Stony Coral Tissue Loss Disease

A PRESENT AND GROWING THREAT TO

CORAL REEFS

K. NEELY, NSU

Sea Grant Florida

NOAA CORAL REEF CONSERVATION PROGRAM

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Funded by NOAA's Regional Collaboration Network and the Southeast and Caribbean Regional Team (SECART)

What is Stony Coral Tissue Loss Disease?

STONY CORAL TISSUE LOSS DISEASE (SCTLD) is a highly lethal, infectious disease that has devastated coral reefs throughout Florida and the wider Caribbean in recent years. First detected off Miami's coast in 2014, the disease affects many important reef-building coral species and has high rates of mortality. Indeed, once infected corals begin to lose living tissue, many will die within weeks to months without active intervention. Experts believe this may be the most lethal coral disease ever recorded.[1] While extensive efforts are now underway to treat sick corals, understand the disease's origins, rescue coral diversity, and restore reefs, more needs to be done if we are to protect the region's remaining reefs and ensure they are resilient and sustainable for future generations.

CORAL REEFS

What are coral reefs?

Coral reefs first formed around 500 million years ago, making them one of the oldest ecosystems on the planet.[2] Often dubbed "the rainforests of the sea," coral reefs are incredibly productive ecosystems[3] that provide critical resources — such as medicine, food, and coastal protection — to over 500 million people around the world.[4] Notably, chemicals found on coral reefs have been used to treat infections, viruses, and cancer.[5] Indeed, we are 300-400 times more likely to find new medical treatments from reef ecosystems than we are from land-based ecosystems,[6] despite the fact that they only cover 0.2% of our oceans.[7]

In addition to benefiting human health, coral reefs support a quarter of all marine life by providing shelter for fishes, crustaceans, and other animals.[8] The incredible biodiversity found on coral reefs supports economically important tourism, recreation, and commercial fishing industries. In 2007, coral reefs across the United States generated an estimated $1.04 billion from tourism and commercial fishing industries alone, with a total economic value of $3.1 billion.[9] Healthy reefs also shelter coastlines from waves and flooding, absorbing 97% of wave energy and preventing waves from reaching the shoreline.[10] The protection from storms provided by coral reefs nationwide is estimated to be greater than $1.8 billion annually.[11]

Unfortunately, approximately half of the world's corals have been lost since the 1970s, which, in turn, means they have lost half of their capacity

DID YOU KNOW?

Protection from storms provided by coral reefs nationwide is estimated to be greater than $1.8 billion annually

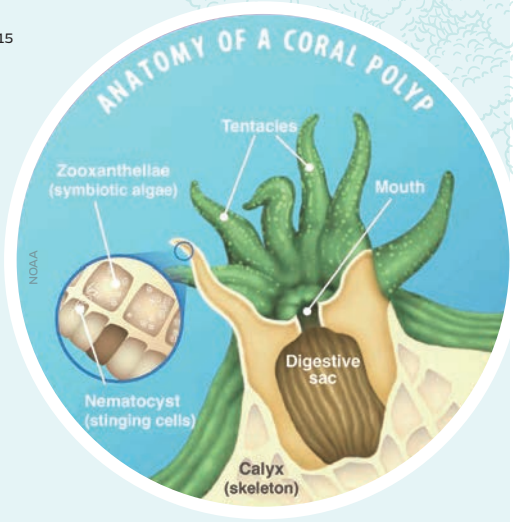
to provide us benefits and resources.[12] The deterioration of coral reefs is due to a confluence of local and global stressors. Local threats like development, pollution, marine debris, and unsustainable fishing have caused a reduction in coral diversity and abundance. A loss of herbivores on coral reefs has led to a subsequent increase of algae, which then outcompete corals.[13] Despite the severity of impacts from local factors, climate change has precipitated the most significant decline in reefs in recent decades. Rising air temperatures are warming ocean waters faster than ever before, leading to large-scale bleaching events[12] where heat-stressed corals expel the photosynthetic algae that give them color and provide them with food. The impacts wrought by climate change could cause a loss of 90% of all tropical corals within one hundred years,[14] making them one of the most vulnerable ecosystems on the planet.[15]

WITHIN THE NEXT 100 YEARS, CLIMATE CHANGE COULD CAUSE THE LOSS OF UP TO 90% OF TROPICAL CORALS

What makes a coral reef?

