

**Observations of rapidly progressing lesions on corals within the
Florida Keys National Marine Sanctuary: a Quicklook report**

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March 10, 2023

PART I: Fast Lesion Progression on *Orbicella faveolata*

Appearance:

We report here on rapid coral tissue loss caused by disease lesions seen within the Florida Keys National Marine Sanctuary. For the purpose of this report, we will refer to this syndrome as Fast Lesion Progression (FLP). FLP has primarily been observed on *Orbicella faveolata* colonies (although see the section below for information on lesions seen on *Pseudodiploria clivosa*). Lesions can be single (only one on the colony), or multifocal (several on a colony). Progression is sometimes, but not always, from the bottom of the colony moving upwards (Figure 1A&B). It has also been observed radiating out from a midpoint of the colony (Figure 1D), progressing sideways (Figure 1C), or moving downward from the top of a colony (Figure 1E&F). Progression is rapid, with sometimes 50 cm or more of stark white skeleton behind the lesion (see Appendix I for examples of progression across 1-2 months). The lesions present as defined lines of tissue loss (Figure 1G), but occasionally a loose film of brown substance (possibly decaying tissue) can be seen adjacent to the active lesion (Figure 1H). This material is loose (can be dislodged with a swish of water), and we suspect the appearance or lack thereof of this film is dependent on the water flow at the site during observation.

