TECHNICAL REPORT
1999 - 2019

WE NEED HEALTHY REEFS

CCMI

Coral Reef Resilience Over Two Decades at Little Cayman Island

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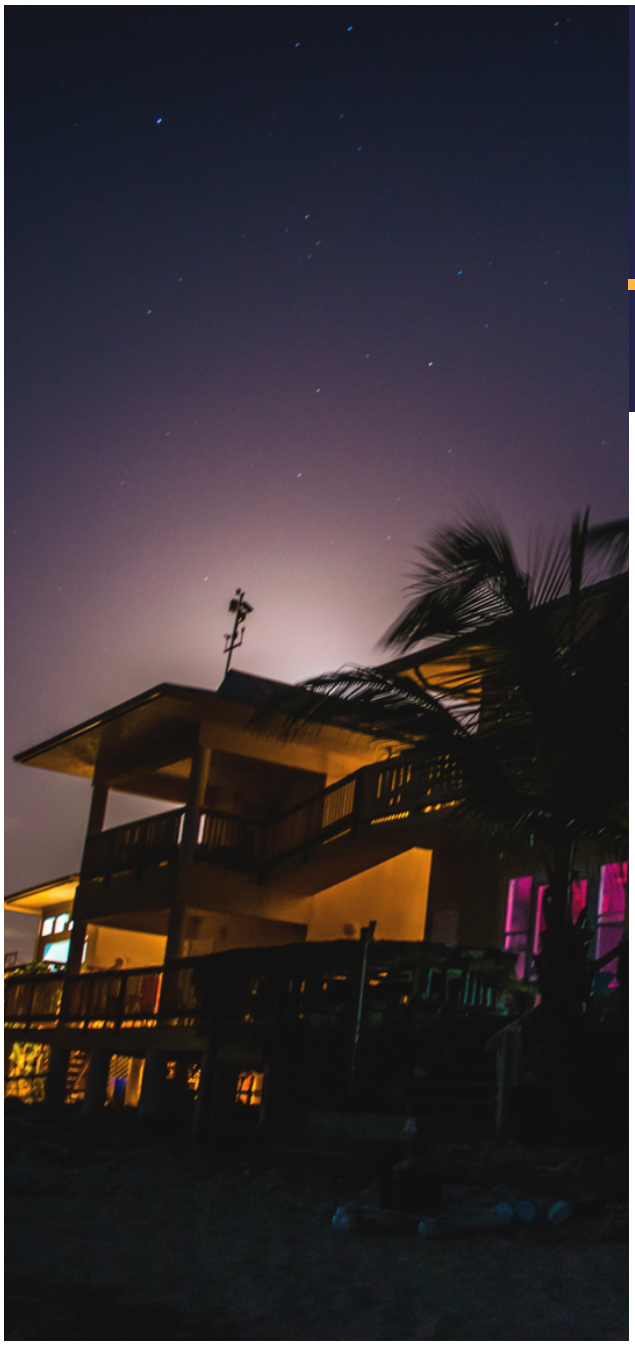

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Introduction

Since 1999, researchers at CCMI have been monitoring the health of the coral reefs around Little Cayman Island by surveying various aspects of the community on an annual basis. Long-term monitoring studies such as this enable assessment of the resilience of the reef to changing conditions over time and also give a better understanding of the true impact of global climate change (Hughes, et al., 2003). Following the standardized protocol of the Atlantic and Gulf Rapid Reef Assessment (AGRRA), these surveys document patterns of local change over the last two decades and enable regional comparisons through the Healthy Reef Framework developed for evaluating the Mesoamerican Barrier Reef.

KEY RESULTS

- There has been a gradual decline in coral cover in Little Cayman over the last 21 years, going from circa 24% to 20% coral cover. However, this change is not statistically significant (P = 0.092, R2 = 0.018; GLM). The slow rate of decline indicates that the reefs of Little Cayman are more resilient than reefs in other parts of the Caribbean where declines were rapid and reefs have not rebounded from global events (see Jackson et al. 2014).

- An overall coral cover of 20% is classified as "good" in terms of reef health. Over time, the health state in Little Cayman has fluctuated with an increasing number of sites classified as "poor" (5-10% coral cover) and fewer sites classified as "very good" (>30% coral cover). However, in 2019, none of the surveyed sites were "poor", and the majority were either "good" (18-25%) or "good +" (25-30%), indicating a relatively stable reef system overall.