CORALS ARE LIVING, OCEAN-DWELLING ANIMALS

Each coral colony is made up of small, identical coral polyps. Wherever corals make up the foundation of an underwater habitat, a coral reef occurs. Coral reefs are complex marine ecosystems that include diverse collections of colorful fish and other sea creatures. But what is it that allows coral to grow and support so much life?



1 CORAL COLONIES ARE MADE OF MANY POLYPS

A coral colony is comprised of many individual coral animals known as coral polyps. These polyps, no bigger than a nickel in size, are the building blocks of each coral colony as they eat, reproduce, grow and recover if ever injured.

2 CORALS BUILD CORAL REEFS

Some corals build skeletons from calcium carbonate in seawater. The skeleton not only gives corals their structure, but it also provides the architecture for the coral reef overall.

3 CORAL REEFS PROVIDE FOOD AND SHELTER

With small animals seeking shelter in coral and herbivorous fish keeping coral clean of nuisance algae—coral lies at the heart of a complex food web system that also allows marine life to thrive.

New medical treatments are 300 to 400 times more likely to come from reefs than land

The **total economic value** of coral reef services for the U.S. is over $3.4 billion each year

Coral reefs support a **quarter of all marine life**

IMPACT

How is SCTLD affecting coral reefs?

Like humans, corals are susceptible to a variety of diseases. Unfortunately, disease has been taking an increasingly high toll on the health of corals in recent years, particularly in South Florida and the Caribbean region. Scientists believe that worsening water quality, climate change, and rising ocean temperatures are behind this increase; as climate change continues, diseases will become deadlier and more corals will become susceptible.[16] SCTLD is considered one of the most lethal disease outbreaks among corals in modern history.[17] First detected in September 2014 off the coast of Miami, Florida, the disease spread like wildfire along Florida's Coral Reef and starting in 2017, throughout the wider Caribbean. As of September 2022, SCTLD has been detected in 25 countries and territories.[18] The damage wrought by SCTLD has been unprecedented.

Relative to most other coral diseases, SCTLD is deadlier, affects more species of corals, spreads faster, and persists in the environment for longer periods of time. While other coral diseases may affect between two and five species,[19] SCTLD affects at least 30 species of Caribbean corals, targeting those that are most important for building the stony foundation that characterizes coral reefs.[17] The high number of susceptible species means that this disease can be found on 44-100% of corals at any given reef site,[19] a higher prevalence percentage than all other coral diseases combined. Once SCTLD is spotted on a coral, it spreads rapidly, and can kill an entire large coral colony that took decades to grow within weeks, whereas other diseases may progress a few centimeters every month.[19] The damage caused by SCTLD is further compounded by lack of areas of refuge from the disease, as even corals in deeper waters do not appear immune.[20]