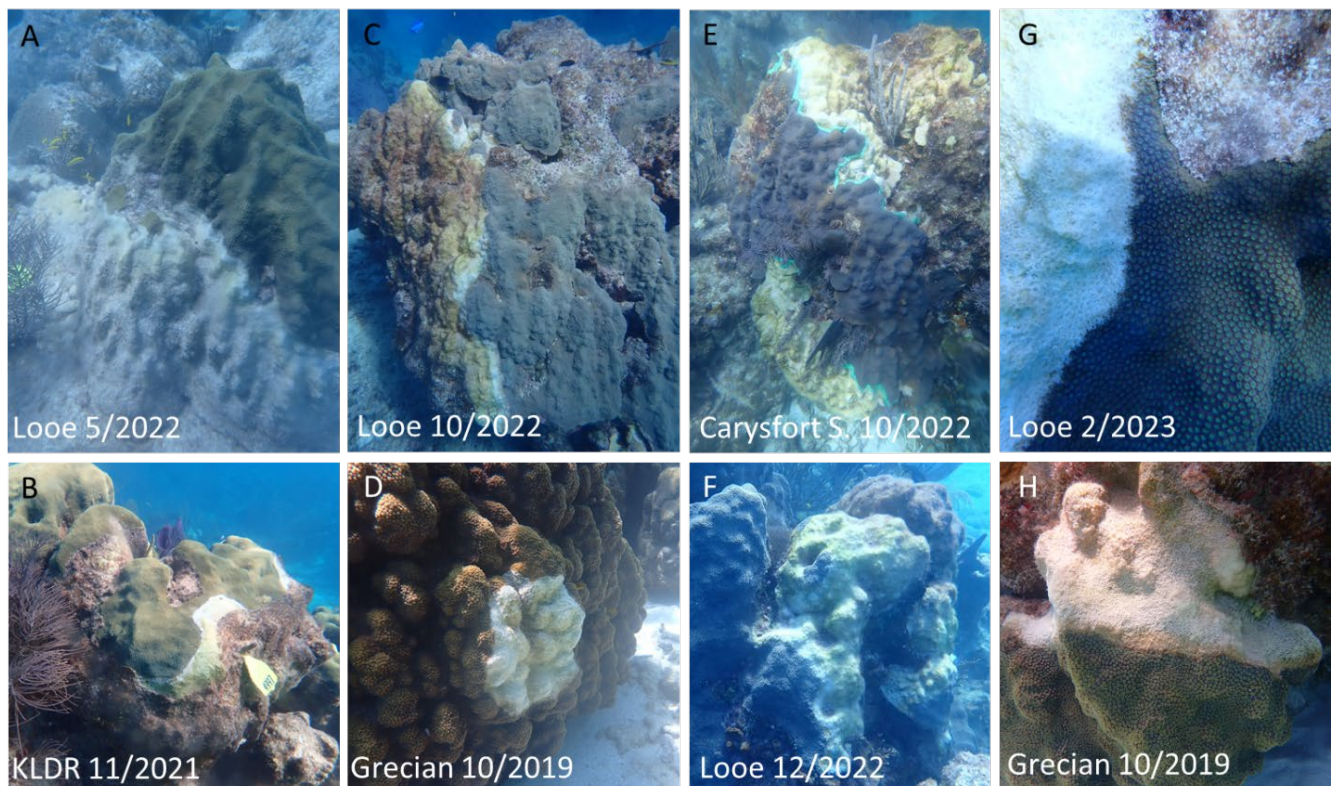


Figure 1: Appearance of Fast Lesion Progression (FLP) on *Orbicella faveolata* colonies. A&B: rapid lesion progression upwards, similar to white plague. C: progression of lesion sideways across colony. D: Lesion radiating from a midpoint of the colony. E&F: Lesions progressing downwards from the top of the colony and, in image E, an example of multi-focal lesions (which have been treated with a green topical paste). G: Close-up of lesion. H: Close-up of lesion showing loose brown film seen on some lesions, particularly during times of calm water.

Identification of diseases is challenging, and FLP may represent variations of known diseases, or a new disease entirely. Disease progression can appear similar to white plague, but notably is not always from the bottom of the colony, and FLP also presents more frequently as multifocal than white plague. FLP can also appear similar to SCTLD during outbreak conditions, particularly in being multifocal and also appearing on reefs where SCTLD is obviously present on other species. Additionally, we have observed *O. faveolata* colonies with FLP which also have more classic SCTLD endemic lesions (smaller, less acute, and more multifocal), indicating that colonies can be afflicted with both conditions simultaneously.

Spatiotemporal Observations:

During the second half of 2022 while looking for potential colonies to test probiotics on at Looe Key, we began anecdotal note taking on FLP as compared to standard SCTLD. Similarities to rapidly progressing lesions on *O. faveolata* at other reefs prompted us to opportunistically review a subset of photos from *O. faveolata* colonies at other sites for comparison.

We now think that FLP has been present on *O. faveolata* colonies at numerous sites in FKNMS since at least early 2019, when intervention work and follow-up monitoring began. Some of the first colonies treated at Carysfort South reef (January 2019) presented with these same types of lesions, and colonies at Key Largo Dry Rocks and Grecian Rocks from 2019 through the present also present similarly. In particular, Key Largo Dry Rocks and Grecian Rocks have abnormally large *O. faveolata* colonies in the shallow backreef environments on which lesions nearly always present in this manner. Surveying photos from the large number of *O. faveolata* at Sombrero Key and Sand Key (as well as inshore sites like Cheeca and Hen & Chickens) would take a concerted (and funded) amount of future time and effort, but it is likely that similar FLP lesions have and continue to occur on these and other reefs as well.

