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Stony Coral Tissue Loss Disease - Special Issue

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Stony Coral Tissue Loss Disease – a major threat to Caribbean coral reefs, biodiversity and economies

Coral reefs are vitally important for biodiversity, the economies and livelihoods of local people, and entire countries in the Caribbean reliant on tourism. Corals are under threat from rising sea-temperatures, leading to coral bleaching, and ocean acidification. They are also subject to various diseases, exacerbated by the fact that they are already under pressure.

Stony Coral Tissue Loss Disease (SCTLD) is a relatively newly found disease which spreads rapidly and affects some of the slowest-growing and longest-lived reef-building corals, including the iconic brain corals, star corals and pillar corals that provide habitat, shelter and nursery areas for numerous other marine organisms. The loss of these corals affects overall coral reef health, tending to destroy the reef, and can have cascading impacts on the ecosystem services they provide – like food security, tourism economies, and coastal protection for local communities.



6-week time lapse of affected coral off St. Thomas, US Virgin Islands (Photo sequence Sonora Meiling, University of the Virgin Islands (in Martin, 2019))

Over the last six years, coral reefs in the Caribbean have been succumbing to the fatal SCTLD. UKOTCF's Wider Caribbean Working Group highlighted this problem in TCI earlier in 2020, in *eBulletins* 25 and 26

(see <https://www.ukotcf.org.uk/newsletters/wcwg-newsletter-1/>)

As Secretary of the Wider Caribbean Working Group, I was asked to pull together what is known about this growing threat to coral reefs in another *eBulletin*, which provides information and links to the current situation, and reviews the research on treatment options. Any errors in the presentation of the information I have found are my own, and if anyone has any other updates, further information or comments, I would be happy to receive them (apienkowski@ukotcf.org).

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Background

First noted in Florida in 2014, apparently a bacterial infection, SCTLD has spread throughout the Caribbean, possibly by water currents, fish and divers, although ballast water is also being considered as a likely cause of spreading.

Characteristic of this disease is that sick colonies display multiple lesions and quickly die. Highly susceptible species are the meandroid corals – i.e. pillar corals *Dendrogyra cylindrus*, elliptical star corals *Dichocoenia stokesii*, smooth flower corals *Eusmilia fastigiata* and maze corals *Meandrina spp.* Starlet corals that develop numerous “blotchy” lesions, as well as diverse brain and star (boulder) corals, are also dying fairly quickly, followed by star corals *Orbicella spp.*, *Montastraea cavernosa* and other coral species.

Scientists in Florida have been working intensively over the last six years to find effective treatments. This co-ordinated effort has included researchers from the Florida Department of Environmental Protection (DEP) and academic institutions such as the University of Florida and Nova Southeastern University. This article will consider these findings.

Tracking the Disease

One output from a workshop held in August 2019, in Key West, Florida, attended by Caribbean coral reef managers from 17 countries and territories, was the request for a Caribbean SCTLD dashboard.



Experts convene at Stony Coral Tissue Loss Disease Workshop, Key West – August 1-2, 2019

Photo credit – Gulf and Caribbean Fisheries Institute (GCFI)

Attendees at the workshop included Alizee Zimmerman, Turks & Caicos Reef Fund (TCRF), Roddy McCleod, TCI Department of Environment and Coastal Resources (DECR) and Ms. Argel Horton from the Ministry of National Resources, Labour and Immigration, British Virgin Islands. The workshop resulted in agreement to proceed using only amoxicillin paste. At the time of the workshop, the Cayman Islands were not affected [presence notified June 2020] and to date Anguilla, Bermuda and Montserrat have not reported SCTLD presence.