- Our results show that the composition of the coral community on the reef has changed over time, from reefs dominated by massive boulder corals, such as *Orbicella* spp, to smaller plating and branching corals such as *Agaricia* spp and *Porites* spp.

- Importantly, there was a significant trend of declining algal cover over the 21 years (P = 0.023, R2 = 0.041; GLM). This decrease in algal cover, again indicates a healthy reef that has not undergone a phase shift from coral to algae, as was previously documented on other reefs in the Caribbean (e.g. Carpenter 1990, Hughes 1994, Schutte et al. 2010, Jackson et al. 2014).

- In terms of fish communities, we found no significant trend in mean density (P = 0.373) or biomass (P = 0.795), suggesting that local regulations and marine protected areas are effectively maintaining fish populations.

- The density of all grouper species in the family Serranidae declined significantly over the 20 years (P = 0.009, R2 = 0.06; GLM), despite no change in mean biomass (P = 0.618, R2 = 0.002; Linear Regression), and no significant change in the average grouper size (P = 0.143, R2 = 0.019; GLM). The density of Nassau Grouper, however, did not change over time (P = 0.143, R2 = 0.019; GLM), yet biomass increased significantly (P = 0.016, R2 = 0.089; GLM) as did the average fish size (P = 0.003 and R2 = 0.13; GLM).

- We found a significant trend of increasing parrotfish density over the 21 years (P = 0.043, R2 = 0.037; GLM), but no significant change in mean parrotfish biomass (P = 0.451, R2 = 0.005; GLM), which corresponds with a significant decrease in the average size of parrotfish (P < 0.001, R2 = 0.18; GLM). Thus, while the average number of parrotfish increased, the average size of each fish decreased, which may suggest an influx of juveniles into the community, indicative of a sustainable parrotfish population.

- Importantly, parrotfish density was found to positively correlate with coral cover (P < 0.05), indicating that sites with high densities of parrotfishes have higher percent coral cover. Likewise, overall algal cover was found to negatively correlate with overall herbivore density (P < 0.05), meaning that sites with higher densities of herbivorous fishes maintained lower percent cover of macro algae.

- Results from 21 years of AGRRA therefore indicate that whilst Little Cayman reefs are not immune to the impacts of local and global change, they have remained stable over time and appear to be more resilient than other Caribbean coral reef systems.

CORAL COVER

There has been a gradual decline in coral cover in Little Cayman over the last 21 years, going from circa 24% to 20% coral cover. However, this change is not statistically significant (P = 0.092, R2 = 0.018; GLM). The slow rate of decline indicates that the reefs of Little Cayman are more resilient than reefs in other parts of the Caribbean where declines were rapid and reefs have not rebounded from global events.

Highlights

- **No significant change in coral cover indicating a resilient reef ecosystem**
- **Mean coral size has decreased significantly, with an overall shift to smaller size classes**
- **Species richness has not changed**
- **Diversity has declined significantly**
- **Decline in the frequency of *Orbicella* spp with a corresponding increase in frequency of *Agaricia* spp and *Porites* spp**
- **Overall health state of the reefs remains in "good" and "good+" but we did not find any reefs with a rating of "very good" (>30% cover) in 2019**

An overall coral cover of 20% is classified as "good" in terms of reef health. Over time, the health state in Little Cayman has fluctuated with an increasing number of sites classified as "poor" and fewer sites classified as "very good". However, in 2019, none of the surveyed sites were "poor", and the majority were either "good" or "good +", indicating a relatively healthy reef system overall.