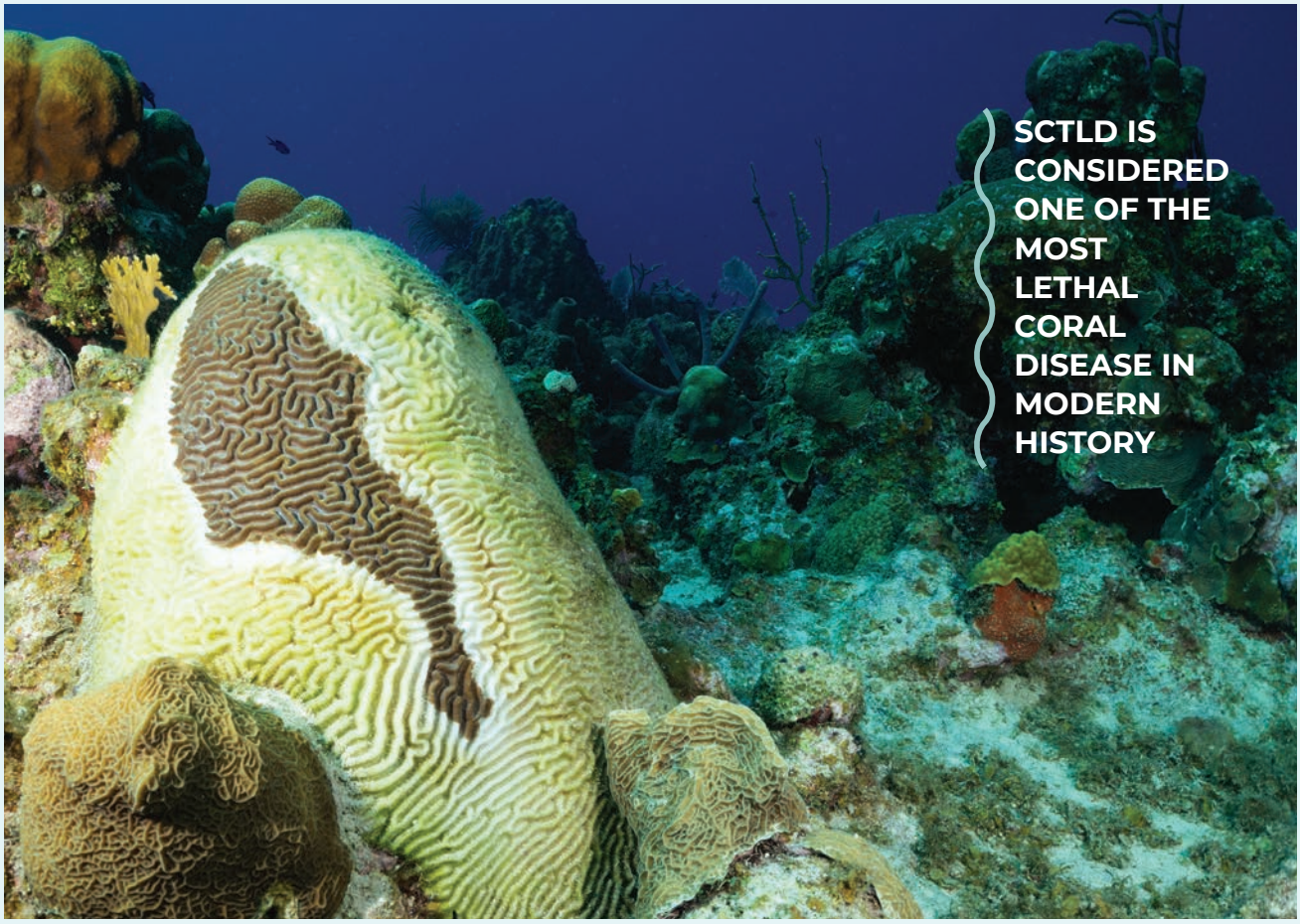
BELOW: After infection with SCTLD, two stony corals develop disease lesions that leave behind only the coral skeleton

SCTLD IS DECIMATING STONY CORALS, THE BUILDING BLOCKS OF CORAL REEFS, THROUGHOUT FLORIDA AND THE CARIBBEAN

Because of its prevalence, long tenure, and wide geographic pervasiveness, SCTLD has left an undeniable mark on coral reefs throughout the Atlantic and Caribbean. Since its first observation in 2014, the disease has spread along the entire 350-mile expanse of Florida's Coral Reef,[21] with a loss of up to 60% coral coverage and significant decline in species diversity documented in some areas over just a few short years.[22] This 60% loss is in addition to significant declines in Florida's reefs since the 1970s.

In 2020, the National Oceanographic and Atmospheric Administration released a status report for Florida's Coral Reef, classifying the reef tract as impaired in its ability to function and provide its many benefits.[23] The disease has had a similar impact in the U.S. Caribbean. In the U.S. Virgin Islands, the disease encircled the shores of St. John, St. Thomas, and St. Croix in just two short years, with some sites having already lost half their coral coverage.[24,25] The disease has also caused a 50% mortality on Puerto Rico's reefs, where it was

Relative to most other coral diseases, SCTLD is **deadlier, affects more species** of corals, **spreads faster,** and **persists** in the environment for longer periods of time.



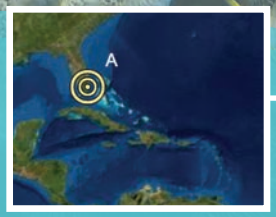
first detected in late 2019.[26] While other diseases and stressors such as coral bleaching contribute to reef decline, SCTLD has decimated reefs at an unparalleled rate, leaving a profound mark on Atlantic and Caribbean coral reefs. It is important to note that while corals can recover from bleaching if proper environmental conditions return, they cannot recover from SCTLD without active intervention and restoration.

