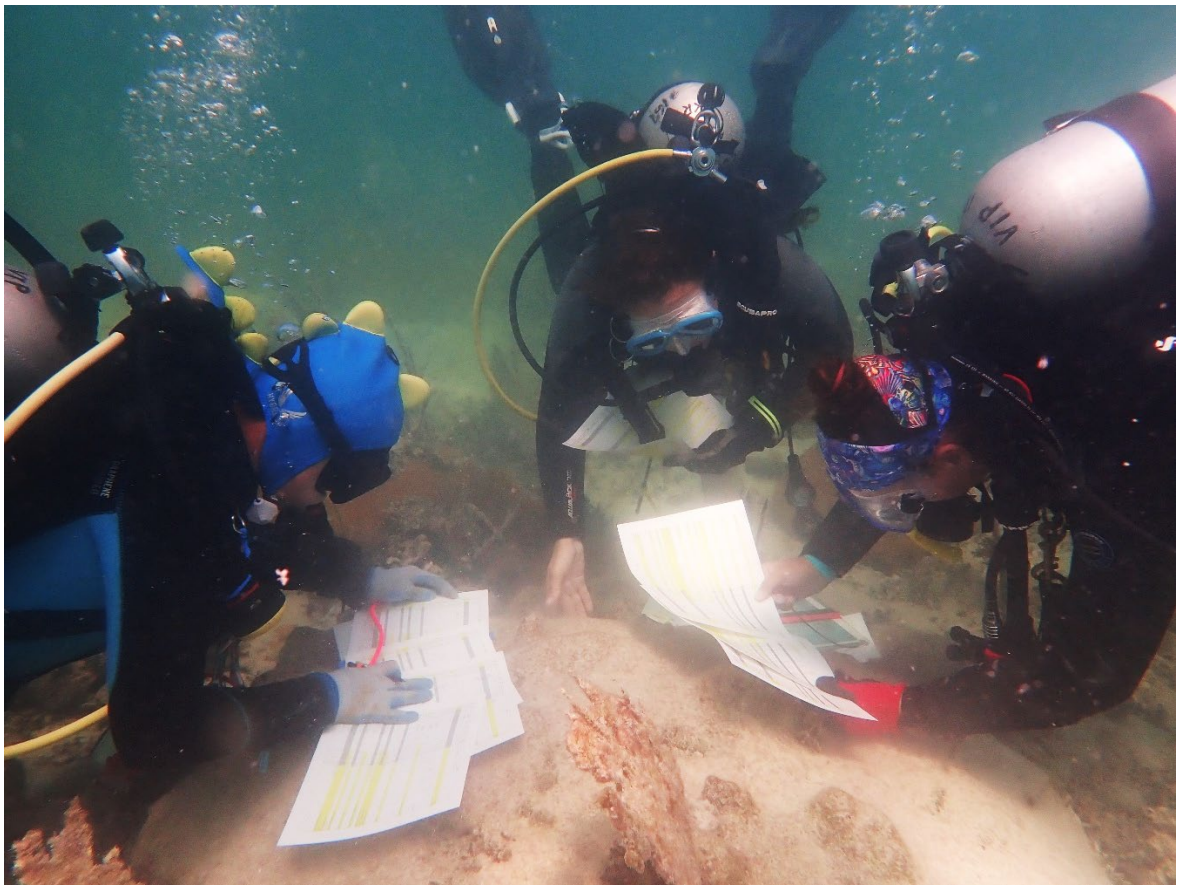
# Florida Keys Coral Disease Intervention Strike Teams



# Florida Keys Coral Disease Intervention Strike Teams

Final Report

Prepared By:

Karen Neely, Ph.D.

Nova Southeastern University

June 10, 2024

**Completed in Fulfillment of PO C22220 for**

**Florida Department of Environmental Protection**
**Coral Protection and Restoration Program**
**8000 N Ocean Dr.**
**Dania Beach, FL 33004**

**This report should be cited as follows:**
**Neely, KL. 2024. Florida Keys Coral Disease Intervention Strike Teams: Final Report. Florida DEP, Miami FL. vi + 9 pp.**

**This report was prepared for the Florida Department of Environmental Protection's (DEP) Coral Protection and Restoration Program by Nova Southeastern University. Funding was provided by the DEP Award No. PO C22220. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida or any of its sub-agencies.**

## Executive Summary

The Florida Keys Disease Intervention Strike Team was funded to treat and monitor SCTLD-affected corals during the 2023-24 fiscal year. Between July 1, 2023 and May 31, 2024, intervention work was conducted over 255 diver-days, including 784 dives and 1040 hours of underwater work. Over 246 acres of reef throughout the Florida Keys were surveyed every two months. During this time frame, a total of 283 newly infected corals were tagged, measured, mapped, photographed, and treated. Newly treated corals were from 10 species, with an average diameter of 131 cm. Additionally, 613 corals treated during previous years required new treatments. The estimated amount of coral tissue protected from SCTLD lesions during this fiscal year was 5421 $m^2$. This tissue area is equivalent to over 2.09 million outplants, the cost of which to raise and outplant is estimated to be between $21 million and $210 million.

