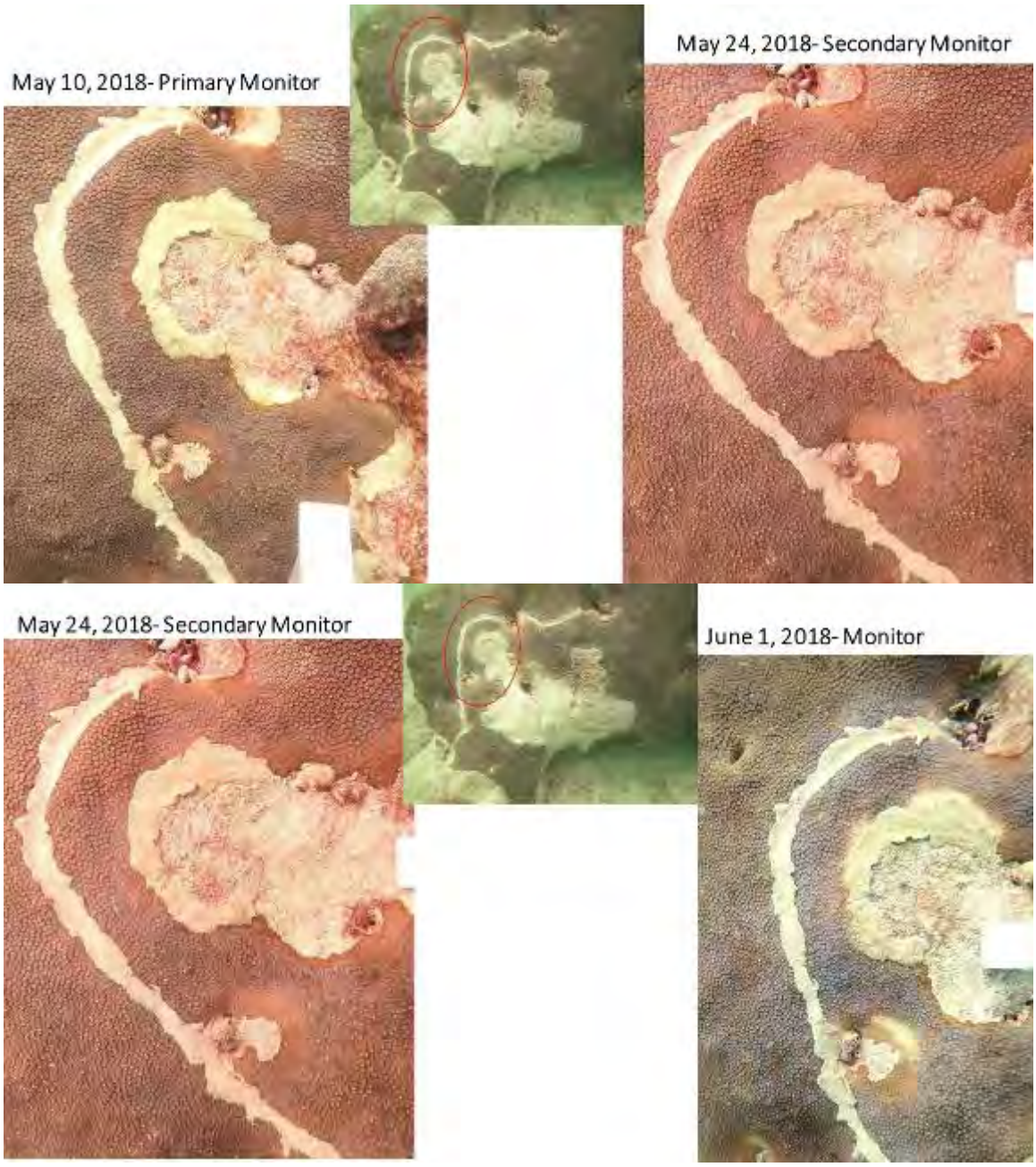
June 1, 2018- Monitor

June 1, 2018- Monitor

June 11, 2018- Monitor

April 27, 2018- Treatment

May 10, 2018- Primary Monitor


May 10, 2018- Primary Monitor
May 24, 2018- Secondary Monitor
May 24, 2018- Secondary Monitor
June 1, 2018- Monitor

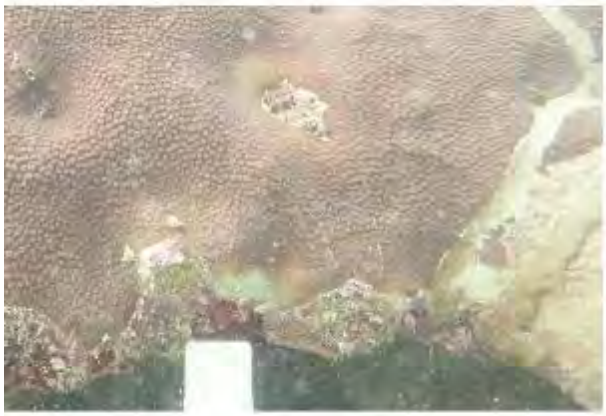

June 1, 2018- Monitor
June 11, 2018- Monitor
June 1, 2018- Add FB treatment
June 11, 2018- Monitor


June 1, 2018 Add FB treatment
June 11, 2018- Monitor
May 24, 2018- Secondary Monitor
June 1, 2018- Add FB treatment