Given these factors, it is clear that SCTLD will have dramatic impacts on the health, diversity, and species composition of coral reefs in the Atlantic and Caribbean for decades to come. It will also impact the ability of reefs to provide key ecosystem goods and services that coastal communities and economies depend on. Coral loss impacts reef fish populations that depend on coral habitat and decreases the amount of fish caught on reefs even when fishing effort increases.[11] Decreased coral coverage due to SCTLD may also put coastlines at a greater risk for storm damage. Fewer live coral reefs means less effective absorption of wave energy. Reef degradation could cause $1 billion in flood damage annually by 2100.[27]

SCTLD will have dramatic **impacts on the health, diversity, and species composition** of coral reefs in the Atlantic and Caribbean for decades to come.

SCIENTISTS ARE CALLING SCTLD "THE MOST DEADLY CORAL DISEASE WE HAVE EVER ENCOUNTERED

SCTLD Progression throughout the Caribbean



1 LOCATION
NOVEMBER 2014

4 LOCATIONS
NOVEMBER 2018

February 1, 2019

February 21, 2019

March 3, 2019

Understanding SCTLD

In just a short amount of time, scientists have made great strides in understanding how SCTLD spreads, confirming that it can be transmitted directly through contact with sick corals and indirectly through methods like ocean currents and sediment.[28,29] For example, research indicates that disease-associated microbes may reside in sediments, which has implications for port expansion and dredge projects.[30] While these methods of transmission can explain the movement of the disease locally (e.g., how the disease spread along Florida's Coral Reef), they cannot explain how the disease has moved across greater distances (e.g., from Florida to Jamaica, where the disease was first detected in the Caribbean).[16]

The way SCTLD has spread throughout the wider Caribbean suggests that human activities may play a role in transmitting the disease.[31] Indeed, a recent study shows that ballast water — water stored in a ship's hull to provide stability — may be transmitting the disease when ballast water or sediment potentially contaminated with SCTLD is discharged near coral reef ecosystems.[32]

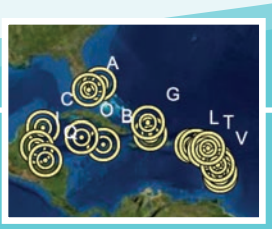
Despite remarkable advances in SCTLD research, scientists are still working to understand the relationships with environmental factors and have not been able to pinpoint what is causing the disease. The fact that antibiotic paste can stop disease progression on sick corals suggests the disease has a bacterial component.[28] However, scientists are also investigating the role viruses may play, hypothesizing that the underlying cause could potentially be a virus that attacks zooxanthellae, the symbiotic algae that lives within corals.[33]

EVIDENCE SUGGESTS THAT HUMAN ACTIVITIES MAY PLAY A ROLE IN TRANSMITTING THE DISEASE

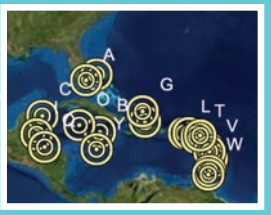
At different times and in different locations, various environmental factors (e.g., temperature fluctuations and freshwater flow) appear to influence disease dynamics. Because the exact cause(s) remains unknown, there is currently no diagnostic test for the disease.

12 LOCATIONS
DECEMBER 2019

18 LOCATIONS
OCTOBER 2020



22 LOCATIONS
OCTOBER 2020



25 LOCATIONS
APRIL 2022

CONSERVATION

How are we protecting our coral reefs from SCTLD?

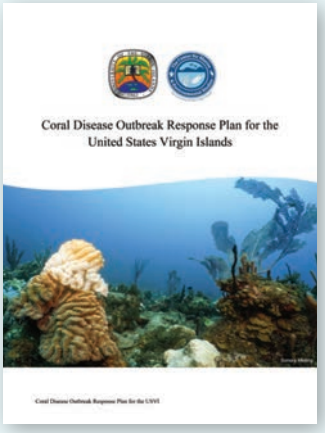
Regional Response

Fortunately, there is reason for hope. In response to the threats posed by SCTLD, a massive collaboration has emerged among scientists, resource managers, universities, nonprofits, aquariums, and citizens across the globe. In Florida alone, over 100 projects have been funded, including research focused on identifying the underlying cause of the SCTLD, the methods by which it spreads, novel treatment methods, and the environmental conditions that may be associated with the disease.

Because SCTLD spreads rapidly, early detection is key. Surveillance efforts can help identify corals showing signs of SCTLD, triggering intervention techniques such as the application of antibiotic paste. To date, in U.S. waters alone over 30,000 corals have been treated for SCTLD[34,35,36] using antibiotics with high rates of success.[37] However, it is important to note that while successful, the application of antibiotics is also time and resource intensive and multiple treatments may be needed to halt the spread of disease lesions. Scientists are also researching alternative treatments, such as probiotics, that can be used to help prevent corals from becoming infected.[38] By better understanding the causes of the disease and creating a framework for effective surveillance and intervention, coral managers and practitioners are advancing innovative strategies to protect imperiled coral reefs.