The required regular monitoring of sites and corals through the intervention project has created an unprecedented patient history of known corals across sites, habitats, and species. Value-added components of this work have been to track the progression of SCTLD on known susceptible colonies through space and time, to follow large numbers of known colonies through the 2023 bleaching event, and to monitor species and temporal detail not picked up in other monitoring programs. Knowing the health histories of these colonies has also allowed us to identify a potentially novel disease (FLP – fast lesion progression), look at whether antibiotic resistant genes have developed through amoxicillin use, assess gametogenesis across health and treatment regimes, select highly susceptible colonies for probiotics testing, and select colonies for the Reef Resilience Consortium to determine potential factors influencing resistance to SCTLD. None of this work would be possible without the extensive efforts of tagging, monitoring, and keeping corals alive done to date.

In early May, 2024, FKNMS and Florida DEP announced they were not renewing SCTLD intervention permitting/funding within the Sanctuary. Whether the tags that identify the fate-tracked corals will be allowed to remain is still in question. Our primary recommendations are that the tags be allowed to remain, at least until further consideration can be given to the value and opportunities they continue to provide; removing them is akin to throwing out medical records. We also hope that managers will recognize the incredible value of intervention. For the first time in history, we have a tool that can actually prevent the mortality of the biggest, oldest animals in the world. Even with orders of magnitude more time and money than restoration has, these centuries-old organisms cannot be replaced, and their losses to a disease we can prevent from killing them is unconscionable.

**Acknowledgements**

We thank Florida Department of Environmental Protection and the National Fish and Wildlife Foundation for funding this work. All work was conducted under Florida Keys National Marine Sanctuary permits FKNMS-2020-077 and FKNMS-2019-177.

The NSU Disease Intervention lab members put in countless hours underwater as well as topside, and this work would not be possible without them. Michelle Dobler, Sami Miller, Arelys Chaparro, and Katy Toth conducted the work during this fiscal year, but many others have also contributed in past years. We also thank the entirety of the Florida coral disease response for collaborative efforts to move the science and conservation of SCTLD-affected reefs forwards.

# Table of Contents

# List of Figures



# List of Acronyms

**DEP:** Department of Environmental Protection
**FKNMS:** Florida Keys National Marine Sanctuary
**FY:** Fiscal year
**H&C:** Hen and Chickens reef
**KLDR:** Key Largo Dry Rocks reef
**QA:** Quality assurance
**SCTLD:** Stony coral tissue loss disease

Coral Codes:
**AAGA:** *Agaricia agaricites*
**CNAT:** *Colpophyllia natans*
**DLAB:** *Diploria labyrinthiformis*
**DSTO:** *Dichocoenia stokesii*
**MALI:** *Mycetophyllia aliciae*
**MCAV:** *Montastraea cavernosa*
**MLAM:** *Mycetophyllia lamarckiana*
**OANN:** *Orbicella annularis*
**OFAV:** *Orbicella faveolata*
**OFRA:** *Orbicella franksi*
**PAST:** *Porites astreoides*
**PCLI:** *Pseudodiploria clivosa*
**PSTR:** *Pseudodiploria strigosa*
**SBOU:** *Solenastrea bournoni*
**SINT:** *Stephanocoenia intersepta*
**SSID:** *Siderastrea siderea*

## 1. DESCRIPTION

The arrival and spread of stony coral tissue loss disease (SCTLD) throughout Florida's Coral Reef has had catastrophic impacts on corals and reef functionality. SCTLD has resulted in unprecedented mortality rates on a variety of susceptible species (Precht et al. 2016), has led to the functional extinction of at least one coral species in Florida (Neely et al. 2021a), and caused significant declines in coral density and percent coral cover (Walton et al. 2018).