June 1, 2018- Add FB treatment

June 11, 2018- Monitor

June 1, 2018- Add FB treatment



June 1, 2018- Add FB treatment

June 11, 2018- Monitor

June 1, 2018- Add FB treatment

June 1, 2018- Add FB treatment

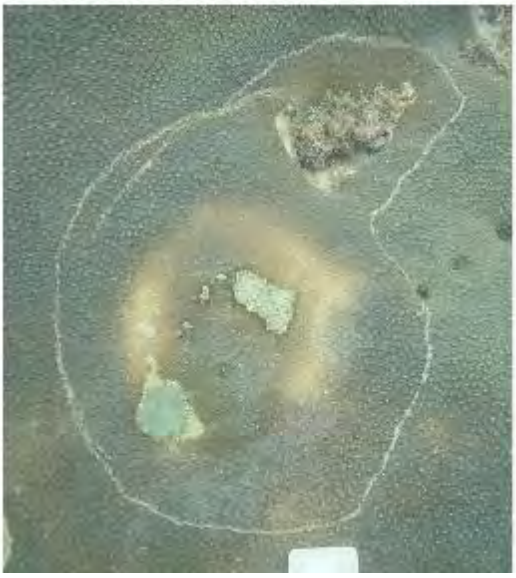
June 11, 2018- Monitor

June 1, 2018- Add FB treatment

June 1, 2018- Add FB treatment

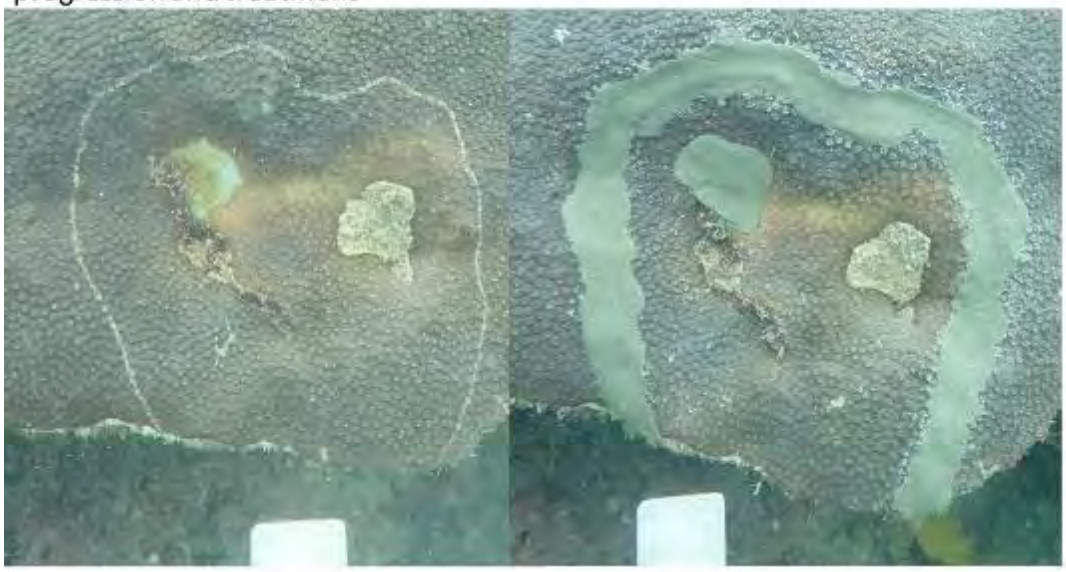
June 11, 2018- Monitor

June 11, 2018- New disease progression and treatment



June 11, 2018- New disease progression and treatment

June 11, 2018- New disease progression and treatment



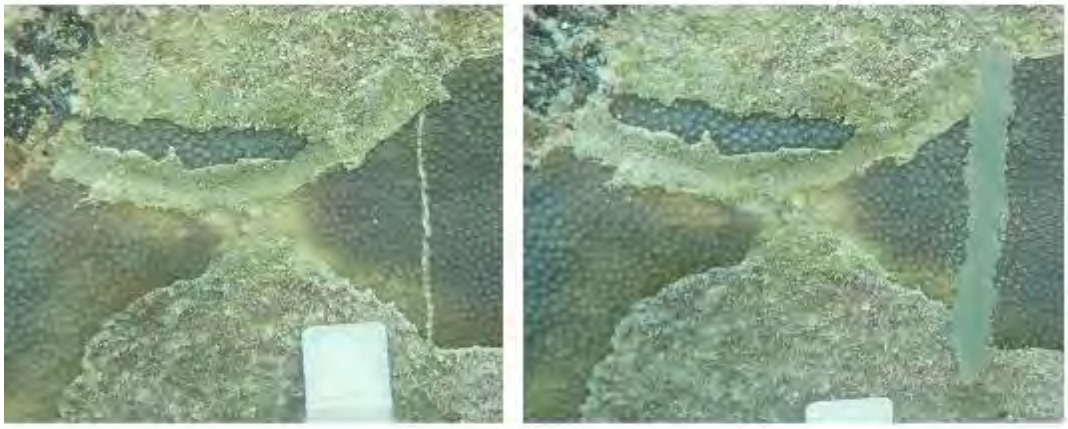
June 11, 2018- New disease progression and treatment