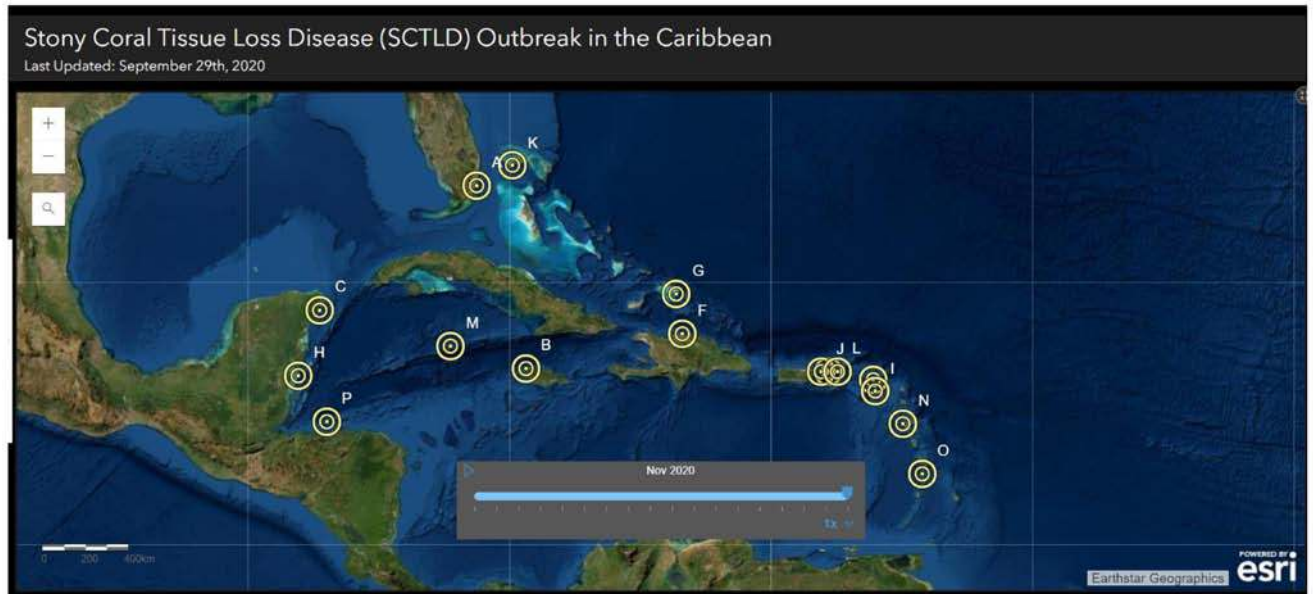
The dashboard has been produced by a collaboration between the Atlantic and Gulf Rapid Reef Assessment programme (AGGRA) and MPACConnect, a partnership between the Gulf and Caribbean Fisheries Institute (GCFI) and NOAA’s (National Oceanic and Atmospheric Administration, USA) Coral Reef Conservation Program. The dashboard provides summary information on the outbreak of SCTLD in the Caribbean and the regional efforts to respond to the disease.

The dashboard SCTLD Tracking Map is an interactive map that shows where SCTLD has been confirmed in the Caribbean. Sightings are submitted through the Online SCTLD Survey Form which then appears on the map as purple markers while the information is being thoroughly reviewed. Once reviewed, the markers turn green if SCTLD is not present/confirmed or red if presence of SCTLD is confirmed. Florida data is provided by Florida Fish

& Wildlife Research Institute.

The dashboard can be found here:

<https://www.agrra.org/coral-disease-outbreak/#sctld-dashboard>



A time-series of the first known appearances of the outbreak stage of SCTLD by location. To examine in more detail, go to the link and click on the play button arrow on the time lapse bar at the bottom of the map to see the time progression of the disease.

SCTLD Outbreaks: Date and Location (as shown on dashboard end September 2020)			
Year	Date	Location	Map ID
2014	November 18	Florida	A
2018	February 6	Jamaica	B
	July 3	Mexico	C
2019	November 22	Sint Maarten	D
	January 29	St Thomas - US Virgin Islands	E
	March 3	Dominican Republic	F
	Early March	Turks & Caicos Islands	G
	June 21	Belize	H
	August 13	Sint Eustatius	I
	December 23	Puerto Rico	J
	Mid December	Bahamas	K
2020	May 17	British Virgin Islands	L
	June 29	Cayman Islands	M
	June 9	Guadeloupe	N
	August 9	St Lucia	O
	September 25	Roatan, Honduras	P

What is being done?