Though the pathogen for SCTLD is to date unknown, antibiotics have proven effective at halting active disease lesions (Neely et al. 2020; Neely et al. 2021b; Shilling et al. 2021; Walker et al. 2021). The use of a topical paste is thus a management tool for preventing the mortality of corals and/or sites. Since 2019, the Florida Keys disease intervention strike team has developed and utilized methodology to treat SCTLD-affected corals within the Florida Keys National Marine Sanctuary to preserve iconic reefs and corals. This report outlines the work done during the 2023-2024 fiscal year, as well as provides a summary of all similar work to date.

## 2. METHODS

To conduct strike team work, a trained team of divers visited each FKNMS intervention site approximately every two months. Treatments were an amoxicillin and Base 2b paste developed and utilized since 2019. The use of this protocol was outlined in the 2019 QA plan (Neely 2019) and the Coral Disease Intervention Action Plan (Neely 2018).

During each visit to any reef site, the entire area was surveyed. At two sites (Sombrero Reef and Cheeca Rocks), all previously-treated colonies were actively visited and monitored for health status. At all other sites, the full area was surveyed, but only actively diseased colonies were prioritized for action.

At the full monitoring sites (Sombrero Reef and Cheeca Rocks), protocol were as follows:

- Search the entire area for SCTLD-affected colonies.
- Newly diseased coral colonies:
    - Place tag on or near the colony for follow up monitoring
    - Record data on the tag number, species, size, percent live cover, number of treatments applied, and location
    - Apply treatment to all active lesions
    - Take photos of the full coral colony and all lesions
- Previously treated/tagged colonies with active disease lesions:
    - Record data on the number of treatments applied, date, and tag number
    - Apply treatment to all active lesions
    - Take photos of the full coral colony and all new lesions
- Previously treated/tagged coral colonies that are dead:

    - Record date, location, and tag number
    - Take final photograph of the full coral colony
    - Remove tag and any nails.
- Previously treated/tagged coral colonies with no active disease:
    - Record data on colony health status (no active disease)
    - Take photographs of the full coral colony

At all other sites, protocol were:

- Search the entire area for SCTLD-affected colonies.
- For affected colonies that have previously been tagged, record the tag number as well as the number of treatments. Take photos of whole colony and lesions. Treat all active lesions.
- For affected colonies that have not previously been tagged: tag colony, collect information on size and percent live cover, map colony, take photos of full colony and all lesions, and treat all active lesions.
- Revisit approximately every two months.

Data on new corals and any coral monitoring data were entered into the intervention database, which is stored in an online cloud and remains continually accessible to FKNMS and DEP managers. These data are also presented as a deliverable to DEP twice per year. Information on the number, location, and species of treated corals are also uploaded to the FWC Intervention Dashboard (Florida Fish and Wildlife Research Institute 2019), a public-facing product that compiles and presents intervention information across all practitioners and regions.

The strike team was contracted for 225 person-on-water days. All work was conducted under Sanctuary permit FKNMS-2020-077.

## 3. RESULTS

### 3.1. Work Conducted: 2023-24 Fiscal Year

From July 1, 2023 through May 31, 2024, the Florida Keys Strike Team conducted 255 intervention-specific diver days, well above the 225 funded days. A total of 784 intervention/monitoring dives were conducted by strike team members, totaling 1040 hours of underwater work.

Across all intervention sites, over 246 acres of reef were surveyed every two months (Figure 1). These reef areas were Carysfort (North and South), Grecian Rocks, Key Largo Dry Rocks, Molasses, Hen and Chickens, Cheeca Rocks, Marker 48 mid-channel patch reefs, Sombrero Reef, Newfound Harbor, Looe Key, and Sand Key. Due to continually increasing number of corals to monitor as well as additional monitoring tasks mandated by FKNMS and DEP, we requested and were allowed to discontinue sites at which SCTLD prevalence had been low for at least a year. Molasses Reef was last visited in