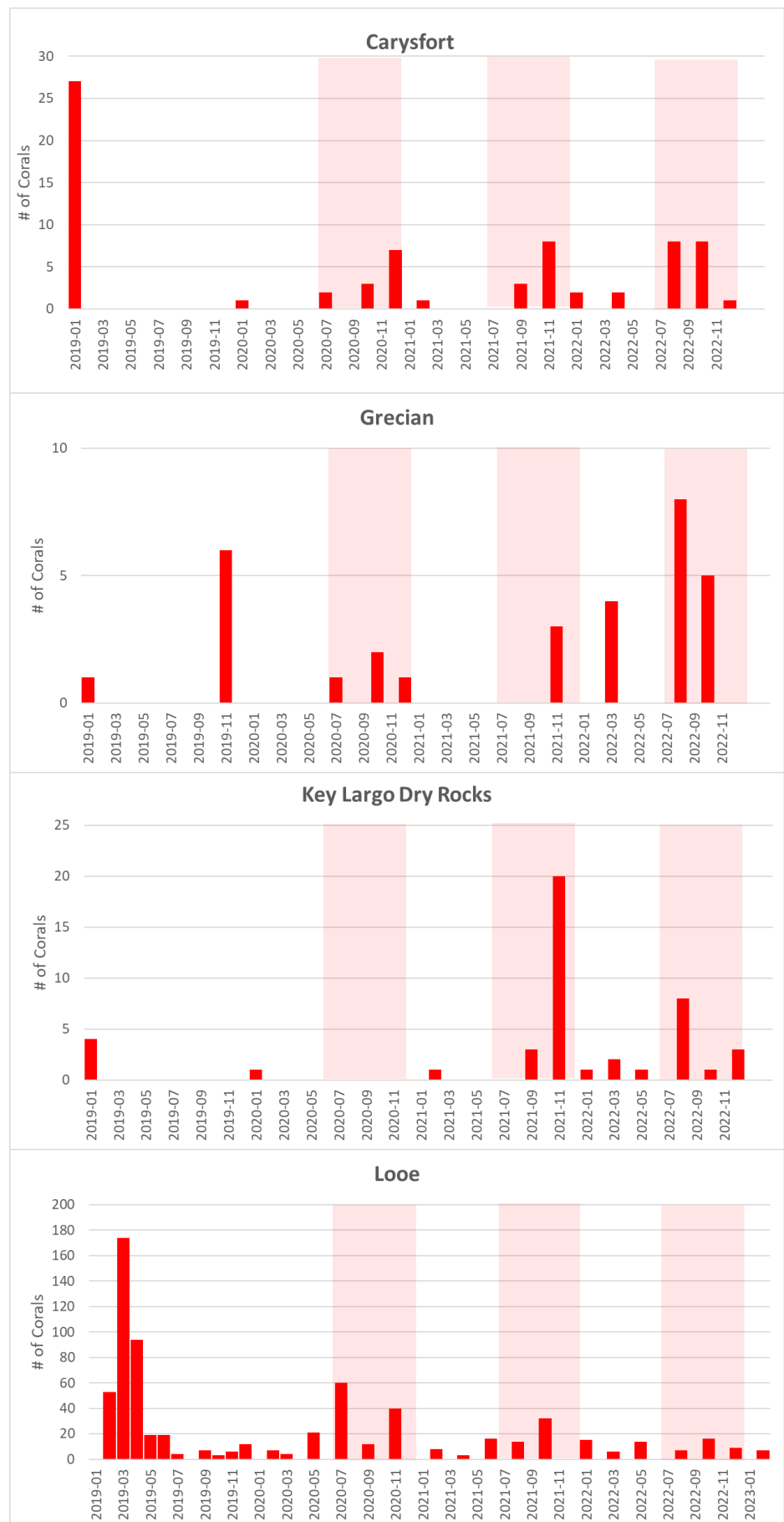
Initial observations suggest that FLP may exhibit seasonality. Photo analysis of all monitored *O. faveolata* colonies in order to separate classic SCTLD lesions from potential FLP lesions would require additional resources, but we have examined temporal patterns for newly diseased colonies (which would include SCTLD as well as FLP). For non-*O. faveolata* species, the number of new colonies treated does not show a seasonal pattern on offshore reefs. For *O. faveolata*, however, the rates of new diseased colonies found appear to be higher within the June – November timeframe, generally peaking in October (Figure 2). Though some of these newly diseased colonies and retreatment events are most certainly SCTLD across all seasons, we hypothesize that the seasonal increases are due to FLP.

Opportunistic photo analysis suggests that many of these lesions halt on their own during the December/January time frame, potentially as a correlation with colder water temperatures. Similar temperature-dependent lesion halting is known from other disease conditions, including white plague, but notably is not seen for SCTLD. Many anecdotal observations of lesion halting within the FKNMS have been documented over the past years, and have been attributed to SCTLD halting on its own. We suggest these observations may in fact have been primarily FLP.

Figure 2: Number of newly-diseased *Orbicella faveolata* colonies found at four reef sites during roughly semi-monthly monitoring intervals from 2019 – 2022. The months of June to December are highlighted in pink for each site, which roughly aligns with increased numbers of newly-diseased corals.

Testing for *Vibrio coralliilyticus*:

We tested 10 active disease lesions from colonies at Looe Key in December 2022 for the presence of *Vibrio coralliilyticus*. Five of these were FLP-type lesions, and five were slower classic SCTLD lesions. All FLP tests were negative. Four of the classic SCTLD tests were conclusively negative, and one showed confusing test signs; while neither of two replicate tests showed a positive result at the normal 15 minutes, one showed an abnormal white test line at 6 minutes, and the other showed a positive result only 2 hours after the test was complete. Nevertheless, there is no indication that *Vibrio coralliilyticus* plays a role in FLP lesions nor that the presence or absence of *V. coralliilyticus* varies between FLP and SCTLD lesion types.



