Florida's Ongoing Coral Disease Outbreak: Current Status, Research, and Management Response

Brote de Enfermedad de Coral en Curso en Florida: Estado Actual, Investigación y Respuesta de Manejo

Épidémie de Maladie de Corail en Floride: État Actuel, Recherche et Réaction de la Direction

MAURIZIO MARTINELLI
Florida Sea Grant – Biscayne Bay Environmental Center,
1277 Northeast 79th Street, Miami, Florida 33138 USA.
mmartinelli1@ufl.edu

EXTENDED ABSTRACT

Disease is increasingly recognized as a major driver of coral community structure (Aronson and Precht 2001; Harvell et al. 2007). Coral disease can significantly alter reef benthic communities and, in extreme cases, lead to ecological phase shifts (Aronson and Precht 2001; Maynard et al. 2015). Coral disease may be as influential as thermal bleaching in the coming decades (Maynard et al. 2015), a position supported by the severity of the ongoing coral disease outbreak along the Florida Reef Tract (FRT). The following extended abstract describes the status of the outbreak, key research findings, and the management response.

In fall 2014, several reports were made of unusually prevalent coral disease affecting multiple species off the coast of Miami-Dade County. Increases in both the number and geographic distribution of reports suggested that a widespread coral disease outbreak was underway. In the years since, the coral disease outbreak has spread to the northern extent of the FRT in Martin County and southward to the Lower Keys of Monroe County (Figure 1). Ongoing observations suggest that the disease – termed Stony Coral Tissue Loss Disease (SCTLD) by local researchers – has become endemic in long-impacted