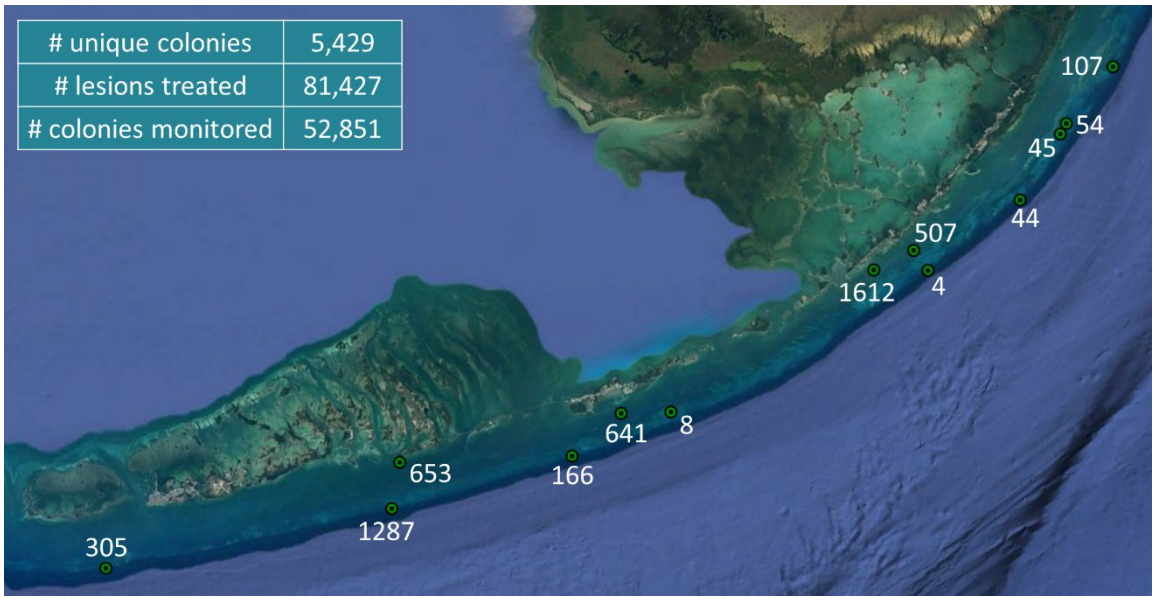



Figure 1. Map of the Florida Keys showing treated reefs. The total number of treated corals, lesions, and monitoring points are shown for the entirety of the strike team project (2019 – May 30, 2024).

July 2023, Sombrero Reef was last visited in December 2023, the Upper Keys offshore reefs (Carysfort, Grecian, and Key Largo Dry Rocks) were last visited in January 2024, and Newfound was last monitored in February/March 2024.

From July 1, 2023 through May 30, 2024, a total of 283 newly infected corals were tagged, measured, mapped, and treated across all sites. Newly treated corals were from 10 different species, had an average maximum diameter of 131 cm, and had an average percent live cover of 59%. The most commonly treated species were *Orbicella faveolata* (36%), *Colpophyllia natans* (29%), *Montastraea cavernosa* (15%), and *Orbicella annularis* (10%) (Figure 2a). The vast majority, 82%, of newly treated corals were located on inshore or mid-channel patch reefs rather than offshore reefs. Reefs with the highest numbers of newly treated corals were Cheeca Rocks (54%), Hen and Chickens (15%), the Marker 48 patch reefs (10%), and the offshore Looe Key (12%) (Figure 2b).

We estimate the amount of live coral tissue on treated colonies using the size measurements and percent cover assessments. The surface area of each colony is calculated as a hemisphere: 2π*height* (diameter/2). Surface area is then multiplied by the proportion of live tissue on the colony (% live cover / 100). Using these calculations, an estimated 1348 $m^2$ of live tissue on newly treated colonies was protected from active SCTLD lesions during this fiscal year. We can also estimate the restoration equivalency of these actions by multiplying the live tissue by the number of outplants required to reskin that area. We use an outplant density estimate of 385 outplants per $m^2$. As such, the number of outplants that would be needed to replace the tissue lost without intervention on newly diseased corals from July 1, 2023 to May 31, 2024 would be 518,798.

In addition to treating newly infected corals, in-water work also involves treating new lesions on previously-treated corals. From July 1, 2022 to May 30, 2023, 613 previously-treated corals required new treatments. The majority (53%) of corals requiring retreatments were *Orbicella faveolata* (Figure 2c), with *C. natans* being the second most retreated species (27% of the total). Cheeca Rocks and Looe Key had the most retreated corals (52% and 30% of the totals respectively) (Figure 2d). We can again estimate the tissue area saved via these retreatments and