Response to Antibiotics:

FLP lesions appear to have little to no response to topical amoxicillin application. As part of the *Vibrio coralliilyticus* testing above, we specifically followed seven FLP lesions treated with the standard amoxicillin + Base2b paste in December 2022 to their outcome in February 2023. Five of these lesions continued unabated past the treatment margins. For two of them, the lesions halted at the treatment line along portions of the lesion, but progressed past the treatment along other parts. Of the seven monitored lesions, one continued to be active in February 2022, and one had killed the tissue isolate entirely. But the other 5 had all halted on their own, either at or past the treatment line. We suggest that while the antibiotics may have been partially effective on part of two of the lesions, it is likely that these lesions either halted on their own coincidentally at these lines, or would have halted on their own slightly past them regardless.

By opportunistically looking at photos of probable FLP from other sites (Grecian, Key Largo Dry Rocks, and Carysfort South), we found similar patterns. Treatments were largely ineffective at halting lesions. Three exceptions (one at Carysfort South and two at Grecian) showed halting at the treatment line, but again these were all treatments in November/December, and so the halting may have been coincidental and corresponding with cold water events. Other treatments during cold-water months were not effective (Table 1).

Relationship to Prior Antibiotic Treatments:

In response to kneejerk reactions that FLP is caused by antibiotic treatments or represents a mutation of SCTLD in response to treatments, we hypothesize on the relationship between FLP and treatments here.

Appearance of FLP on corals or sites does not appear to have any correlation to treatment history. FLP appears to have been present on Upper Keys reefs before any antibiotic treatments were applied in Florida. The addition of Carysfort Main as a new (never treated) site in September 2022 was due to a large number of *O. faveolata* colonies found in the backreef with FLP.

Site	Coral	Year	Month	1-2 month result
Key Largo Dry Rocks	4997	2021	September	Ineffective
Key Largo Dry Rocks	7273	2022	August	Ineffective
Carysfort Main	7298	2022	September	Ineffective
Carysfort Main	7300	2022	September	Ineffective
Carysfort Main	7300	2022	November	Ineffective
Carysfort Main	7261	2022	September	Ineffective
Carysfort Main	7261	2022	November	Ineffective
Carysfort South	33	2019	January	Ineffective
Carysfort South	45	2019	January	Ineffective
Carysfort South	57	2022	October	Ineffective
Carysfort South	3839	2020	December	Effective
Grecian	1402	2019	October	Ineffective
Grecian	1402	2019	November	Effective
Grecian	1426	2019	October	Ineffective
Grecian	1084	2019	November	Effective
Grecian	4528	2020	October	Ineffective
Grecian	4529	2020	October	Ineffective
Grecian	7028	2022	August	Ineffective
Grecian	7639	2022	August	Ineffective
Grecian	7081	2022	October	Ineffective
Looe	7810	2022	January	Ineffective
Looe	7810	2022	May	Ineffective
Looe	7810	2022	August	Ineffective

Table 1: Examples of amoxicillin treatment effectiveness on FLP-style lesions assessed through opportunistic photo analysis of *Orbicella faveolata* at five FKNMS reef sites across four years. In most cases, lesions progressed past the topical amoxicillin treatments. Exceptions occurred during periods of rapid water cooling, and such halting may be a result of effective treatment or of the changing environmental conditions.

At sites with previous treatment histories, treatments of *O. faveolata* colonies during semi-monthly visits include a small proportion of previously-treated colonies as well as the treatment of newly diseased colonies. *O. faveolata* are known to have high SCTLD reinfection rates, although the proportion of colonies reinfected declines with time. Since early 2021, the proportion of *O. faveolata* colonies requiring retreatment at Looe Key has been below 20%. Since early 2022, the proportion has been below 10%. We suggest that the low proportion of previously treated colonies requiring retreatment, along with the substantial number of never-treated colonies that develop FLP, indicate that previous treatments are unrelated to the development or susceptibility of corals to FLP.