The scientists in Florida have experimented with basically three types of treatment:

1. Apply antibiotic (amoxicillin) in a neutral base
2. Apply chlorine in an epoxy resin.

3. Apply six different natural products and placebos in a neutral base.

Treatments were combined with a “fire-break”, a cut in the coral separating healthy from diseased tissue.



*Nova Southeastern University graduate student Murphy McDonald uses an angle grinder to cut a “firebreak” to prevent the spread of disease on a diseased pillar coral *Dendrogyra cylindrus* at Sombrero Reef.*

Karen Neely, Nova Southeastern University

<https://www.the-scientist.com/news-opinion/as-disease-batters-florida-reefs--scientists-and-community-fight-back-65693>

*Firebreaking a coral for application of chlorinated epoxy and appearance of a treated coral showing treatments on the margins as well as the firebreaks.
In Neely et al 2019*



Trials at Sand Key, Florida, in October 2019 demonstrated that none of the natural products (non-antibiotic) and placebos halted disease.

		Pre-Treat	Treatment	1 month
Placebo	PSTR			
	DLAB			
	OFAV			
Amoxicillin	PSTR			
	DLAB			
	OFAV			

*Representative photos of placebo treatments and amoxicillin treatments. Species codes are: PSTR, *Pseudodiploria strigosa*; DLAB, *Diploria labyrinthiformes*; OFAV, *Orbicella faveolata*.*

Photos show the corals immediately before treatment was applied, immediately after treatment was applied, and one month after treatment. The exception is the “1-month” photo of the placebo DLAB (), which was taken two weeks after treatment; the colony was totally dead at one month*

Neely et al 2020

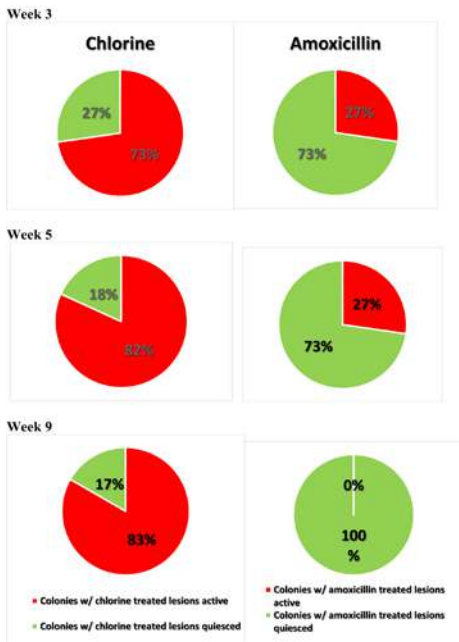
<https://peerj.com/articles/9289/>

A little earlier, an intensive study compared just the antibiotic and chlorine treatments, from January 2019. Large-scale field interventions, of approximately 100 in-water days, were conducted using the two methodologies: antibiotic paste and chlorinated epoxy. Subsequent monitoring showed chlorinated epoxy to be ineffective.

Most disease lesions progressed past both the margin treatment and the trench treatment within three months. [See photo and caption above for explanation of margin and trench.] Progression was particularly rapid on brain corals (*C. natans*, *P. strigosa*, *D. labyrinthiformes*), with 60% failure after 1 month and 95% failure after 3 months. But

complete failure was also high on *O. faveolata* (68%) and *M. cavernosa* (73%) after three months (from Keely 2020).

The results from the Florida experiments clearly demonstrate that the amoxycillin treatment is the most



effective. This is the conclusion of research, with funding of over \$1.5 million, over a period of six years. The disease is so virulent and fast acting that the most appropriate and effective action needs to be taken quickly.