June 11, 2018- New disease progression and treatment

June 11, 2018- New disease progression and treatment

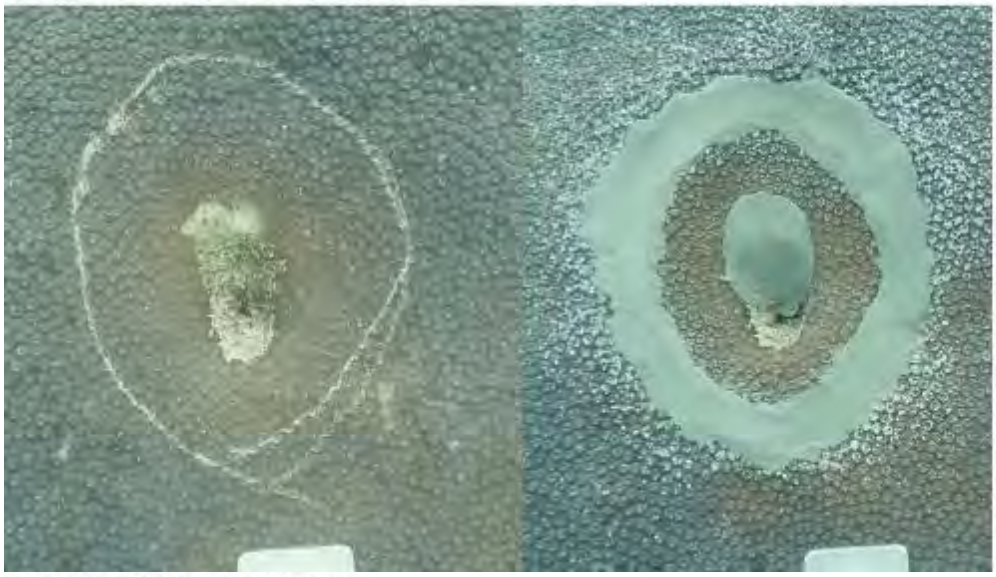
June 11, 2018- New disease progression and treatment