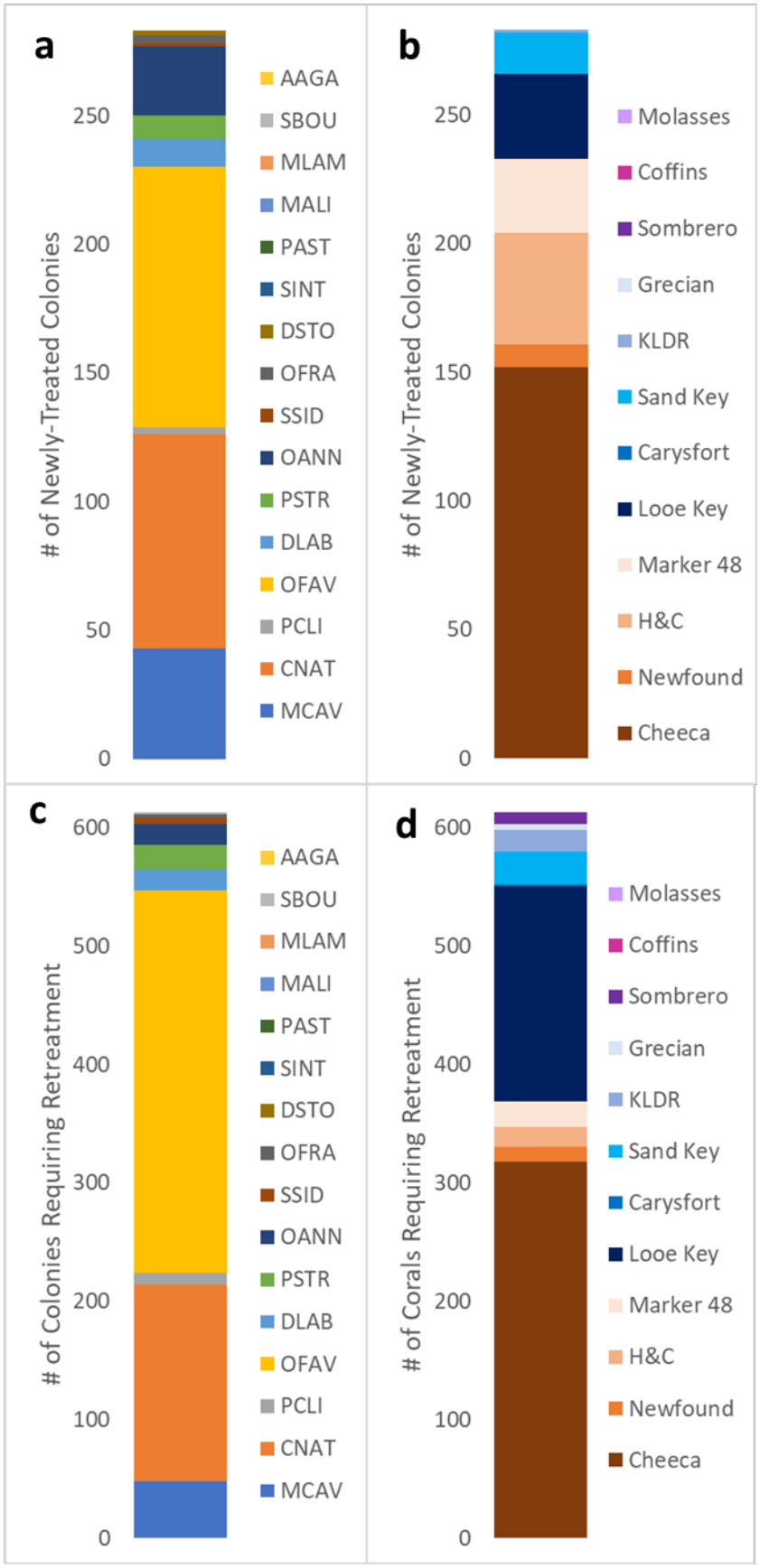



Figure 2. (a) Species distribution of the 283 newly-treated corals during the fiscal year. (b) Geographic distribution of the 283 newly-treated corals during the fiscal year. Offshore sites are in blue tones; inshore sites are in orange tones. (c) Species distribution of the 613 previously-treated corals requiring additional treatments during the 2023-24 fiscal year. (d) Geographic distribution of the newly-treated corals during the fiscal year. Offshore sites are in blue tones; inshore sites are in orange tones.

the restoration equivalency using the same formulas. The estimated tissue saved via these retreatment events is 4074 $m^2$, and the restoration equivalency 1,568,448 outplants. Many of these retreated colonies are extremely large *Orbicella faveolata*, which account for a substantial portion (79%) of these values.

### 3.2 Work Conducted Since 2019

Since late 2018, the Florida Keys disease intervention strike team has tagged, treated, and continually monitored 5,429 coral colonies within the Florida Keys National Marine Sanctuary. Treated corals were from 19 different species and averaged 108 cm in diameter. Of these corals, 759 exceeded 2m in diameter. In-water work since the project's inception has included 81,427 lesion treatments and 43,955 monitoring data points recorded. Accounting for treated corals across all years, 20.262 square meters of coral have been preserved from immediate disease-related mortality. The restoration equivalency of that tissue is over 7.8 million coral outplants.

