Estimating Coral Population Losses Across the Florida Reef Tract due to Stony Coral Tissue Loss Disease

Estimación de las pérdidas de población de corales en el tramo de arrecifes de Florida debido a la enfermedad de pérdida de tejido del coral pedregoso

Estimation des pertes de populations de coraux dans l'ensemble du récif de Floride en raison de la maladie de perte de tissus des coraux pierreux

JENNIFER STEIN[1], ROB RUZICKA[1], STEPHANIE SCHOPMEYER[1], COLIN SHEA[1], AND MIKE COLELLA[1]
[1]*Florida Fish and Wildlife Commission/Fish and Wildlife Research Institute, 100 8th Avenue SE, St. Petersburg, FL 33701, Jennifer.Stein@MyFWC.com, Rob.Ruzicka@MyFWC.com, Stephanie.Schopmeyer@MyFWC.com, Colin.Shea@MyFWC.com, Michael.Colella@MyFWC.com)*

EXTENDED ABSTRACT

With predicted increases in ocean temperatures under climate change, the prevalence of marine diseases and the frequency of coral bleaching events is also expected to increase. Coral mortality associated with thermal stress and disease outbreaks is of paramount concern. Coral disease outbreaks have played an extensive role in transforming the face of Caribbean reefs during the last half century (Aronson and Precht 2001, Jackson et al. 2014, Miller et al. 2009). However, a rise in the frequency, intensity, and severity of disease outbreaks has been attributed to the cumulative impact of numerous anthropogenic stressors intertwined with consequences of climate change which compromises the coral's immune response making it more vulnerable to disease (Maynard et al., 2015).

Over the past eight years, Florida's Coral Reef has been experiencing an unprecedented coral disease outbreak, referred to as Stony Coral Tissue Loss Disease (SCTLD). First documented in 2014, lesions associated with SCTLD started appearing on multiple species in reefs adjacent to Miami-Dade County, FL. Since then, SCTLD has spread across the entire reef tract, including the Dry Tortugas. The disease can be virulent causing acute tissue loss on highly susceptible species, but also be chronically present infecting less-susceptible coral species for months to years after the initial arrival of the disease. Lesions have been confirmed on >20 species of corals (Aeby et al. 2019) with devastating consequences for the most vulnerable species because infection often leads to complete colony mortality.

Previous large scale mortality events on corals have only been quantified using percent coral cover, which is a spatial estimate of change, rather than a population estimate. To understand the ecological significance of coral decline, or recovery, population data are needed that quantify species abundances and size-class distributions (Meesters et al. 2001).

For this study, we utilized Coral Reef Evaluation and Monitoring Project (CREMP), Southeast Florida Coral Reef Evaluation and Monitoring Project (SECREMP), and Disturbance Response Monitoring data collected between 2011 and 2020 to examine SCTLD outbreak impacts on the stony coral community of Florida's Coral Reef from Broward County to the Lower Keys. CREMP and SECREMP are fixed site monitoring programs, while DRM uses random site selection. Incorporating both types of monitoring programs in an analysis is beneficial, as fixed-site data is better suited for estimating temporal trends (like the change rate) while the random-site data are better used for estimating spatial patterns. The specific objective of this study was to calculate a fixed mortality rate for five SCTLD-susceptible species on the FRT by reef strata and to examine ecological impacts to the stony coral community based on the total loss of colonies.

To model and quantify the number of corals killed for each species, we performed three steps. In Step 1, using data from the fixed-site monitoring programs, we estimated pre- and post-SCTLD densities for each region-reef zone grouping. This data was calculated from 1,440 transects. By dividing the post and pre-disease densities, we can calculate a ratio or rate of change.

Step 2, using data from the random-site monitoring programs, we calculated pre-SCTLD densities calculated from 2,021 transects. We used data aggregated between 2012 and prior to the arrival of SCTLD for each of the four regions to estimate the pre-SCTLD population size. Those pre-SCTLD densities are then multiplied by the rate of change that we calculated in Step 1 to calculate the post-SCTLD density. Simulations for both the fixed-site change rates and random-site pre-disease population estimates were fitted using Poisson or negative binomial distribution to account for small values. In cases where the species were in low abundance or absent from a reef zone they were omitted from that analysis.

Step 3, we took the pre-SCTLD densities (calculated from the random-stratified data) and multiplied by the total area for each region/reef zone grouping to get a total abundance. We did the same for the post-SCTLD density calculated in Step 2. To calculate the total losses (or gains) in abundance, we then subtracted the post-disease total abundance from the pre-disease total abundance.

By integrating data from the two long-term monitoring programs in Florida, one using a repeated measures experimental design, the other a probabilistic sampling approach, reef tract-wide estimates of the mortality associated with SCTLD can now be calculated for the corals most vulnerable to SCTLD. In addition, using a variety of metrics, we evaluate where the impact of SCTLD was most significant and whether there was a correlation with coral community composition and the abundance of the coral species most susceptible to SCTLD prior to disease onset.

The results of this study found that there are geospatial differences in the rate of change across the seven targeted species between both regions and between reef zones (**Figure 1**). For *Montastraea cavernosa* and the species complex *Oribicella* spp., the mortality rate was lower compared to the Meandrinidae and brain corals. This is because the disease does not always result in full mortality for these species, or it can take an several years to completely succumb to the disease.

The loss of these corals will be significant because many of the coral species analyzed in this study disproportionately provide live coral cover on reefs (with the exception of *Dichocoenia stokesii*). In addition, we used a cosmopolitan suite of species that differ in abundance across different reef zones and the results indicate that all reefs in all zones were impacted. This was not necessarily the case during previous disturbance events that were less uniform or localized dependent upon the stressor. Since this study only targeted seven of the 20 susceptible species, more corals were inherently killed by SCTLD than reported in this study.