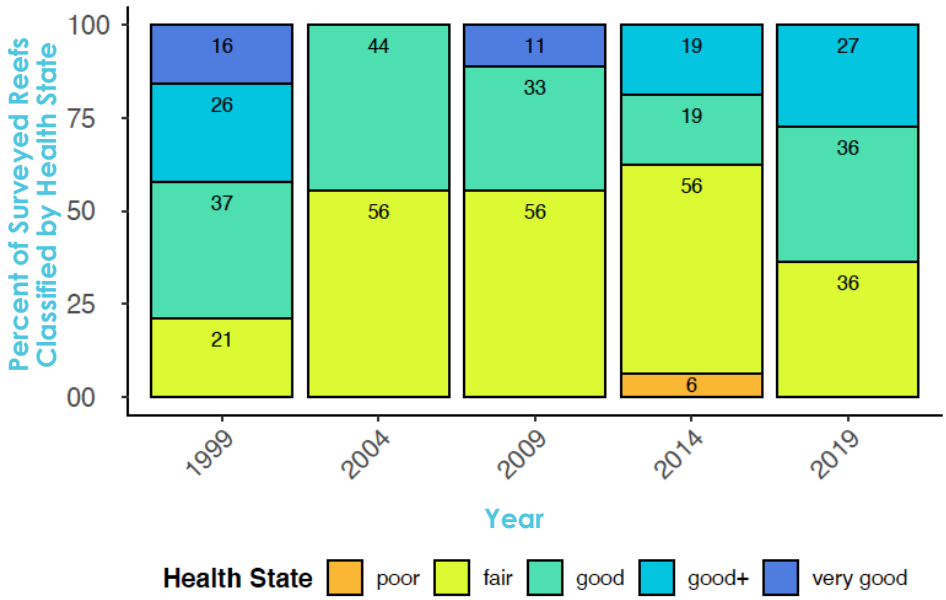


FIGURE 1: *Relative percent contribution of each health state among the surveyed reefs from 1999 to 2019. Health state is classified based on overall percent coral cover into the following categories: "poor" < 10%, "fair" <18%, "good" <25%, "good +" <30%, and "very good" >30%.*

A significant decline in species diversity was found over time based on the relative contribution to overall cover by each species (Shannon Index; P = 0.008), despite no change in the overall number of species found (Richness; P = 0.09). This result indicates that there is a less even distribution of species, with certain types of corals, although still present, being rare, while others have increased in frequency to dominate the reef community.

CORAL SPECIES COMPOSITION

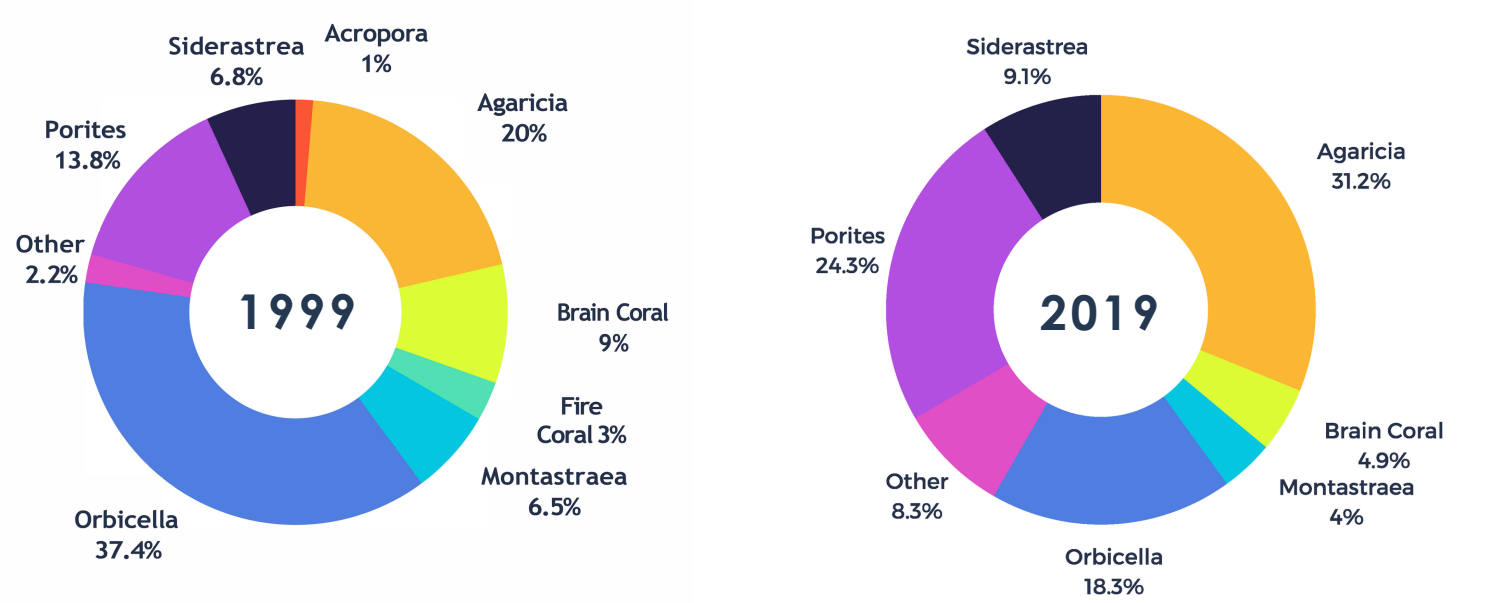


FIGURE 2: *Percent contribution of each coral type to overall coral cover in 1999 compared to 2019 showing a decrease in Orbicella (37.4% to 18.3%) and an increase in Agaricia (20% to 31.2%) and Porites (13.8% to 21.3%).*