### 3.3 Mortality and Reinfection Rates

Survival rates of corals up to 4 years after initial treatments averaged 90% (Figure 3). Brain coral mortality, which is generally 75%-100% for untreated colonies (Precht et al. 2016; Aeby et al. 2019; Thome et al. 2021) ranged from 20% (*P. strigosa*) to 34% (*D. labyrinthiformes*) on treated colonies. Mortality on colonies with slower lesion progression (*M. cavernosa* and *O. faveolata*) was only 4% and 3% respectively on treated colonies; mortality rates on untreated colonies at one year are around 20% (Williams et al. 2021). When new lesions are found on previously-treated corals, they generally appear within the first few months after the first lesions are treated and seen. If these new lesions are not caught in time, colony mortality is the frequent outcome. As such, it is not surprising that most mortality (7% of treated corals) occurs within the first eight months after disease is first observed on a coral.

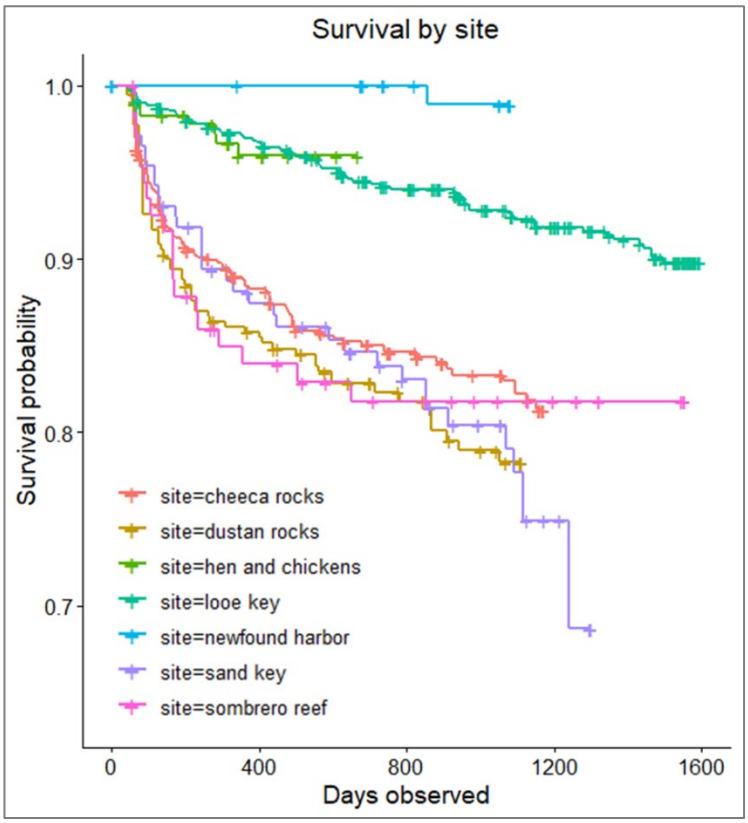



Figure 3. Mortality rates of treated corals, tracked every two months and treated for new lesions as needed. Figure: R. Nowicki.

We assessed what the probable fate of corals would be if they were only visited and treated as needed twice: initial treatment plus a follow-up visit at two months. Overall, we estimate that 36% of SCTLD-affected corals require only the initial treatment, and that 22% of corals would only need two treatments before no longer showing lesions for at least one year. Assuming all other corals would experience mortality, this two-visit regime would be expected to save 58% of treated corals. There are some species- and habitat-specific differences in these rates. Inshore corals are more likely to remain disease free after two visits (67%) than offshore corals (43%). There were also minor, but significant, species differences. *Orbicella annularis* were less likely than average to remain disease free regardless of habitat. At inshore reefs, *C. natans* were less likely than average to remain disease free, but *M. cavernosa* were more likely.