Although Florida was ground-zero for SCTLD, it also emerged as a global leader in SCTLD research, rescue, and restoration efforts. When the disease front in Florida started moving north and south along Florida's Coral Reef, disease responders quickly developed and implemented a plan to rescue vulnerable corals ahead of the disease boundary. With a goal of preserving genetic diversity for 19 important coral species, nearly 2,000 corals have been removed from Florida's reefs and are now housed in over 20 zoos and aquariums across the country in a public-private partnership with the Association of Zoos and Aquariums.[39] This massive rescue effort has allowed for the preservation of over 900 genotypes, providing managers with an opportunity to restore future generations of corals that may be more resilient to environmental stressors and disease.[36]

SCTLD was first observed in the U.S. Virgin Islands in January 2019 and since then has progressed throughout the entire USVI. In response to the detection of SCTLD, the Virgin Islands Coral Disease Advisory Committee (VI-CDAC) was created to facilitate a rapid and coordinated response to the emergence of SCTLD.




S. MEILING

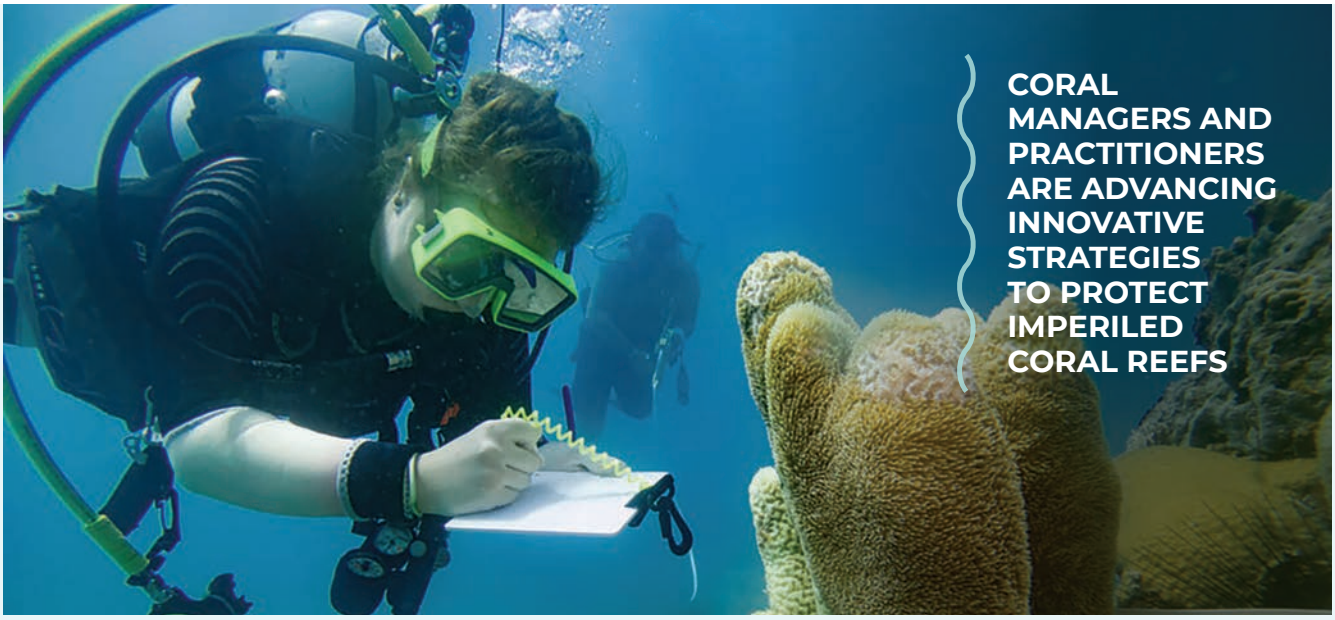
DISEASE SURVEILLANCE


J. SNYDER

ANTIBIOTIC TREATMENT


VI CDAC 3/26/2021

TRIALING PROBIOTIC PREVENTION



CORAL MANAGERS AND PRACTITIONERS ARE ADVANCING INNOVATIVE STRATEGIES TO PROTECT IMPERILED CORAL REEFS

One of the first actions taken by the VI-CDAC was organizing a learning exchange with members from Florida's response team to cover topics of treatment, data management, communications, and research. Later, through a series of workshops, the VI-CDAC developed a formal response plan that strategically defines priorities for the territory, including maximizing the amount of corals treated on affected reefs and developing a coral rescue program for species significantly impacted.[40] Coral rescue efforts led by Coral World Ocean and Reef Initiative Inc. and the University of the Virgin Islands are already underway as corals with active SCTLD lesions are being removed from the reef, housed in land-based nurseries, and then treated and rehabilitated.