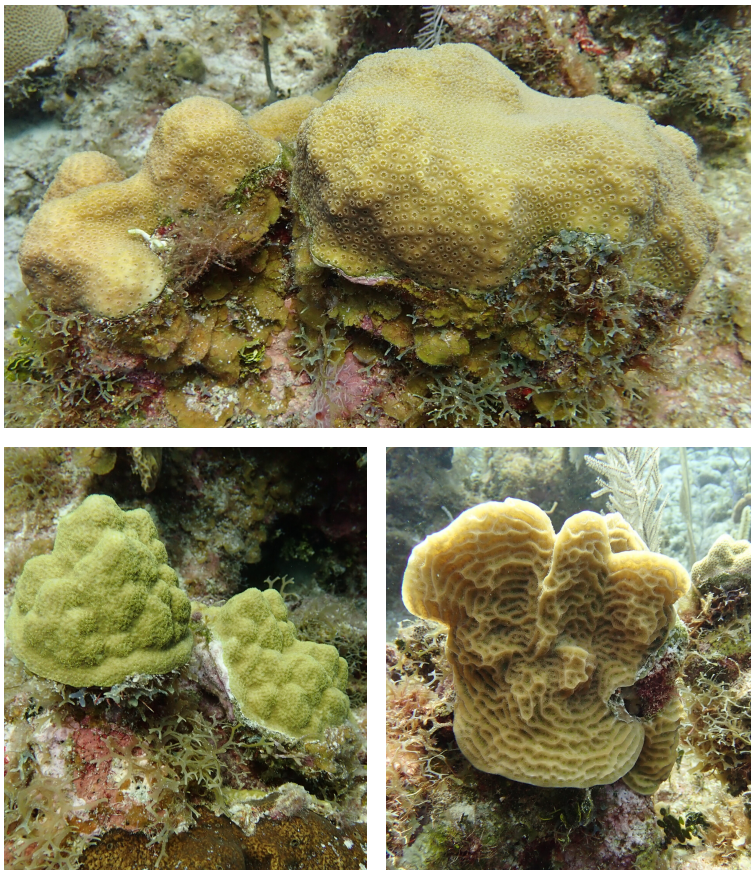


FIGURE 3: *Representative images of the three types of corals that changed in contribution over time, including Orbicella spp. (top), Porites astreoides (bottom left) and Agaricia agaricites (bottom right).*

This change in diversity corresponds to a significant shift in coral composition ($P < 0.0001$; GLM), from predominately large mounding corals to smaller plate and boulder corals. Specifically, key contributing species on the reef have shifted from large mounding corals in the genus *Orbicella*, to smaller plate and boulder corals in the genera *Agaricia* and *Porites*. This shift also represents an overall change in reproductive strategy where the former species are broadcast spawning and the latter are brooding species. Previous studies have found similar trends in species contributions on reefs throughout the Caribbean (Aronson and Precht 2001). This may have long-term impacts on the stability of Caribbean reef systems as the different reproductive modes correspond with different dispersal capacity, which may result in reefs that are reliant on local recruitment. Moreover, this shift in species contribution indicates that the reefs of Little Cayman have not escaped the impacts of global change, and may represent the initial signs of reef decline.

ALGAE

Similar to coral cover, there was a significant decline in algal cover over the 21 years (P = 0.023, R2 = 0.041; GLM). In many other parts of the Caribbean, the benthos has shifted from being predominately covered by corals to algae, and this change is often noted as a clear sign of a degraded reef system. The continued decrease of algal cover on the reefs in Little Cayman indicates that these reefs have not undergone such a phase shift, suggesting a healthy reef system. Algal cover has also been linked to herbivorous fish density, as discussed further in "Fish Density and Biomass" below.