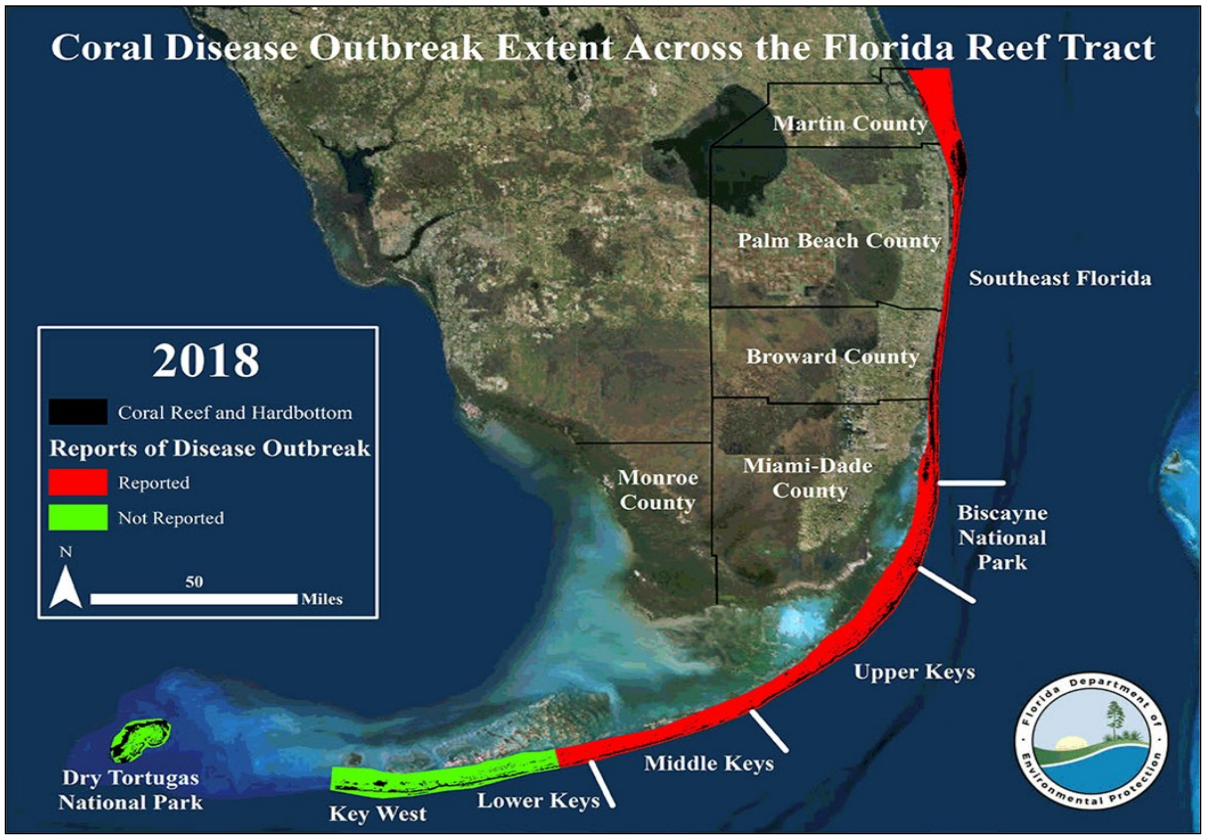

Figure 1. Map of the spatial extent of the Stony Coral Tissue Loss Disease (SCTLD) outbreak in Florida as of 2018. Red denotes coral reef habitats where observations of SCTLD have been made since the beginning of the outbreak in 2014. Best available information suggests that the disease is continuing to spread into areas where SCTLD has not yet been observed, denoted in green.

areas while continuing to spread to unimpacted reefs. There have also been reports of very similar disease signs on reefs in Mexico, Jamaica, and Sint Maarten, but researchers lack the diagnostic tools to confirm with certainty whether the diseases are related to SCTLD.

In Florida, SCTLD is known to affect roughly 26 species (Table 1) – over half of the scleractinian species found along the FRT. Among those impacted are five species listed as Threatened pursuant to the Endangered Species Act and major framework building corals. Researchers have categorized the impacted species according to susceptibility: highly susceptible species are the first to exhibit disease signs on an affected reef and experience rapid tissue loss (in some cases, 20 - 40 cm^2 per day) while intermediately susceptible species express disease signs somewhat later and usually experience slower tissue loss (in some cases, 5 - 10 cm^2 per day) (Sharp and Maxwell 2018); species of unknown susceptibility have been observed with STCLD but there are insufficient data to accurately describe susceptibility. The temporal progression through species (Sharp and Maxwell 2018) is one of the key features that can be used to distinguish SCTLD from other, similarly appearing coral diseases.

Two additional factors that contribute to the severity of the SCTLD outbreak are the species-specific disease prevalence and mortality rates. Researchers have documented disease prevalence of 66 - 100% of colonies of susceptible species at monitoring sites and, historically, SCTLD had a near 100% mortality rate of colonies showing disease signs (Ruzicka 2018). High prevalence and mortality rates have led to the near extirpation of some species from long-impacted regions (Walton et al. 2018). Since summer 2018, however, there has been a slowing of disease progression both in terms of the outbreak advancing through the Lower Keys and tissue loss across colonies monitored in the Middle Keys (Sharp and Maxwell 2018). Whether this trend will hold is yet to be seen, but for now this presents a welcome glimmer of hope for Florida's remaining susceptible corals. Regardless, the tenure of the outbreak, number of species affected, prevalence rates, and frequency of whole colony mortality has led to significant changes in coral community structure in impacted areas (Walton et al. 2018).

Several key research findings contribute to our understanding of SCTLD epidemiology and etiology. Laboratory transmission experiments demonstrate that SCTLD is transmissible both among and between susceptible species, and transmission can occur both via direct contact between colonies and through sterile sea water (Ushijima et al. 2018). Due to the effectiveness of *ex situ* antibiotic treatments, researchers believe that a bacterial pathogen(s) is involved in some stage of SCTLD infection. This is supported by the isolation of several strains of pathogenic bacteria from SCTLD affected specimens, including the coral pathogen *Vibrio coralliilyticus* (Ushijima et al. 2018). However, histological investigations have uncovered crystalline inclusion bodies in SCTLD affected tissue that appear similar to those created by viral infections (Landsberg et al. 2018) or pesticide exposure. Research into the pathology, etiology, and epidemiology of SCTLD is ongoing.