June 11, 2018- New disease progression and treatment

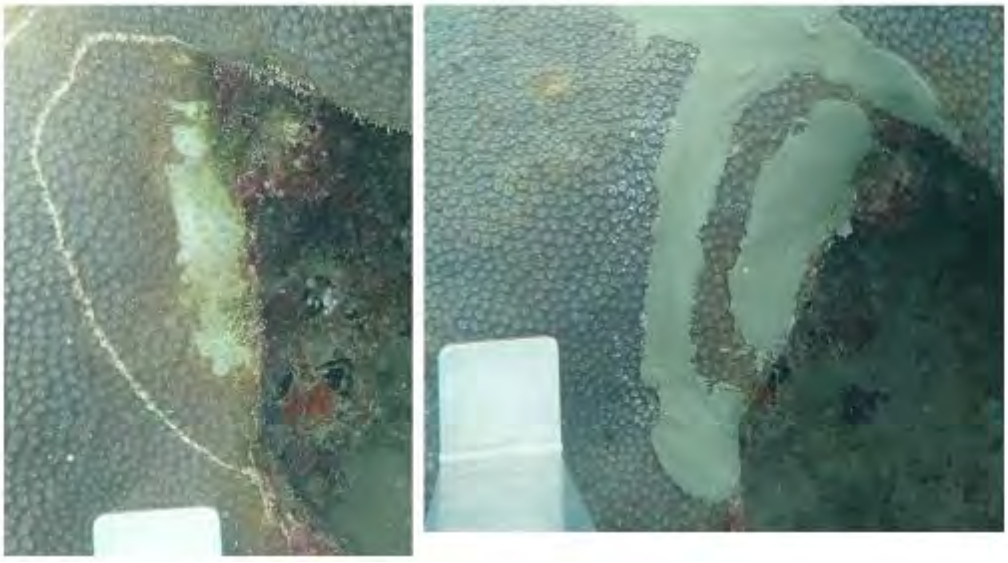


June 11, 2018- New disease progression and treatment

June 11, 2018- New disease progression and treatment



June 11, 2018- New disease progression and treatment

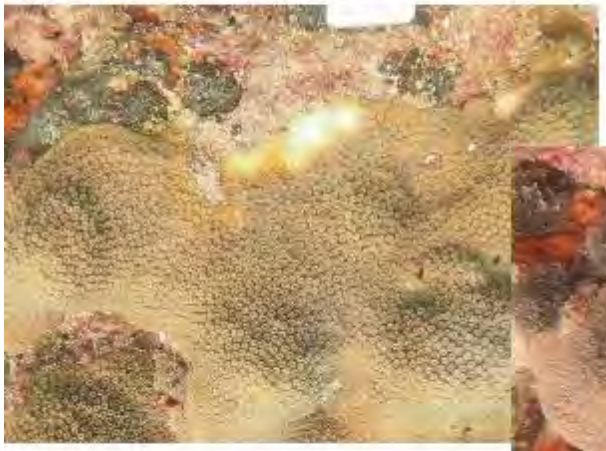


T-317

May 10, 2018- 1st Visit

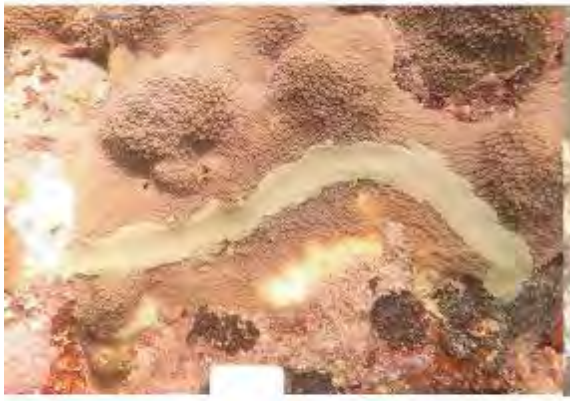
May 24, 2018- Re-check

May 24, 2018- Re-check



June 1, 2018- Treatment

June 1, 2018- Treatment



June 11, 2018- Monitor

June 1, 2018- Treatment