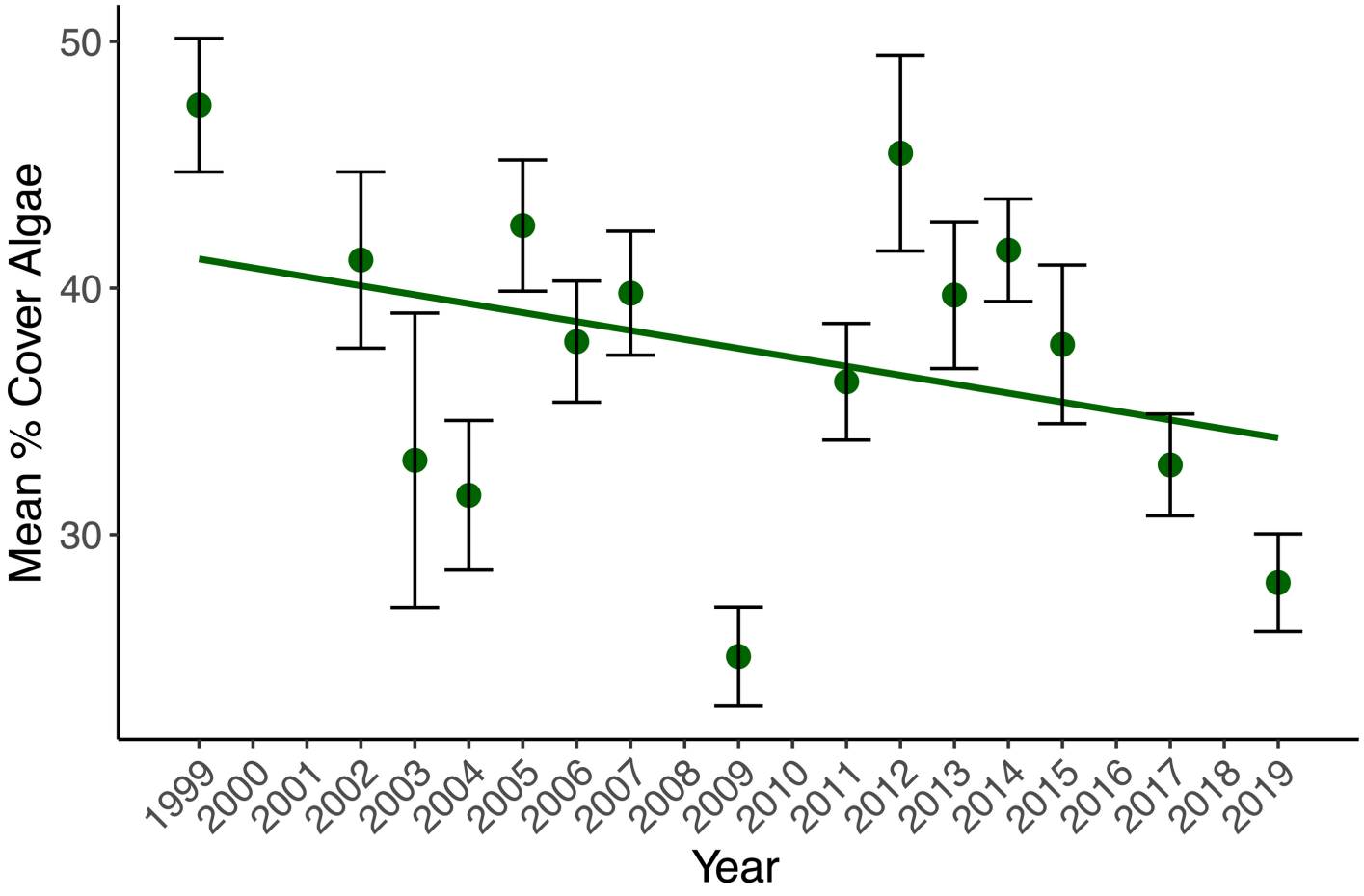


FIGURE 4: *Average percent (+/- SE) algal cover on surveyed reefs from 1999 to 2019 showing a significant decline over the 20-year period (P = 0.023).*

FISH DENSITY & BIOMASS

In terms of fish communities, we found no significant trend in density or biomass over the 21-year survey period. Likewise, species richness (number of species) and species diversity (Shannon Index) did not change over time ($P > 0.05$).

Grouper

The density of all grouper species in the family Serranidae declined significantly over the 21 years ($P = 0.009$, $R2 = 0.06$; GLM), despite no change in mean biomass ($P = 0.618$, $R2 = 0.002$; Linear Regression), and no significant change in the average grouper size ($P = 0.143$, $R2 = 0.019$; GLM).

In contrast, the density of Nassau grouper, specifically, did not change over time ($P = 0.143$, $R2 = 0.019$; GLM) and in fact showed a significant increase in biomass ($P = 0.016$, $R2 = 0.089$; GLM) and average fish size ($P = 0.003$, $R2 = 0.13$; GLM), suggesting that the Nassau grouper population is rebounding following protection initiated by the Cayman Islands Department of Environment in 2000.