In summary, this study provides reef managers, scientists, and other reef stakeholders with the first quantitative assessment of how many of these corals were lost to the disease. Quantifying the impacts of SCTLD is needed to set restoration targets and highlights the significant capacity needed to develop coral propagation infrastructure. In addition, identifying areas where the disease was

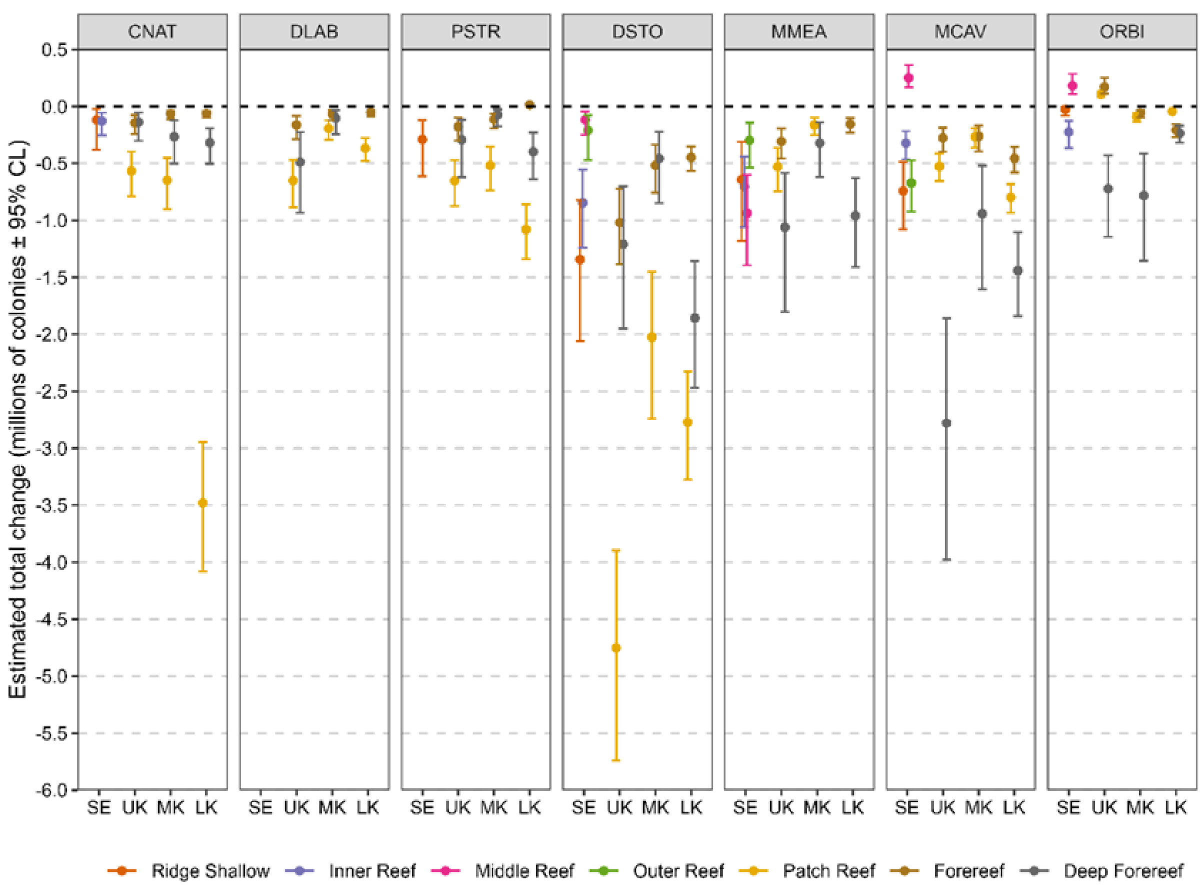

Figure 1. Predicted losses for each of the seven target coral species in each region-reef zone grouping. The Y-axis is in millions of colonies wrapped by 95% CI. The X-axis are the four regions used in this study (SE = Southeast Florida, UK = Upper Keys, MK = Middle Keys, LK = Lower Keys).

less impactful may aid in unlocking potential causes of resistance.

KEYWORDS: Coral, Florida's Coral Reef, Disease, Stony Coral Tissue Loss Disease, Mortality

LITERATURE CITED

Aronson and Precht 2001. White-band disease and the changing face of Caribbean coral reefs. In: Porter, J.W. (eds) The Ecology and Etiology of Newly Emerging Marine Diseases. Developments in Hydrobiology, vol 159. Springer, Dordrecht.

Jackson et al. 2014. Status and trends of Caribbean coral reefs; 1970-2012. Global Coral Reef Monitoring Network. USGS Publications Warehouse. Available at: https://pbus.er.usgs.gov/publications/70115405

Miller et al. 2009. Coral disease following massive bleaching in 2005 causes 60% decline in coral cover on reefs in the US Virgin Islands. Coral Reefs 28, 925.

Maynard et al. 2015. Projections of climate conditions that increase coral disease susceptibility and pathogen abundance and virulence. Nature Climate Change, 5, 688-694.

Aeby et al. 2019. Pathogenesis of a tissue loss disease affecting multiple species of corals along the Florida Reef Tract. Frontiers in Marine Science, 6, 678.

Meesters et al. 2001. Colony size-frequency distributions of scleractinian coral populations: spatial and interspecific variation. Marine Ecology Progress Series, 209, 43-54.