Full results are presented in the final trials reports (Neely 2020, Neely et al 2020, Walker et al 2020). Briefly, only the amoxicillin treatment halted disease. Following the results, NOAA Florida Keys National Marine Sanctuary (FKNMS) staff authorized all surviving corals from the chlorine and natural product/placebo treatments then to be treated with Base2b + amoxicillin. In total, 21% of non-antibiotic treated corals had died before such retreatments occurred. Based on the evidence, one output from the August 2019 workshop in Key West was the agreement to proceed with treating SCTL D only with amoxicillin paste, in other locations.

From Voss et al 2019

Many research papers and reports from the Florida Department of Environmental Protection (DEP) can be accessed at:

<https://floridadep.gov/rcp/coral/content/coral-disease-response-completed-projects>

This extensive body of work includes protocols for the safe use of topical antibiotic treatment, and investigations into the effect of amoxicillin application on the marine environment. The quantity of antibiotics being introduced through SCTL D treatment has been compared to background levels and found to be low. Much higher levels of antibiotics result from release through sewage from Florida.

The use of antibiotics does raise concern about the risk of organisms developing antibiotic resistance. To minimize this risk, a highly concentrated dose of antibiotic is used. This approach is less likely to result in antibiotic resistance compared to multiple low doses. During the course of their study, there were no measurable or observed impacts associated with antibiotic use on the treated corals or surrounding organisms other than to halt disease progression. (Walker et al 2020)

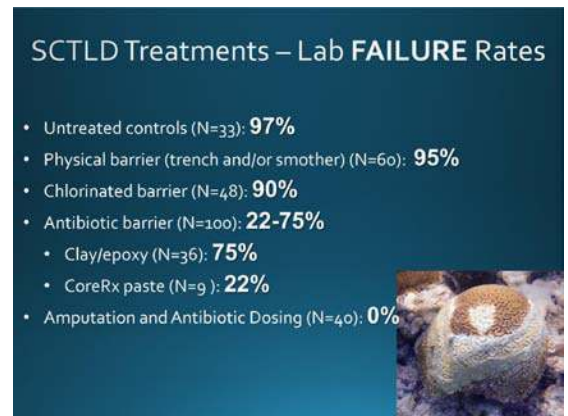
To further address concerns about using an antibiotic in the marine environment, as well as developing protocols for the use of antibiotics, the Florida team also experimented with non-antibiotic natural products, and placebos, which they found not to be effective (see results presented on page 4).

Other diseases

Some treatments of other diseases of corals with chlorine have been effective. In February 2018, coral disease was observed at the Killer Pillar dive site in the Seven Mile Beach Marine Park, Grand Cayman. By June 2018, nine individual colonies of *Dendrogyra cylindrus* were infected by a combination of black-band and white-plague coral disease. Within a few months, the disease had spread rapidly both within and between colonies of *D. cylindrus* leading to high levels of partial mortality and morbidity of the infected colonies. There is some evidence that white-plague disease is caused by a virus, whilst black-band disease is caused by cyanobacteria. The latter has been successfully treated with ordinary marine underwater epoxy putty, amongst other methods.

The results of this Cayman investigation can be found at:

<https://rettalbot.files.wordpress.com/2019/01/warrender-precht-reef-futures-poster.pdf>



From Doyle et al, 2019

UKOT approaches

The British Virgin Islands, working with colleagues in the US Virgin Islands, are treating SCTLD with amoxicillin paste.

The Cayman Islands Department of Environment is considering its options on treating the reefs impacted by SCTLD, including utilising antibiotics and probiotics like those used in the Florida infestation. Active monitoring is ongoing.

At the time of writing, SCTLD has not been reported from Anguilla, Bermuda and Montserrat.

In the Turks and Caicos Islands, the TC Reef Fund (TCRF), an NGO, in collaboration with and with permission from the TCI Government, has been conducting trials of treating infected corals using amoxicillin paste. These trials have demonstrated the efficacy of the amoxicillin treatment.