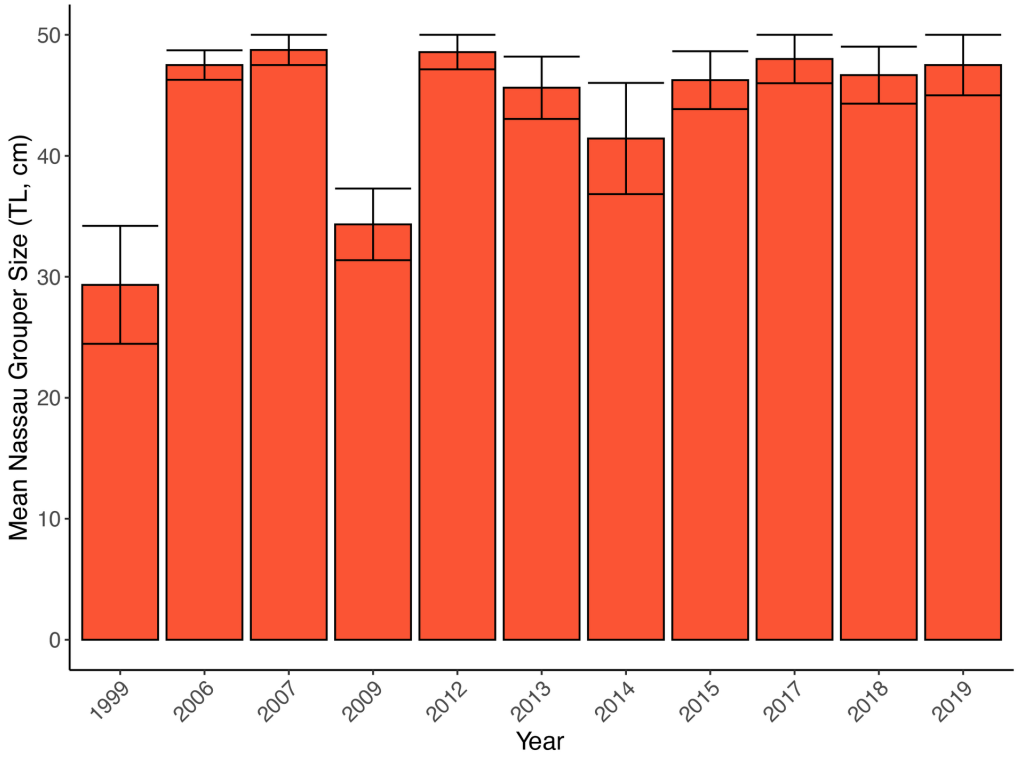
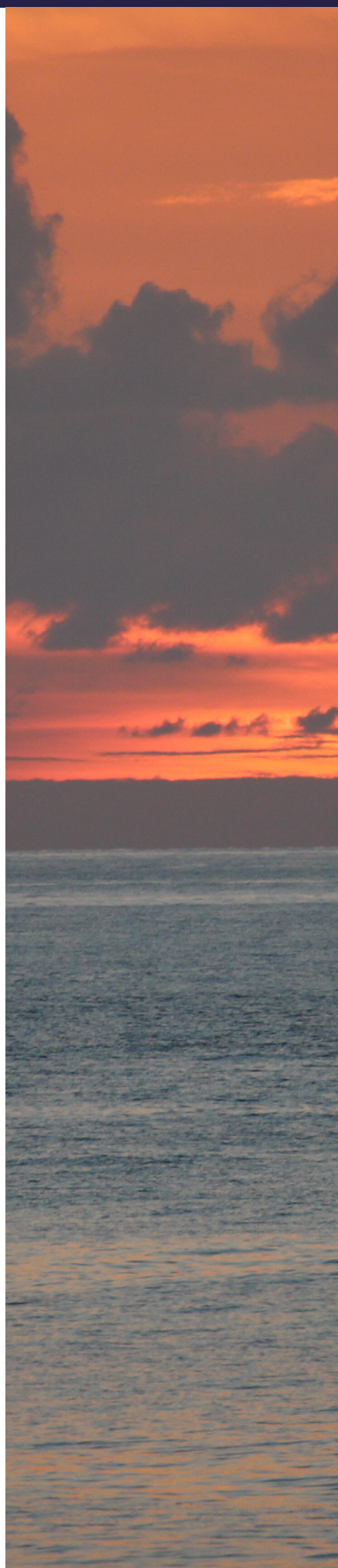


