

From Top to Bottom: Rethinking Coral Reef Community Structure After Decades of Disturbance

Michael Childress, Tokea Payton, Luke Stoeber, Sarah Rider, and Camille White

Clemson University, Clemson, SC, USA

Coral reefs are one of the most biodiverse ecosystems on the planet and ecological theory predicts that diverse communities are the most resistant to change and resilient to disturbance. So why are coral reefs declining at alarming rates? Some have suggested that reefs exist in either one of two alternate stable states, hard coral dominated or macroalgae dominated, for which the transition is rapid and reversal difficult. Alternatively, others have suggested that coral reefs occur along a gradient of coral/macroalgae dominance which can be reversed through a combination of active interventions to reduce macroalgae and accelerate coral recruitment. Here we evaluate the predictions of these two hypotheses using more than a decade of reef community data from the middle Florida Keys. The rapid loss of coral cover has been most dramatic on offshore reefs where the dominant *Acropora* spp. branching corals are now all but extinct. But nearshore patch reefs dominated by massive boulder corals (*Siderastrea siderea*, *Orbicella faveolata*) have fared much better retaining higher live coral cover and higher rugosity. We used this baseline difference in coral composition and structural complexity to test the predictions of these two models by measuring rates of community change over the past decade. We conducted annual surveys of substrate composition, parrotfish biomass, coral disease / bleaching, along with measures of diversity for reef fishes and cryptoinvertebrates on 30 reefs in the middle Florida Keys from 2012-2025. Shallow nearshore reefs are characterized by higher coral cover, and higher *Halimeda* spp. algae also experience more variation in temperature having both hotter summer and colder winter temperatures, whereas deeper offshore reefs are characterized by higher soft coral cover and higher *Dictyota* spp. algae. Abiotic disturbances such as Hurricane Irma of 2017 and the marine heat waves of 2015 and 2023 caused the greatest changes in reef substrate composition through mortality of soft corals. The stony coral tissue loss outbreak of 2017 caused high mortality in brain corals, but only sublethal damage to other species of massive corals. Reef fish biomass, richness, and diversity are different between nearshore and offshore reefs, but have remained relative constant over the decade. Herbivorous parrotfishes vary positively with the abundance of fleshy algae suggesting a lack of top-down regulation. Cryptofauna abundance, richness and diversity increases from nearshore to offshore as rubble abundance increases. Reef community stability and resilience in the face of multiple disturbances over the past decade strongly support the hypothesis of an altered stable state made up of soft corals / weedy hard corals versus thickets of branching corals. Furthermore, we find little evidence that hard coral cover is sensitive to changes in top-down forces due to direct impacts of herbivory or indirect impacts through structural complexity or trophic cascades.