June 11, 2018- Monitor

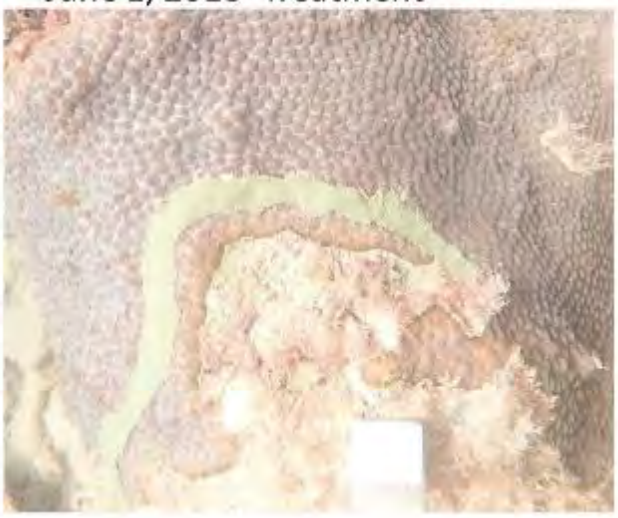
June 1, 2018- Treatment

June 11, 2018- Monitor

T-MCAVs next toT-317

June 1, 2018- Treatment

June 1, 2018- Treatment



June 1, 2018- Treatment

June 11, 2018- Treatment

June 1, 2018- Treatment

June 1, 2018- Treatment

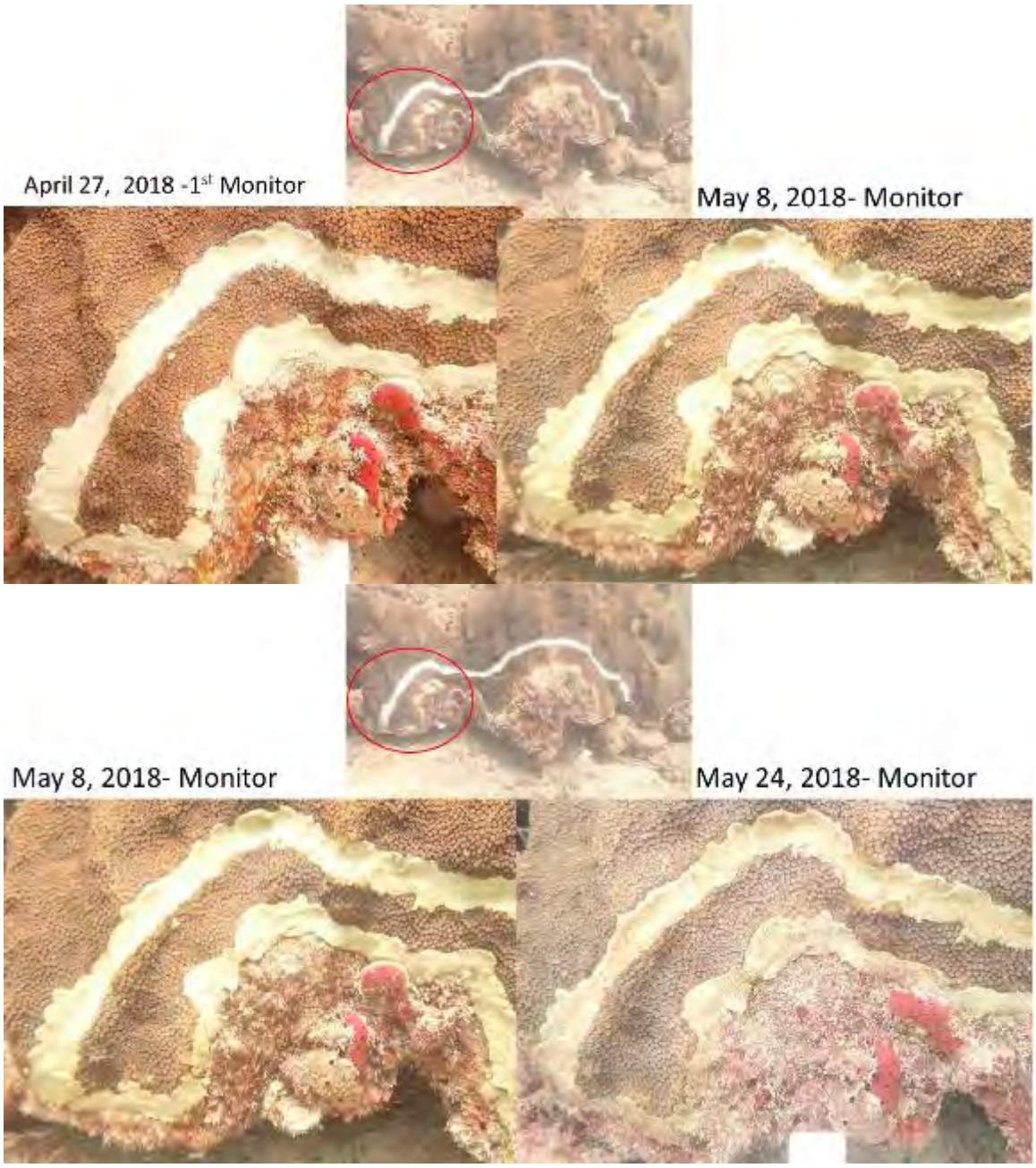
June 1, 2018- Treatment

June 11, 2018- Monitor

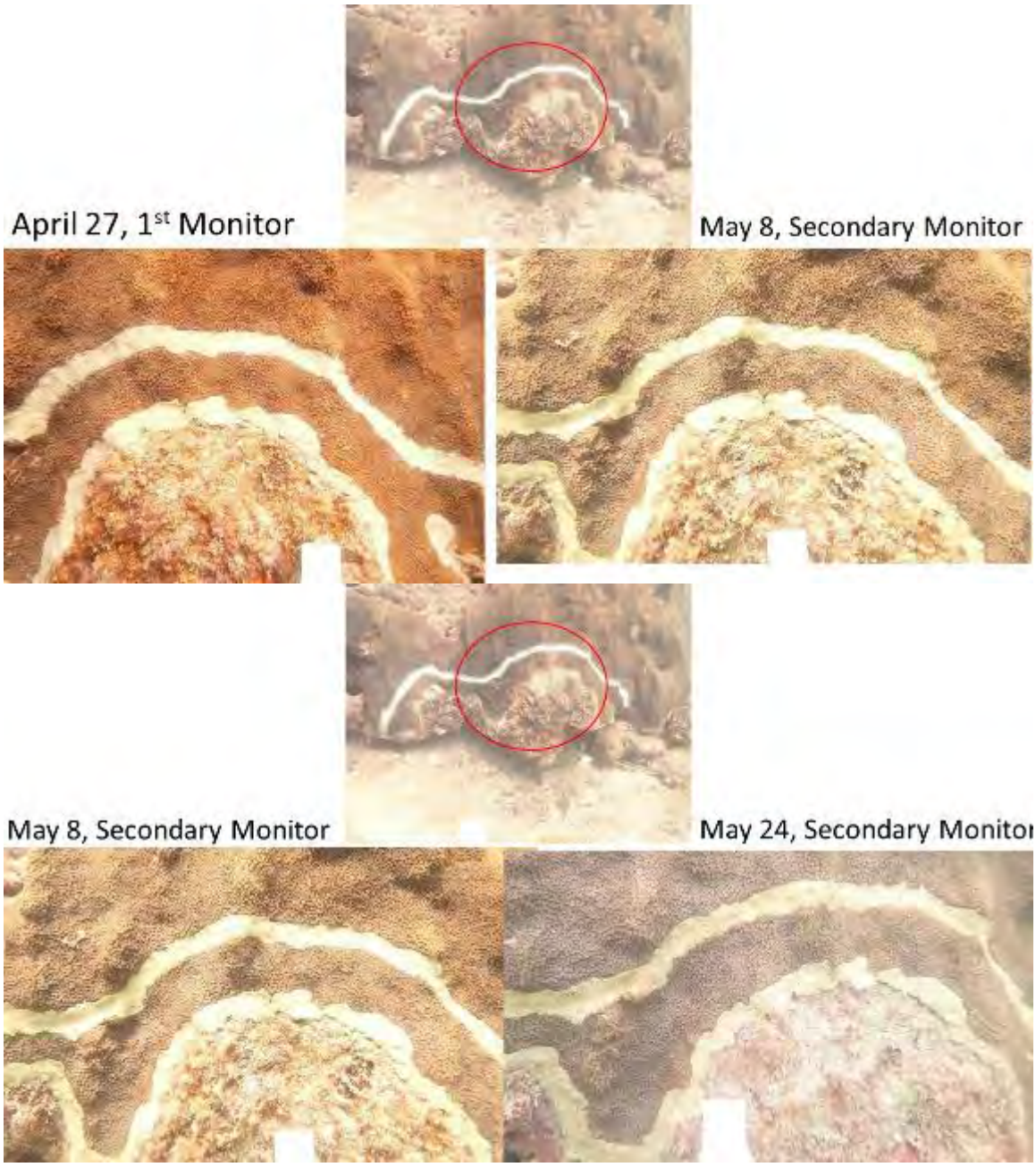
T-323

April 25, 2018-Treatment

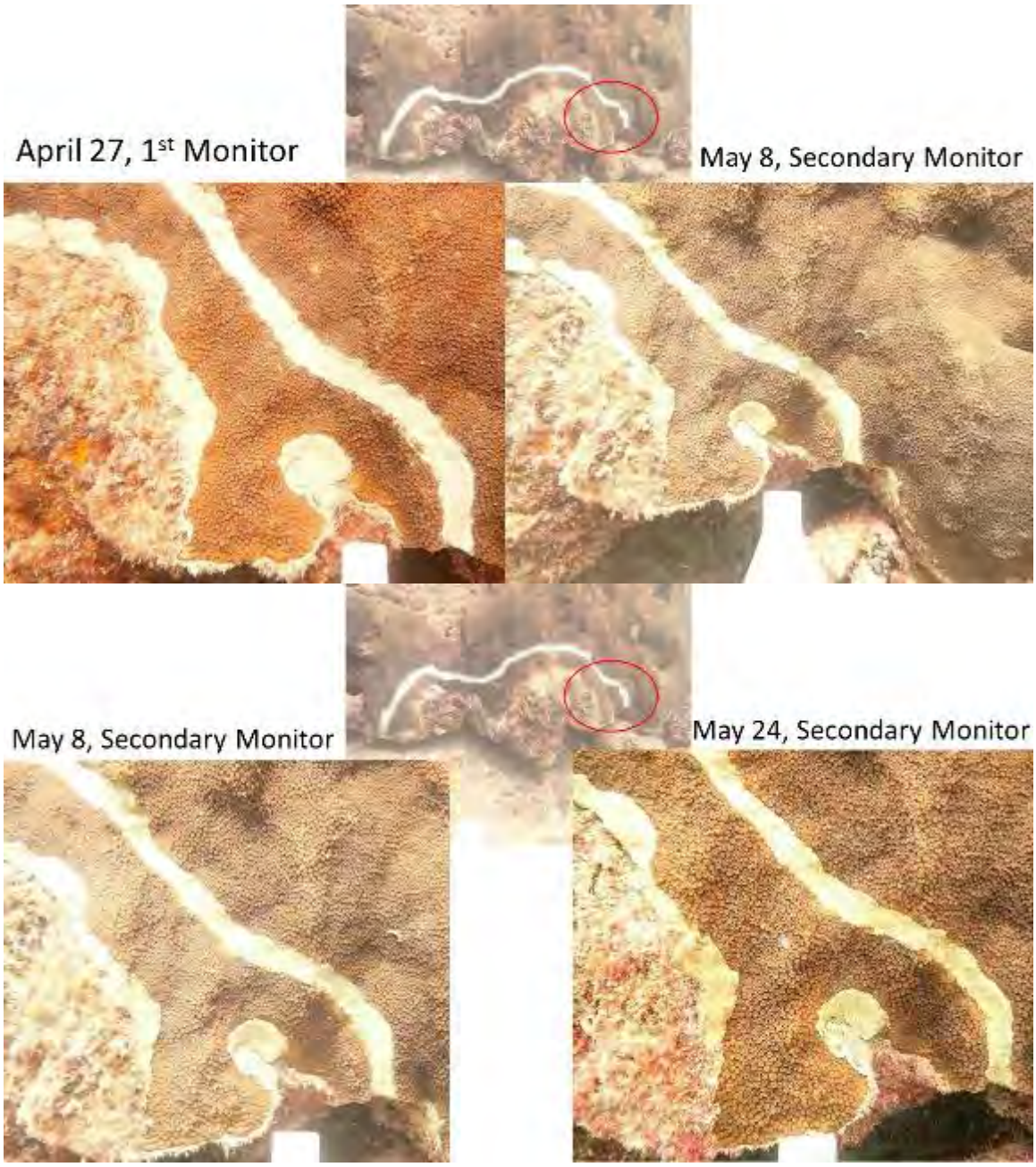
April 27, 2018 -1st Monitor