Recommendations:

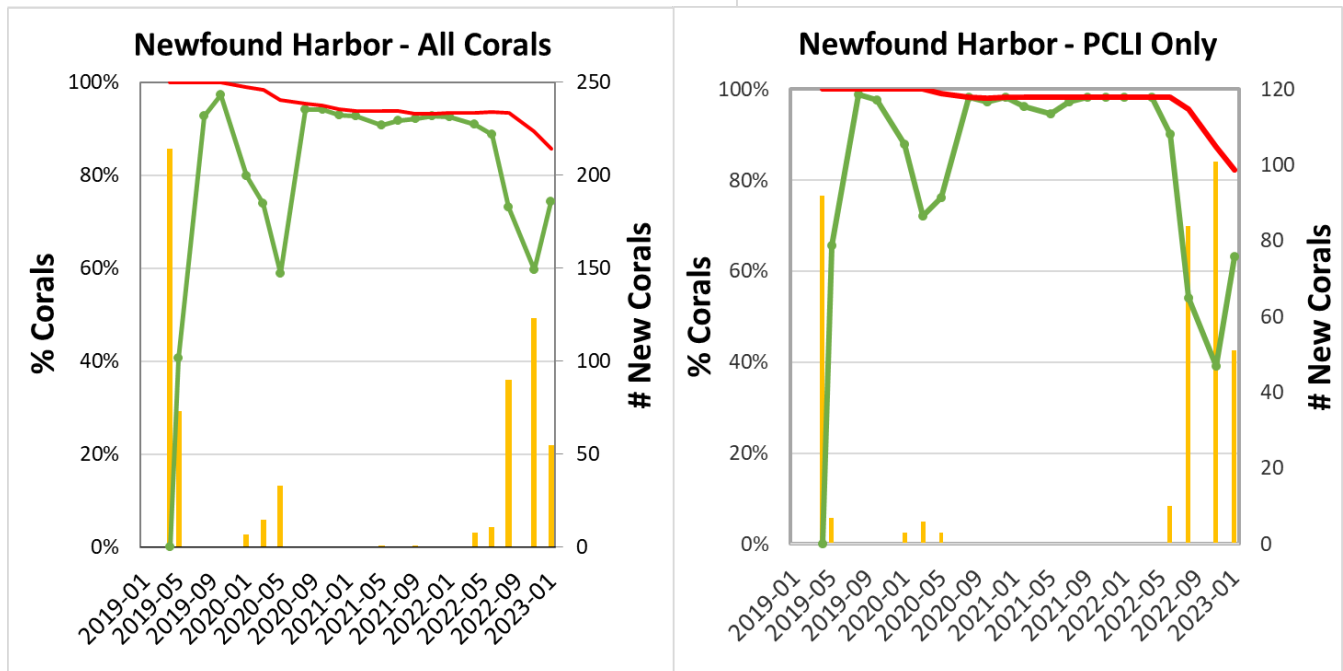
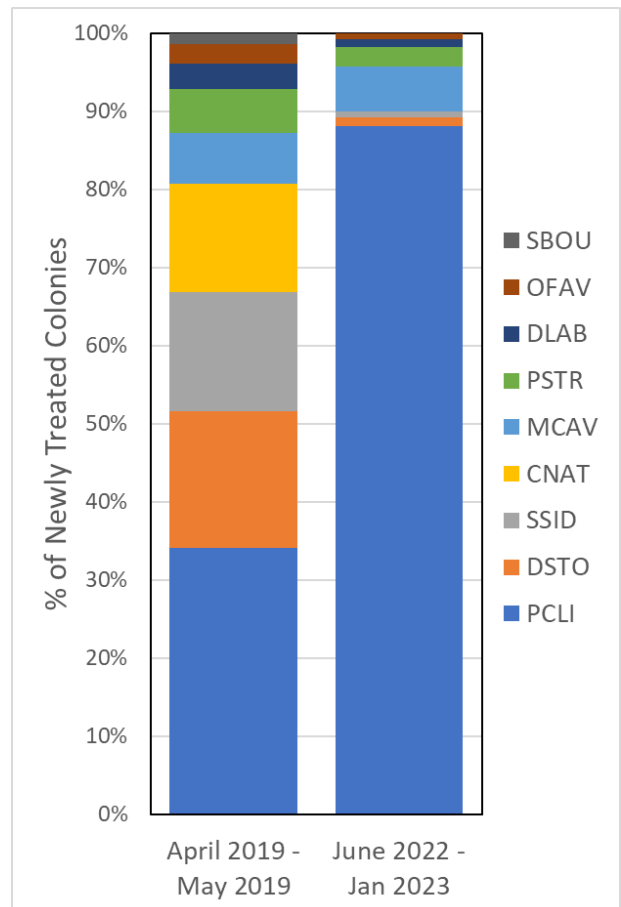
- FLP may represent a new disease or an altered presentation of a known disease, for example white plague. We recommend sampling of FLP lesions to compare histology of adjacent tissues with those from known white plague, SCTLD, and control samples to examine potential similarities and differences.
- FLP-style lesions do not appear to respond to antibiotics. We recommend cessation of antibiotic-treatments on obvious FLP lesions, which constitute a significant use of intervention time and resources with little efficacy.
- Because most of the monitored and treated corals at several Upper Keys sites (Carysfort Main, Grecian, and Key Largo Dry Rocks) are FLP-affected *O. faveolata*, we suggest that treatment and monitoring efforts at these sites be concluded and resources directed to sites experiencing high SCTLD mortality rates.
- FLP-style lesions may benefit from alternative treatment types. We recommend funding and authorizing trials of other intervention efforts on these corals.