FIGURE 5: *Average size (total length +/- SE) of Nassau grouper (Epinephelus striatus) surveyed on reefs from 1999 to 2019, showing a significant increase in size over time (P = 0.003).*



FISH DENSITY & BIOMASS

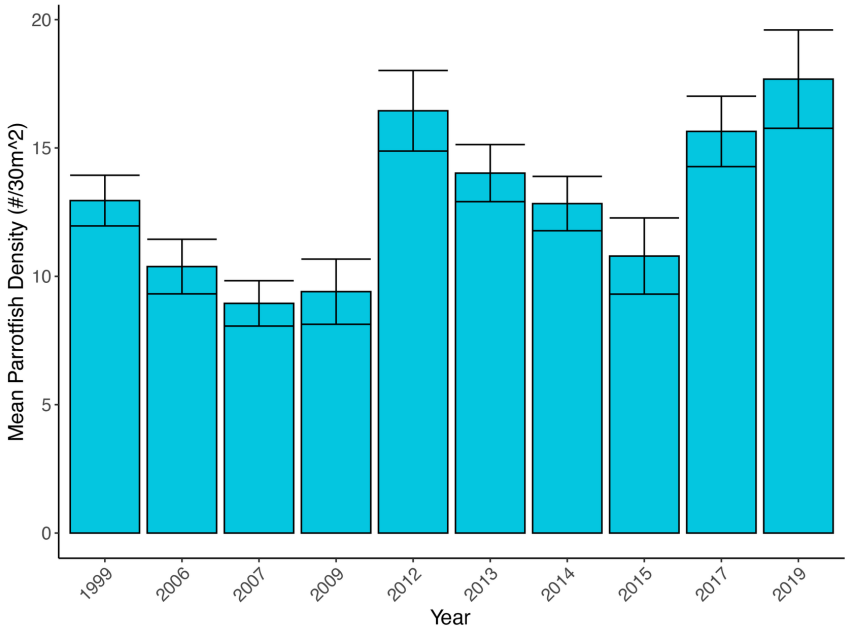


FIGURE 6: *Average density (number of fish per 30m^2 +/- SE) of parrotfish species in the family Scaridae on surveyed reefs from 1999 to 2019 showing a significant increase over time (P = 0.043).*

Parrotfish

Parrotfish in the family Scaridae were found to increase in density over the 21 years (P = 0.043, R2 = 0.037; GLM), but no significant change was found in mean biomass (P = 0.451, R2 = 0.005; GLM), which corresponds with a significant decrease in the average size of parrotfish (P < 0.001, R2 = 0.18; GLM). Thus, while the average number of parrotfish increased, the average size of each fish decreased, which may suggest an influx of juveniles into the community, indicative of a sustainable population.

Importantly, parrotfish density was found to positively correlate with coral cover (P < 0.05), indicating that sites with high densities of parrotfishes have higher percent coral cover. Likewise, overall algal cover was found to negatively correlate with overall herbivore density (P < 0.05), meaning that sites with higher densities of herbivorous fishes maintained lower percent cover of macro algae.

Healthy populations of herbivorous fishes, and specifically parrotfishes, are often suggested to be critically important to maintaining coral dominated systems and preventing coral-algae phase shifts (see Jackson et al. 2014; Pandolfi et al. 2005). The increase in parrotfish density over time coupled with the positive correlation between parrotfish and coral cover found in Little Cayman over the last 21 years, therefore, further indicates a healthy and resilient reef system.

SUMMARY

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Overall, our long-term monitoring efforts show a reef system that is persistent over time. While there are signs of impact from global change, such as a shift in species contribution, overall coral cover and fish abundances have remained relatively stable for over 20 years. Thus, the reefs of Little Cayman appear to be more resilient than other Caribbean reef systems and warrant further protection as a refuge for coral reef health and diversity.

Future Considerations

As global coral reefs continue to degrade due to a wide range of natural and anthropogenic impacts, and particularly global climate change, it becomes increasingly important that we identify areas where these ecosystems can persist. Our data indicate that Little Cayman is one of these areas and should therefore be of high conservation priority. As a potential refuge for coral reef health, Little Cayman may represent a unique region where local impacts have been minimized enabling the system to adapt and acclimate to changing global conditions. Future research investigating the adaptation and acclimatization potential of corals should therefore focus on the reefs of Little Cayman as the corals appear to express higher resilience than those in other Caribbean reef systems. Likewise, the large MPA system at Little Cayman appears to be effectively protecting local fish populations, particularly parrotfish and Nassau grouper, and thus additional studies addressing the long-term impacts of MPAs to the sustainability of regional fish populations are warranted.