In Puerto Rico, the disease was first documented in Culebra in November 2019, and has since quickly spread from east to west. Following initial trials done by Sociedad Ambiente Marino, the Puerto Rico Department of Natural and Environmental Resources (DNER) started applying treatments at several sites and continues today with the cooperation of partners. On August 30, 2021 the Governor of Puerto Rico, Lic. Pedro Pierluisi Urrutia, issued an executive order declaring an ecological emergency for SCTLD and allocated $1 million for key response activities. Through collaborative efforts the DNER developed an emergency response plan that focuses on short-term activities like treatment and longer-term activities like coral rescue and restoration.[41]

Though many coral reefs worldwide have experienced heavy losses in the last 50 years, coral reefs are resilient and have the ability to recover if stressors are reduced. Innovative restoration techniques and intervention methods can help increase survival and number of live corals on the reef, allowing them to spawn and help build back the reefs that sustain life both above and beneath the sea.

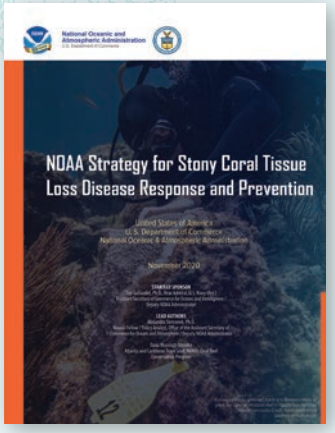
COLLECTING CORALS

CORAL RESCUE

RESTORING SUSCEPTIBLE CORALS

National Response

At the national level, efforts are underway to increase coordination of response, prevention, and preparedness efforts. In December 2020, NOAA published its Strategy for SCTLD Response and Prevention, which aims to expand capacity to respond to the disease outbreak in the Atlantic-Caribbean region and to slow the outbreak by unifying regional efforts under a NOAA response framework that is national in scope. It also highlights strategies to prevent and prepare for the potential spread of SCTLD to the Indo-Pacific region.

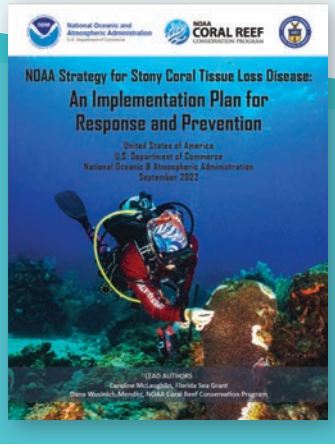


In response to the Strategy, in early 2021 a national coral disease coordinator was hired in a partnership position between NOAA's Coral Reef Conservation Program and Florida Sea Grant to establish cross-jurisdictional coordination. In October 2022, NOAA published an Implementation Plan for its Strategy. The plan outlines a detailed, five-year course of action for SCTLD response and prevention, building on goals and agency priorities identified in NOAA's strategy.

In response to the growing threat posed by coral disease, the U.S. Coral Reef Task Force established a Coral Disease Working Group to provide support for local response, mitigation, and prevention efforts, and enhance coordination among activities occurring at the national level. With more than 50 members representing federal and jurisdictional agency staff, the Working Group has prioritized initiatives focused on communication and collaboration, the development of national SCTLD priorities, support for response in affected jurisdictions, disease preparedness in the Indo-Pacific region, and the prevention of further transmission of the disease.

Coordinated Response

To support response efforts in affected jurisdictions, efforts are underway to enhance coordination across Florida, Puerto Rico, and the U.S. Virgin Islands, helping to identify information and resource gaps and facilitate increased communication. NOAA is supporting an annual U.S. Regional Caribbean Workshop that brings together response teams from Puerto Rico and the U.S. Virgin Islands to facilitate shared learning and the development of joint strategies to build response capacity. Finally, NOAA and Florida's Fish & Wildlife Conservation Commission are leading efforts to implement an SCTLD Research Audit that will help catalog existing SCTLD data from research, surveillance, and intervention activities, and identify important gaps.