PART II: Fast Lesion Progression on *Pseudodiploria clivosa*

Beginning in June 2022, a rapidly-progressing disease was observed primarily on *Pseudodiploria clivosa* at Newfound Harbor SPA.

Beginning in 2019, the site was heavily impacted by SCTLD and 287 corals were treated in April-May 2019. Treated corals were from 9 different species, with the largest representation (34%) by *Pseudodiploria clivosa* (Figure 1). Following the initial April/May 2019 treatments, the site had low prevalence of SCTLD in August and October 2019; 93% of monitored colonies and 97% of monitored colonies respectively showed no signs of SCTLD. This also corresponded with a paling/bleaching event at the site. SCTLD reappeared in early through mid-2020. Of all previously treated colonies plus all new SCTLD-affected colonies, 20% (January 2020), 25% (March 2020), and 40%

Figure 1: Proportion of treated corals across different coral species. During initial treatment efforts in 2019, numerous species were affected and treated. During the autumn 2022 outbreak, impacts were primarily constrained to *Pseudodiploria clivosa* colonies.



(May 2020) had SCTLD lesions. Another paling/bleaching event in August 2020 helped to clear up SCTLD, and

Figure 2: The number of newly treated corals (yellow bars), proportion of live corals (red line), and proportion of previously-treated corals with no signs of disease (green) line at Newfound Harbor since treatments began in 2019. After the 2019 and 2020 SCTLD peaks, the site remained largely disease free until June 2022. Disease during 2022 impacted primarily *Pseudodiploria clivosa* colonies from June to December, and showed signs of halting by January 2023.

from August 2020 through April 2022, SCTLD was essentially non-existent at the site. Across the 10 monitoring periods during this time frame, 97% or more of visited colonies were disease free (Figure 2).

A notable increase in the number of newly diseased colonies in June 2022 marked a resurgence in tissue mortality at the site. In that month, rapidly-progressing disease lesions were seen on 10 *Pseudodiploria clivosa* and 1 *P. strigosa*. Two months later, in August 2022, 90 newly diseased corals were tagged; 84 of them were *P. clivosa*. In October 2022, an additional 123 newly sick corals were tagged; 101 were *P. clivosa*. Disease began to wane by January 2023, with only 55 newly sick corals; 51 were *P. clivosa*. Throughout the outbreak, the *O. faveolata* at the site did not display signs of FLP-type lesions.

Disease lesion progression during this outbreak was rapid and often multi-focal, appearing much the same as SCTLD on *P. clivosa*. Lesions were observed progressing laterally across colonies as well as radiating out from center points. Often there was a brown film of tissue at the leading edge of the lesion, but this was easily detached with any water flow (Figure 3).

The majority of sick corals had never before been treated for SCTLD. In June 2022, the percentage of diseased corals which had been previously treated was 0%. In August 2022, it was 1% (which had first been tagged and treated two months prior). In November 2022, it was 44% (5 corals that had not been treated since either 2019 or early 2020 plus 40 corals first treated during this outbreak two months previously). And in January 2023, the percentage of sick corals which had been previously treated was 33% (15 corals treated during this outbreak and 2 which had not been treated since 2019/2020). In short, the disease was primarily impacting *P. clivosa* colonies that had never before been treated.