A montage (May 2020) of one of the corals treated with antibiotic on 7 March 2020 in TCI. Over 2 months later it had not succumbed and there were no new lesions.

The Turks and Caicos Islands Government's Department of Environment and Coastal Resources (DECR), under guidance from the UK Government's Joint Nature Conservation Committee (JNCC) from whom it sought advice, received funding from the UK Government for exploring the use of chlorine treatment, including a workshop in TCI delivered by Dr Greta Aeby. The comparative trial of amoxicillin (TC Reef Fund) vs chlorine (DECR) was started before the Covid shut-down. TC Reef Fund were able to continue and evaluate their trial when Covid restrictions eased, but DECR, despite being eager to do so, were unable to get back to their sites due to logistical and resource constraints. However, TCRF checked the DECR's chlorine test sites and found that the chlorine treatment had failed. A further grant from UK Government of £200,000 has recently been provided to DECR, which is being used to repeat their chlorine treatment trials, which were abandoned following Covid restrictions.



Other countries and territories currently using, or acknowledging the efficacy of, the amoxicillin treatment are: US Virgin Islands, Dominican Republic, Puerto Rico, Dutch Caribbean territories, Mexico, Belize, Guatemala, Honduras.

Other affected countries and territories, such as Bahamas, Jamaica, Saint Lucia and Guadeloupe have not yet reported carrying out any interventions.

Discussion

We may not yet have the perfect answer, but we do have an effective answer. This is the treatment with amoxicillin in a neutral base, the result of six years of research, at a cost of over \$1.5 million, in Florida. Stony Coral Tissue Loss Disease is so virulent, and kills corals so fast, that rapid effective treatment is necessary.



Stony Coral Tissue loss disease progresses rapidly once stony corals are infected. This coral lost 60% of its living tissue over the course of roughly a month.

Photos: Brian Reckenbeil, Florida Fish and Wildlife Conservation Commission.



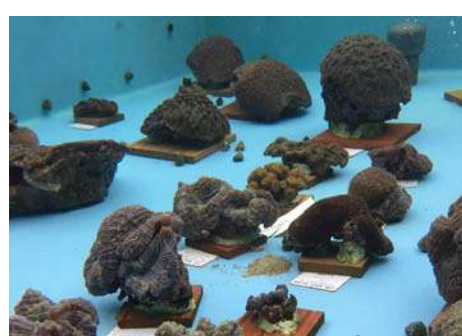
A Force Blue team treating an infected coral with amoxicillin paste.

A response priority has been active in-water intervention to treat diseased corals. As such, a collaborative coral disease response strike team was established between Nova Southeastern University (NSU) and FORCE BLUE, a non-profit organization composed of former elite combat divers who are retrained and deployed on missions of conservation.

However, *in-situ* treatment, even when very effective, is very expensive and time-consuming. For the long-term preservation of key reef-building species, in addition to treating with the antibiotic ointment, a species-survival programme for brain, maze, pillar and other susceptible species needs to be established. This would involve building a land-based nursery in which coral fragments from wild colonies can be housed and raised until the disease threat either passes or is under control, at which time the land-based nursery-raised corals could be used to repopulate these important reef-building species back on to the reefs. This is already being done in Florida and elsewhere throughout the Tropical Atlantic and Caribbean Region.



Florida Fish and Wildlife Conservation Commission coral scientist Stephanie Schopmeyer carefully chisels an elliptical star coral off a reef in the Lower Keys. The coral was taken back to the lab for captive breeding and future reef restoration. Florida Fish and Wildlife corals program.



Left: Dr Erinn Muller in the coral disease lab at Mote Marine Laboratory. Photo: Conor Goulding, Mote Marine Laboratory. Right: Corals mounted on terra cotta tiles at their new home at the Florida Aquarium's Center for Conservation in Apollo Beach. Florida Fish and Wildlife corals program.