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For citation: Goodbody-Gringley, G. and Manfrino, C., 2020, Coral Reef Resilience Over Two Decades at Little Cayman Island. Technical Report from the Central Caribbean Marine Institute. 20201: 11 pp.

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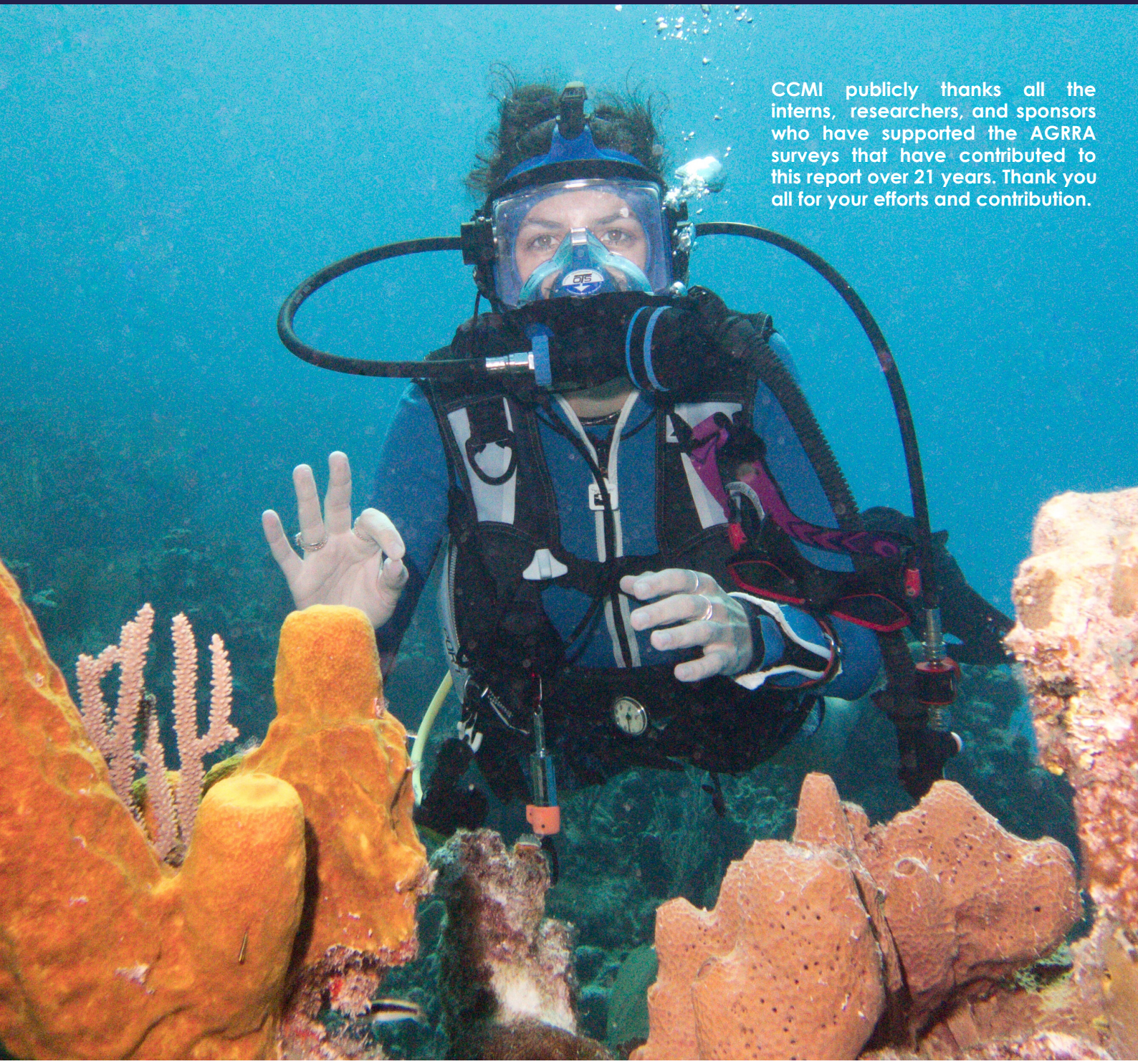

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