Sick corals were presumed to be SCTLD-affected and treated accordingly, with the standard amoxicillin + Base2b methods. Treatments during this outbreak were found to be largely ineffective. Of the 10 new colonies treated in

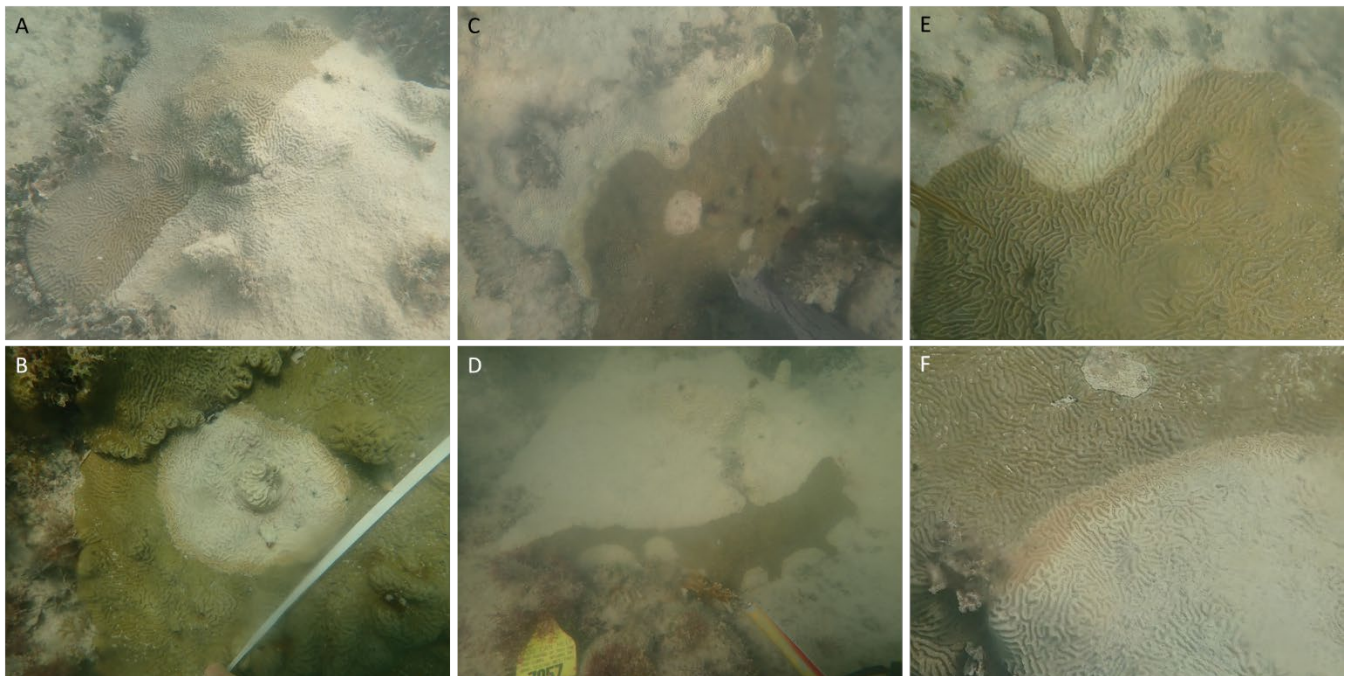


Figure 3: Images of disease-affected *Pseudodiploria clivosa* colonies at Newfound Harbor in October/November 2022. Lesions were seen progressing laterally across colonies (A), or radiating outwards from mid-colony points (B). Lesions could be individual on a colony (A&B), or could be multifocal (C&D). Lesions were delineated by a stark tissue margin (E), although in calmer water conditions a brown film, presumably of dead tissue, could be found over recently dead skeleton (F).

June 2022, 8 of them were dead or still sick two months later. Of the 84 new colonies treated in August 2022, 70 were dead or still sick two months later.