Due to the severity and persistence of the SCTLD outbreak, a response has coalesced among management authorities, academia, conservation practitioners, non-governmental organizations, veterinarians, and engaged citizens. The response is led by three agencies: the Florida Department of Environmental Protection, the Florida Fish and Wildlife Conservation Commission, and the National Oceanic and Atmospheric Administration. Under the leadership of these agencies, ten Response Teams work to address priority focus areas: management, research and epidemiology, reconnaissance and intervention, coral rescue, restoration trials, data management, communications, citizen engagement, and international cooperation. Members of these teams also comprise a technical advisory body that reviews project proposals and reports and which serves as an open forum for discussion of pertinent issues.

Two important components of the response have been disease treatments and a coral rescue effort. Numerous disease treatments have been tested *ex situ* that aim to stabilize SCTLD affected colonies and reduce pathogen loads. Two treatments that have shown some success are the topical application of chlorine and the topical application of amoxicillin. These two treatments have since been applied in the field to varying degrees of success and are being used in comparative experiments both in Southeast

Table 1. List of scleractinian coral species known to be impacted by Stony Coral Tissue Loss Disease (SCTLD) in Florida. The species are categorized according to susceptibility: highly susceptible species are the first to exhibit disease signs on an affected reef and experience rapid tissue loss, intermediately susceptible species express disease signs after the highly susceptible species and often experience slower tissue loss, and species of unknown susceptibility have been observed with STCLD but there are insufficient data to accurately describe susceptibility. Common names of the corals are included within parenthesis.

Highly susceptible species	Intermediately susceptible species	Unknown susceptibility
Colpophyllia natans (Boulder brain)	*Montastraea cavernosa* (Great star)	*Agaricia agaricites* (Lettuce)
Dendrogyra cylindrus (Pillar)	*Orbicella annularis* (Lobed star)	*Agaricia fragilis* (Fragile saucer)
Dichocoenia stokesii (Elliptical star)	*Orbicella faveolata* (Mountainous star)	*Favia fragum* (Golfball)
Diploria labyrinthiformis (Grooved brain)	*Orbicella franksi* (Boulder star)	*Helioseris cucullata* (Sunray lettuce)
Eusmilia fastigiata (Smooth flower)	*Siderastrea radians* (Lesser starlet)	*Isophyllia rigida* (Rough star)
Meandrina meandrites (Maze)	*Siderastrea siderea* (Massive starlet)	*Isophyllia sinuosa* (Sinuous cactus)
Pseudodiploria strigosa (Symmetrical brain)	*Solenastrea bournoni* (Smooth star)	*Madracis arenterna* (Pencil)
Pseudodiploria clivosa (Knobby brain)	*Stephanocoenia intersepta* (Blushing star)	*Mussa angulosa* (Spiny flower)
		Mycetophyllia sp. (Cactus)
		Scolymia spp. (Disk)

Florida and the Florida Keys. However, neither of these approaches represents a holistic treatment (i.e., they treat a disease lesion but not the whole colony) and reinfection of treated colonies can occur. As such, researchers are working to improve the long-term success of these treatments and to develop novel interventions that can be applied at a larger scale. In response to the limited treatment options for this disease, a coral rescue operation has begun: colonies of susceptible species are collected from unimpacted areas to preserve some of the remaining genetic diversity. These colonies are then distributed among land-based care and propagation facilities to serve as the basis for future restoration efforts.

The current responses are important for short-term mitigation of disease impacts but it is imperative that the large-scale drivers of reef decline and coral disease are addressed. Globally, rising temperatures and coral bleaching have been tied to increases of coral disease incidence, prevalence, and severity (e.g., Selig et al. 2013). Locally, chronic poor water quality and land-based sources of pollution are recognized as serious threats to south Florida reefs and eutrophication (e.g., Kaczmarsky and Richardson 2011), sedimentation (Pollock et al. 2014), and freshwater runoff (Haapkylä et al. 2011) can be drivers of coral disease. Addressing these and other stressors will be crucial to providing Florida's corals an opportunity to persist in the face of severe impacts like the current outbreak of SCTLD.