### 3.4 Value Added Components

Our regular, semi-monthly, visits to treated reef sites provided an unprecedented opportunity to track the impacts of the 2023 hyperthermal bleaching event throughout the FKNMS. The monitoring of fate-tracked colonies provided data at a temporal resolution and across rarer species that is unmatched by other Sanctuary-wide monitoring programs. We collected data on bleaching-related mortality and black band disease, as well as SCTLD, on over 4000 colonies at multiple time points through the event. We presented these data to the FKNMS Sanctuary Advisory Council, the Disturbance Advisory Council, and the 2024 Benthic Ecology Meeting. The results are currently in preparation for publication. In brief, we identified only two of the nine sites across the reef tract with any notable mortality through the bleaching event. Both sites were inshore patch reefs, and within those there were highly significant differences in mortality among the different species. The upcoming publication will highlight temperature-driven differences among sites, which suggests that sites with higher survival are not necessarily more resilient, but just driven by variations in temperature. It also highlights the species-specific differences in mortality which suggests which outplanted species would be most likely to survive future high-heat events. An NSF RAPID grant has been submitted to track these corals through the 2024 expected bleaching event to identify whether stochastic patterns or possible resistance patterns emerge among colonies.

During these semi-monthly surveys, we also observed a near or total extirpation of gorgonians on inshore reefs through the 2023 thermal event. As a part of this, we documented unusual behavior of basket stars utilizing bleached *O. faveolata* as daytime habitat. A note on these observations was published (Neely 2023b), and we hope to further examine the temporal recovery periods of these inshore gorgonians.

The foundation laid by these fate-tracked colonies has also facilitated multiple other projects and collaborations. By regularly observing fate-tracked *O. faveolata* across multiple sites, we were able to identify lesions that did not react to treatments or time the same way SCTLD lesions did, and used these observations to document a possibly novel disease (Neely 2023a) and set up a monitoring and sampling program to further assess. The health history of fate-tracked corals at two sites was also critical for setting up the Reef Resilience Consortium dataset which assesses colonies of varying susceptibility to

SCTLD; the first of many upcoming papers on these fate-tracked corals assessed the role of coral and symbiont genotypes in resilience (Klein et al. 2024).

We also were able to use health histories to identify colonies likely to reinfect and thus set up probiotics experiments in collaboration with the Smithsonian Institute; those results are being reported under their project deliverables. We also opportunistically collaborated with USGS and UF to collect samples looking at the presence of antibiotic resistant genes in healthy vs. treated corals; both projects identified no development of antibiotic resistant genes, and the publication is currently in peer review. Fate-tracked corals' histories were also used to develop an NSU-funded project to assess gametogenesis in healthy, diseased, and previously treated corals. The results identify treated corals as highly capable of producing gametes, and the manuscript is in peer review. These projects are all possible because of the corals saved and data collected by this strike team project.

## 4. DISCUSSION

### 4.1. Benefits of work conducted and management applications

By preventing the mortality of SCTLD-affected corals, the strike team has preserved many of the iconic corals and reefs of the Florida Keys. As a result of its in-water efficiency and high survival rate, intervention is an effective and relatively cost-efficient way to prevent mortality of the largest and oldest animals in Florida. On average, a coral takes approximately two minutes and $2 in materials to treat active lesions. The time and cost to replace a lost coral through restoration is orders of magnitude more. The surface area of coral preserved via Florida Keys intervention efforts since 2019 is estimated to be equivalent to approximately 7.8 million coral outplants. Costs of outplanting vary dramatically based on origin of fragments, type of nursery, rearing or grow-out time, and labor and boat costs, but we provide two bookends for restoration costs: $10 and $100 per outplant. At $10 per outplant, replacing the tissue saved via intervention from July 1, 2023 to May 30, 2024 would cost between $21 million (approximately 50x more than annual strike team costs). At $100 per outplant, replacement costs would be $210 million. For all efforts to date (2019-present), intervention efforts are equivalent to between $78 million and $780 million in restoration costs.

Survival rates of treated corals are approximately an order of magnitude greater than untreated corals as reported in other studies (Precht et al. 2016; Walton et al. 2018; Aeby et al. 2019; Neely et al. 2020; Thome et al. 2021; Williams et al. 2021). We identified that only a minority of corals require regular visitation in order to survive long term, and that most can be saved from SCTLD lesions with just one or two visits. As such, even moderate intervention efforts can be critical in preventing the continued loss of genetic diversity, species richness, and coral cover. Though SCTLD at most sites is not as prevalent as it once was, it does continue to have flare ups that cause notable loss of untreated corals. We know that bleaching has an inverse correlation with SCTLD progression (Meiling et al. 2020), which we saw across all sites during the 2023 bleaching event. However, SCTLD has returned to many monitored reefs, including a prevalence rate of 7% on susceptible species at Cheeca Rocks in May 2024. We estimate that in the absence of intervention, hundreds of corals, equivalent to hundreds of

thousands of outplants, at previously treated sites will experience preventable SCTLD-related mortality in upcoming months.