The Implementation Plan for NOAA's SCTLD Strategy outlines a detailed, five-year course of action for SCTLD response and prevention

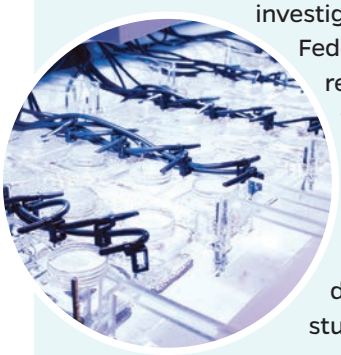
NOAA'S SCTLD IMPLEMENTATION PLAN HIGHLIGHTS KEY ACTIONS NECESSARY TO PROTECT CORAL REEFS FROM SCTLD OVER THE LONG-TERM

ARI HALPERIN/FWRI

PREVENTION & PREPAREDNESS

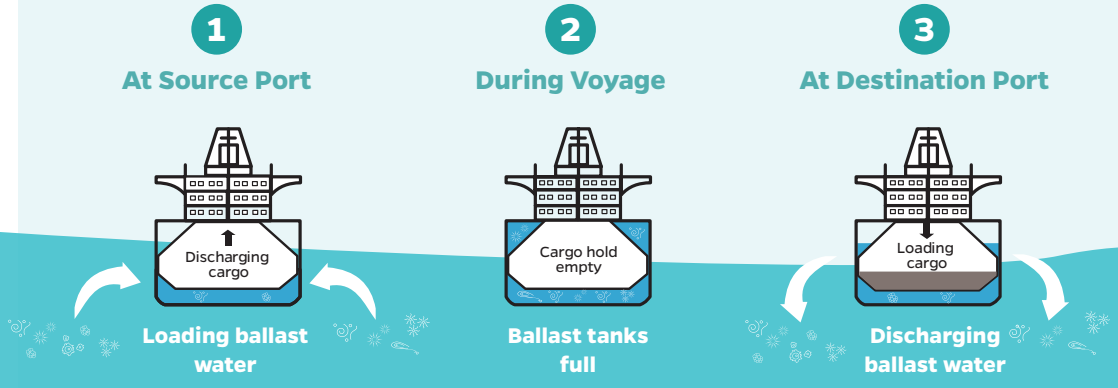
Preventing Disease Transmission

Shipping activities have been identified as a common pathway for the introduction of non-native marine species into a new region,[42,43,44] and scientists suspect that they may play a role in spreading SCTLD across wider geographic scales.[31] In 2019, the U.S. Environmental Protection Agency led an analysis of ballast water discharge and management records within the context of SCTLD reports to investigate a potential relationship. Federal, state, and university researchers are still working to better understand the relationship between vessels and disease transmission and identify strategies for preventing further spread of the disease. These efforts include studies evaluating how long SCTLD may remain infectious in ballast water, whether UV sterilization systems present on many vessels can reduce the threat of disease spread, and whether biofilms, or the biological material on ship's hulls, can serve as a potential vector. A recent study indicates that SCTLD pathogens can indeed persist in both untreated and UV-treated ballast water, and thus that ballast water may pose a risk in continuing to spread the disease.[45] The U.S. Coast Guard has assembled an SCTLD Task Force dedicated to increasing ballast water discharge compliance and is working to develop a risk profile that identifies high-risk vessels transiting from the Atlantic/Caribbean region to the Pacific. In 2019, the U.S. Coast Guard released a Marine Safety Information Bulletin that included a series of voluntary best management practices aimed to limit the transmission of SCTLD.[46]



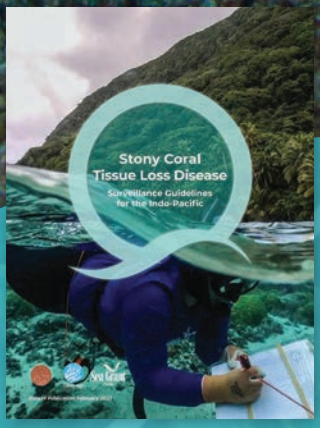
Preparing the Pacific

If SCTLD is indeed spread via the movement of vessels, it is possible for the disease to spread west from the Caribbean through the Panama Canal and into the Pacific Ocean. SCTLD has not yet been detected in the Indo-Pacific and the likelihood of the continued spread of the disease westward is unknown. However, given the scale of devastation caused by the disease in the Atlantic/Caribbean region, it makes sense for the Pacific to be prepared. To promote SCTLD preparedness in the Indo-Pacific region, the U.S. Coral Reef Task Force Coral Disease Working Group has established a Pacific Preparedness Team to generate resources, facilitate trainings, and share lessons learned from the Atlantic and Caribbean with coral managers and practitioners from Hawai'i, American Samoa, Guam, and the Commonwealth of the Northern