KEYWORDS: Coral, disease, management

LITERATURE CITED

Aronson, R.B. and W.F. Precht. 2001. White band disease and the changing face of Caribbean coral reefs. *Hydrobiologia* **460**:2 - 38.

Haapkylä, J., R.K. Unsworth, M. Flavell, D.G. Bourne, B. Schaffelke, and B.L. Willis. 2011. Seasonal rainfall and runoff promote coral disease on an inshore reef. *PLoS One* **6**(2):e16893. Correction issued 8 March 2011: https://doi.org/10.1371/annotation/365162ee-3718-44ce-b2e9-88302d5e0801

Harvell, D., E. Jordán-Dahlgren, S. Merkel, E. Rosenberg, L. Raymundo, L., et al. 2007. Coral disease, environmental drivers, and the balance between coral and microbial associates. *Oceanography* **20** (1):172 - 195.

Kaczmarsky, L. and L.L. Richardson. 2011. Do elevated nutrients and organic carbon on Philippine reefs increase the prevalence of coral disease? *Coral Reefs* **30**(1):253 - 257.

Landsberg, J., Y. Kiryu, P. Wilson, N. Perry, Y. Waters, and L Huebner [2018]. *Disease Lab Analyses Update*. [Unpubl.] Presentation to the Florida Reef Tract Coral Disease Coordination Call #13, December 2018, Miami, Florida.

Maynard, J., R. van Hooidonk, C.M. Eakin, M. Puotinen, M. Garren, et al. 2015. Projections of climate change conditions that increase coral disease susceptibility and pathogen abundance and virulence. *Nature Climate Change* **5**:688 - 694.

Pollock, F.J., J.B. Lamb, S.N. Field, S.F. Heron, B. Schaffelke, et al. 2014. *Sediment and Turbidity Associated with Offshore Dredging Increase Coral Disease Prevalence on Nearby Reefs*. *PLoS One* **9** (7):e102498. Correction issued 1 November 2016: https://doi.org/10.1371/journal.pone.0165541

Ruzicka, R. [2018]. *Brief Overview and Preliminary Synopsis of Coral Loss Due to the Coral Disease Outbreak in SE FL and Florida Keys: CREMP and SECREMP Results*. [Unpubl.] Presentation to the Florida Reef Tract Coordination Call #11, January 2018, Miami, Florida.

Selig, E.R., C.D. Harvell, J.F. Bruno, B.L. Willis, C.A. Page, K.S. Casey, and H. Sweatman. 2006. Analyzing the relationship between ocean temperature anomalies and coral disease outbreaks at broad spatial scales. Pages 111-128 in: J.T Phinney, O. Hoegh-Guldber, J. Kleypas, W. Skirving, and A. Strong (Eds.) *Coral Reefs and Climate Change: Science and Management*. American Geophysical Union. Washington, D.C. USA.

Sharp, B. and K. Maxwell. [2018]. *Investigating the Ongoing Coral Disease Outbreak in the Florida Keys: Collecting Corals to Diagnose the Etiological Agent(s) and Establishing Sentinel Sites to Monitor Transmission Rates and the Spatial Progression of the Disease*. [Unpubl.] Florida Department of Environmental Protection, Miami, Florida. 26 pp.

Ushijima, B., C. Häse, V. Paul, and G. Aeby,. [2018]. *Pathogen Isolation Update.* [Unpubl.] Presentation to the Florida Reef Tract Coral Disease Coordination Call #12, April 2018, Miami, Florida.

Walton, C.J., N.K. Hayes, and D.S. Gilliam. 2018. Impacts of a Regional, Multi-Year, Multi-Species Coral Disease Outbreak in Southeast Florida. *Frontiers in Marine Science* **5**(323).