April 27, 2018 -1st Monitor
May 8, 2018- Monitor
May 8, 2018- Monitor
May 24, 2018- Monitor

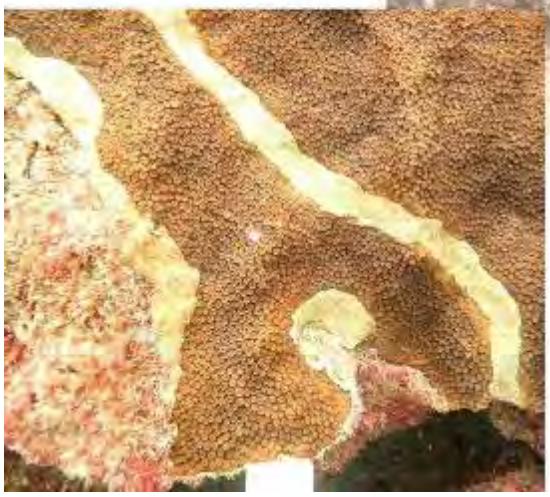

June 11, 2018- Monitor
May 24, 2018- Monitor
April 25, 2018-Treatment
April 27, 1st Monitor


April 27, 1st Monitor
May 8, Secondary Monitor
May 8, Secondary Monitor
May 24, Secondary Monitor


June 11, 2018- Monitor
May 24, Secondary Monitor
April 25, 2018-Treatment
April 27, 1st Monitor


April 27, 1st Monitor
May 8, Secondary Monitor
May 8, Secondary Monitor
May 24, Secondary Monitor