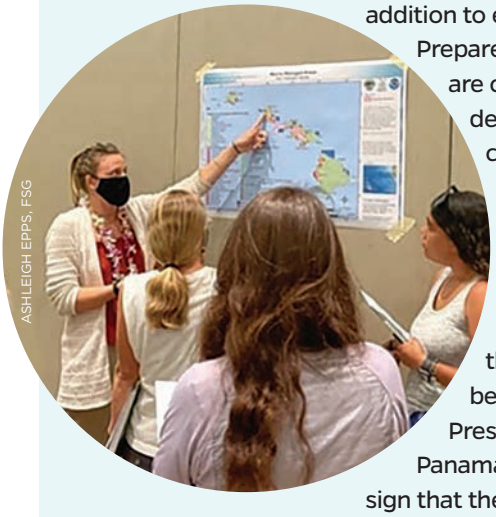
SCTLD HAS NOT YET BEEN DETECTED IN THE INDO-PACIFIC REGION. THE LIKELIHOOD OF THE CONTINUED SPREAD OF THE DISEASE WESTWARD IS UNKNOWN.

JEFFREY KUWABARA, UHM



The Pacific Preparedness Team generates resources, facilitates trainings, and shares lessons learned from the Atlantic and Caribbean with coral managers and practitioners from Hawai'i, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands to help advance SCTLD preparedness planning.

Mariana Islands. The team recently published SCTLD Surveillance Guidelines for the Indo-Pacific region and has hosted several workshops focused on preparedness, surveillance planning, and options for intervention. In addition to efforts by the Pacific Preparedness Team, experiments are currently underway to determine whether Pacific coral species are susceptible to this new disease. Moreover, plans are in the works to coordinate with partners in Panama to ensure Panamanian reefs in the Atlantic and Pacific are being monitored for SCTLD. Presence of the disease in Panama would be an early warning sign that the disease is moving west towards reefs in the U.S. Pacific.



ASHLEIGH EPPS, FSG

A Path Forward

Stony coral tissue loss disease may well be the most severe threat American coral reefs have ever faced, and will continue to shape their composition and ability to support marine wildlife and coastal communities for decades to come. It is critical to prioritize actions that will slow the progression of the disease, prevent its spread to the Indo-Pacific, and promote active protection and recovery along affected reefs. The following actions provide a clear path forward for disease response, prevention, and preparedness efforts.

- **Expand research and data collection:** Enhance capacity for collaborative research and data collection that will 1) advance our understanding of the disease, 2) identify effective intervention techniques, and 3) improve decision-making.
- **Stop the spread of the disease:** Prevent the spread of SCTLD to the Pacific and unaffected Atlantic/Caribbean reefs and limit the reinfection of corals in the Atlantic and Caribbean region. Advance preparedness and response planning for unaffected Pacific jurisdictions.
- **Preserve coral cover and biodiversity:** Save priority corals, such as those that form large boulders contributing to reef structure and those that are rare or endangered, by increasing the scope of treatment and intervention activities on affected reefs. Promote the preservation of genetic diversity via coral rescue.
- **Restore ecosystem health and resilience:** Advance coral restoration that accounts for the impacts of SCTLD. Improve reef health by reducing other stressors to coral reefs like pollution, unsustainable fishing practices, and climate change and by building ecosystem resilience.
- **Increase capacity for response and prevention:** Enhance capacity by growing partnerships, increasing collaboration and communication, and securing additional resources (funding and people) to support disease response and prevention efforts.

Ultimately, these actions must occur in tandem with efforts to reduce chronic stressors affecting reefs so that corals can build resilience to future threats and disease outbreaks. Large-scale, collaborative actions that mirror the severity of the threat posed by this disease must be taken to protect coral reefs and preserve the benefits they provide for humans now and for future generations.

Large-scale, collaborative actions that mirror the severity of the threat posed by this disease must be taken.

SOURCES

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