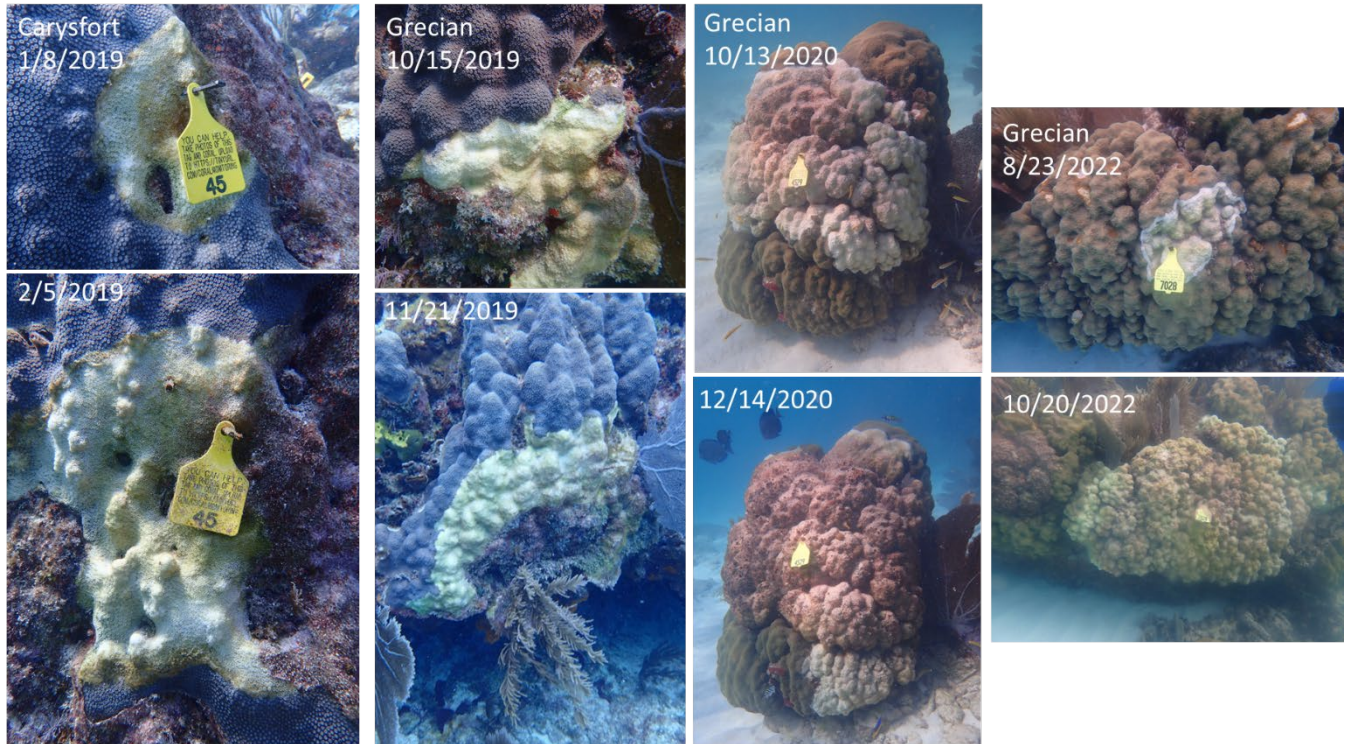
This outbreak began subsiding between November 2022 and January 2023. Many of the colonies first treated in November 2022 were visually healthy in January 2023. Photo analysis on a subsample of treatments showed that lesions did not necessarily halt at the treatment lines, but appeared to progress until some external force (potentially the first cold snap of the year which occurred during that time frame) halted them (Appendix II).

Similarities of this disease to SCTLD include the multi-focal nature and rapid progression of lesions across affected colonies. However, unlike SCTLD, this outbreak was largely constrained to *P. clivosa* and also showed a seasonality with lesions halting on their own in January 2023. We hypothesize this was an outbreak of *P. clivosa*-focused white plague, or some yet unidentified disease.

Recommendations:

- This outbreak appears to have been temporally and spatially constrained to fall 2022 at Newfound Harbor (although the dearth of *P. clivosa* colonies at other monitoring sites would make detection at other reefs difficult). The outbreak subsided in December/January. We suggest that no management action would be useful at this time.
- Should this outbreak repeat itself in the future, sampling of lesion-adjacent tissue may be useful for comparisons to SCTLD lesions, white plague lesions, or other potential similar diseases.
- Should the outbreak repeat itself in the future, we recommend authorization and funding for trialing alternate treatment types in an effort to increase the tools available for halting the suite of diseases seen on corals.

APPENDIX I: Examples of FLP progression across *O. faveolata* colonies, showing the extensive amounts of tissue which can be lost over short periods of time to these lesions.



APPENDIX II: Examples of disease progression across *Pseudodiploria clivosa* colonies at Newfound Harbor. For both colonies, disease lesions were treated in August 2022 and November 2022, but disease progressed past them. In January 2023, lesions had recently halted and were no longer causing mortality.