May 24, Secondary Monitor

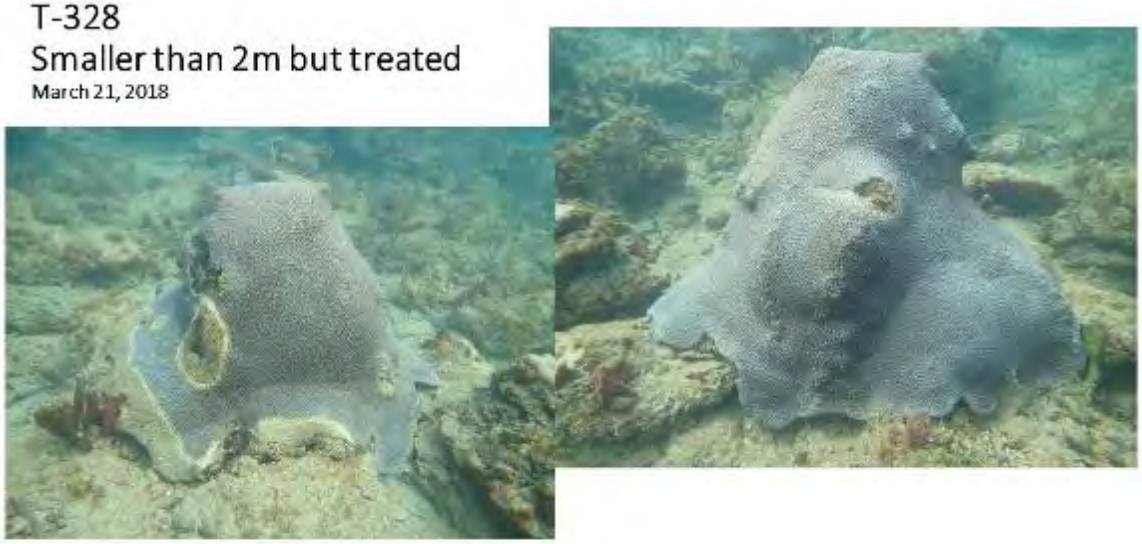


June 11, 2018- Monitor

June 11, 2018- Monitor- New active disease margin?

June 11, 2018- Monitor- New active disease?

T-328
Smaller than 2m but treated
March 21, 2018



March 21, 2018- First Visit

May 8, 2018- Treatment

May 11, 2018 -1st Monitoring

May 11, 2018 -1st Monitoring

May 24, 2018 - Secondary Monitoring

May 24, 2018 - Secondary Monitoring

June 14, 2018 - Monitor

May 11, 2018 -1st Monitoring

May 24, 2018 - Secondary Monitoring

May 24, 2018 - Secondary Monitoring

June 14, 2018 - Monitor

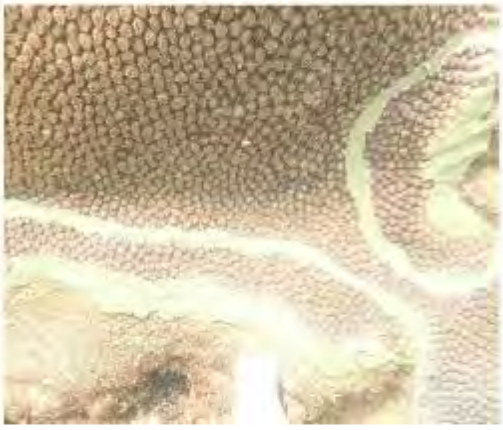
May 11, 2018 -1st Monitoring

May 24, 2018 - Secondary Monitoring

May 24, 2018 - Secondary Monitoring

June 14, 2018 - Monitor

May 11, 2018 -1st Monitoring

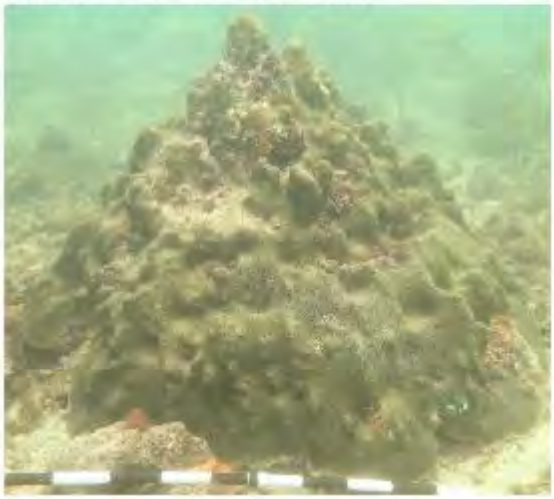


May 24, 2018 - Secondary Monitoring

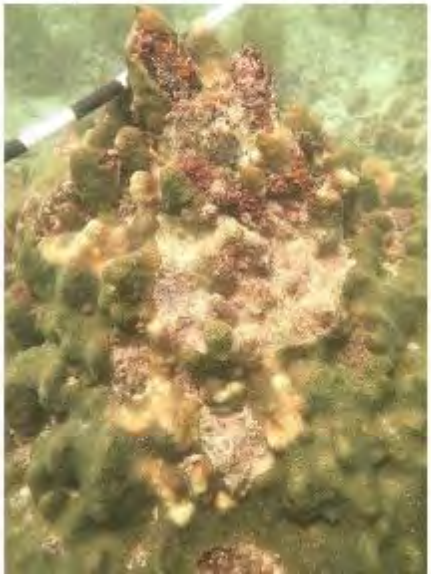

June 14, 2018 – Disease progression halted by firebreak
June 14, 2018 – New legion emerging
May 24, 2018 - Secondary Monitoring
June 14, 2018 - Monitor