And finally some observations from people in the field

The Association of Reef Keepers (the NGO which is leading the attack on the disease in BVI): “There are no words to describe seeing corals that have survived decades or even centuries wasting away. We treated 14 corals with antibiotics but our supply will run out pretty quick. Nine dive sites now show outbreaks with nine different coral species affected. Visitors will not want to see a lot of dead coral, and with a rapid increase of algal growth on the surfaces of dead corals, the potential for ciguatera [food-poisoning due to toxins in fish] will also increase.”

Karen Neely of Nova Southeastern University (in Jackson, 2019): “It is a huge disaster that’s going on underneath the waves, this is on the level of the Amazon burning. It is on the level of a disease that’s wiping out all of America’s forests.”

Lauren Toth of U.S. Geological Survey (USGS) (in Voosen, 2019). “How do we keep from losing what was built over the last 8000 years? Because we don’t have another 8000 years to rebuild it.”

Marilyn Brandt of the University of the Virgin Islands (in Jackson & Prentice, 2019). “I have never seen anything that affects so many species, so quickly and so viciously - and it just continues. All the diseases I’ve studied in the past could be considered like the flu. They come every year, seasonally, and sometimes there are worse outbreaks. This thing is more like Ebola. It’s a killer, and we don’t know how to stop it.”

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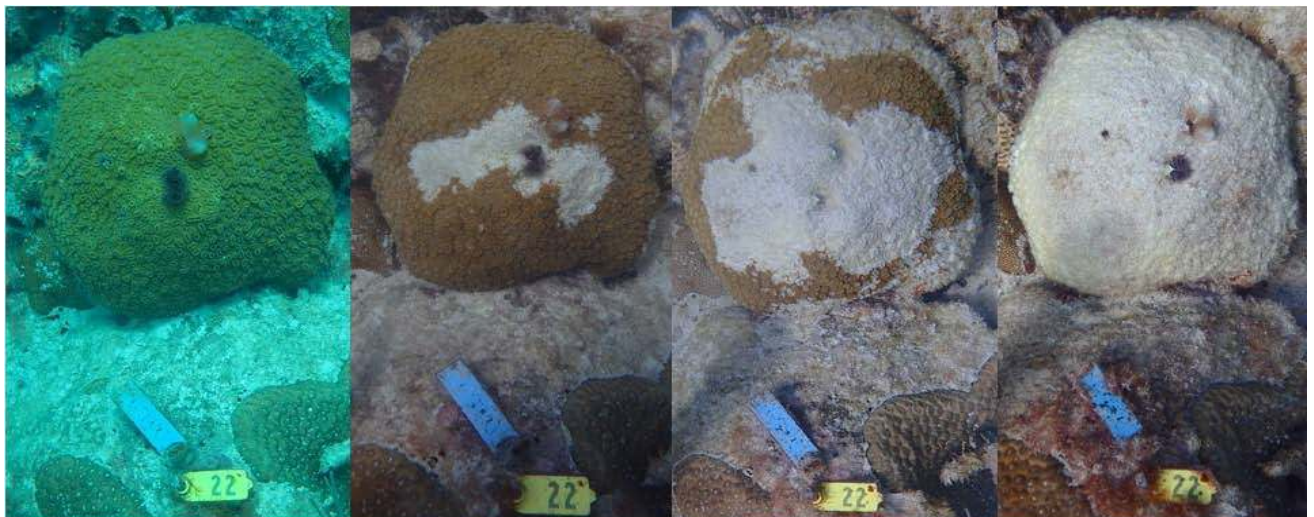
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March 1, 2018
99% Alive, 1% Old
Rapid Tissue Loss

March 18, 2018
89% Alive

April 5, 2018
35% Alive

April 19, 2018
0% Alive

Photo credit: Florida Fish and Wildlife Conservation Commission

***The speed of progression of Stony Coral Tissue Loss Disease, and the need for effective action, is illustrated by this photo sequence.
Photos: Florida Fish and Wildlife Conservation Commission***