### 4.2. Recommendations

In May 2024, FKNMS and DEP stated they would not be renewing permitting or funding of intervention within the Florida Keys. They requested that coral identification tags be removed. We strongly recommend that these decisions be reconsidered, as they are likely to result in extreme and unnecessary loss of coral colonies, coral cover, species richness, and genetic diversity. These losses are expected to be particularly pronounced at some of the highest diversity and high coral cover sites where SCTLD has currently been observed in increasing prevalence. The impacts of the cessation of intervention, particularly at sites experiencing outbreaks, could easily be assessed with follow-up monitoring.

We also recommend that, whether intervention be allowed or not, the identifying coral tags be left in place for ongoing and future studies. These tags are the key features of a unique monitoring program, the only one in Florida that fate tracks myriad corals across a broad geographic range and, importantly, many species too rare to be picked up in standard transect monitoring. These corals have already provided numerous opportunities to answer questions requiring health history information, and have enormous potential to continue providing knowledge on reef status.

## 5. REFERENCES


Aeby G, Ushijima B, Campbell JE, Jones S, Williams G, Meyer JL, Hase C, Paul V (2019) Pathogenesis of a tissue loss disease affecting multiple species of corals along the Florida Reef Tract. Frontiers in Marine Science 6

Florida Fish and Wildlife Research Institute (2019) Coral Disease Intervention Dashboard https://arcgis/0L1LWX

Klein AM, Sturm AB, Eckert RJ, Walker BK, Neely KL, Voss JD (2024) Algal symbiont genera but not coral host genotypes correlate to stony coral tissue loss disease susceptibility among *Orbicella faveolata* colonies in South Florida. Frontiers in Marine Science 11:1287457

Meiling S, Muller EM, Smith TB, Brandt ME (2020) 3D Photogrammetry Reveals Dynamics of Stony Coral Tissue Loss Disease (SCTLD) Lesion Progression Across a Thermal Stress Event. Frontiers in Marine Science 7:597643

Neely K (2023a) Observations of rapidly progressing lesions on corals within the Florida Keys National Marine Sanctuary: a Quicklook report. AGRRA

Neely KL (2018) Coral Disease Intervention Action Plan. Florida DEP, Miami, FL 1-27

Neely KL (2019) QA plan for NSU/FORCE BLUE Disease Intervention Strike Teams. Florida DEP, Miami, FL 20 pp

Neely KL (2023b) Habitat shift of a basket star during a coral bleaching event. Marine Biodiversity 54:2

Neely KL, Macaulay KA, Hower EK, Dobler MA (2020) Effectiveness of topical antibiotics in treating corals affected by Stony Coral Tissue Loss Disease. PeerJ 8:e9289

Neely KL, Lewis CL, Lunz KS, Kabay L (2021a) Rapid Population Decline of the Pillar Coral *Dendrogyra cylindrus* Along the Florida Reef Tract. Frontiers in Marine Science 8

Neely KL, Shea CP, Macaulay KA, Hower EK, Dobler MA (2021b) Short- and Long-Term Effectiveness of Coral Disease Treatments. Frontiers in Marine Science 8

Precht WF, Gintert BE, Robbart ML, Fura R, van Woesik R (2016) Unprecedented Disease-Related Coral Mortality in Southeastern Florida. Scientific Reports 6:31374

Shilling EN, Combs IR, Voss JD (2021) Assessing the effectiveness of two intervention methods for stony coral tissue loss disease on *Montastraea cavernosa*. Scientific Reports 11:1-11

Thome PE, Rivera-Ortega J, Rodríguez-Villalobos JC, Cerqueda-García D, Guzmán-Urieta EO, García-Maldonado JQ, Carabantes N, Jordán-Dahlgren E (2021) Local dynamics of a white syndrome outbreak and changes in the microbial community associated with colonies of the scleractinian brain coral *Pseudodiploria strigosa*. PeerJ 9:e10695

Walker BK, Noren H, Buckley S, Pitts K (2021) Optimizing stony coral tissue loss disease (SCTLD) intervention treatments on *Montastraea cavernosa* in an endemic zone. Frontiers in Marine Science 8:746

Walton CJ, Hayes NK, Gilliam DS (2018) Impacts of a Regional, Multi-Year, Multi-Species Coral Disease Outbreak in Southeast Florida. Frontiers in Marine Science 5

Williams SD, Walter CS, Muller EM (2021) Fine scale temporal and spatial dynamics of the stony coral tissue loss disease outbreak within the lower Florida Keys. Frontiers in Marine Science