T-332

May 24 2018-First Visit



May 24 2018-First Visit



June 1, 2018- Treatment

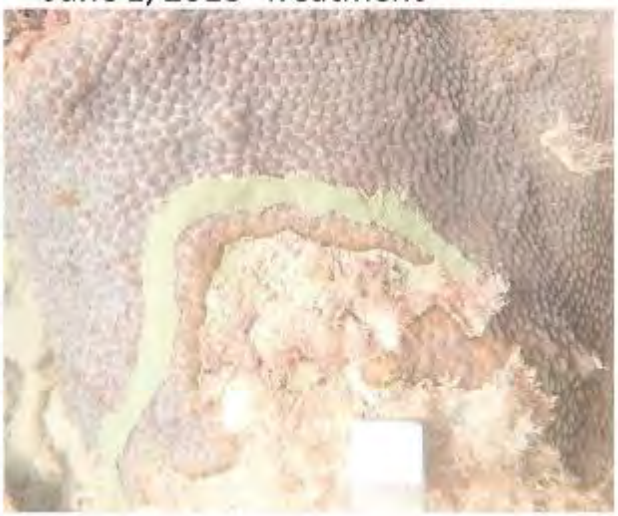

June 1, 2018- Treatment
June 11, 2018- Monitor
June 1, 2018- Treatment
June 11, 2018- Monitor


June 1, 2018- Treatment
June 11, 2018- Monitor
June 1, 2018- Treatment
June 11, 2018- Monitor

T-MCAVs next toT-317

June 1, 2018- Treatment

June 1, 2018- Treatment



June 1, 2018- Treatment

June 11, 2018- Treatment

June 1, 2018- Treatment

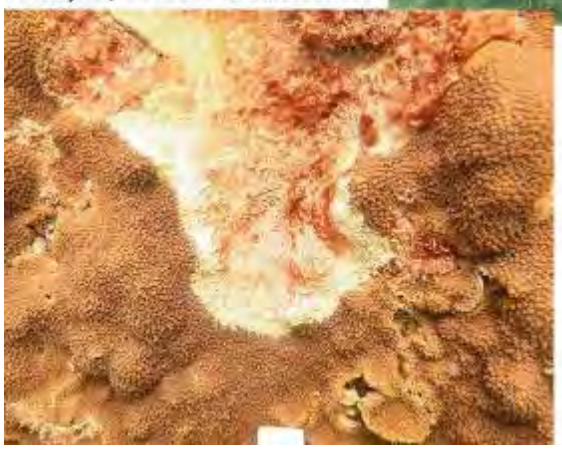
June 1, 2018- Treatment

June 1, 2018- Treatment

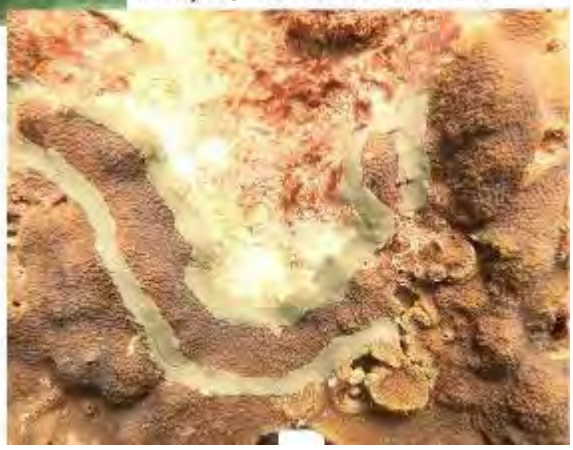
June 11, 2018- Monitor

T-333

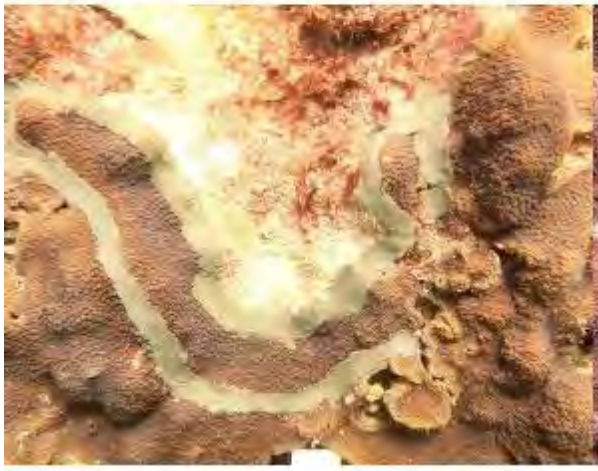
May 8, 2018-Treatment



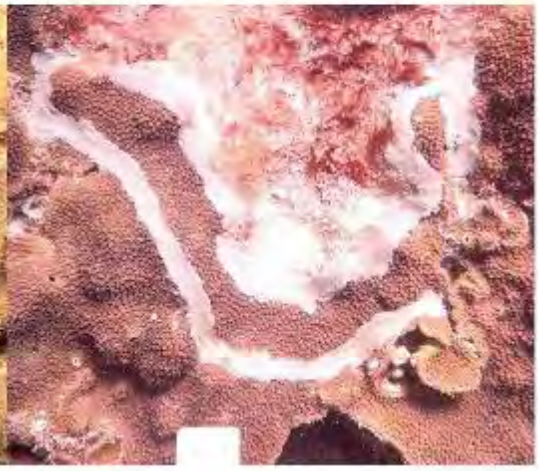
May 8, 2018-Treatment



May 8, 2018-Treatment



May 10, 2018-1st Check




May 10, 2018-1st Monitor
May 24, 2018-
Secondary
Monitor
May 24,
2018-
Secondary
Monitor
June 1, 2018-
Monitor


June 1, 2018-
Monitor
June 11, 2018- Monitor