Impacts of reduced human activity due to COVID-19 on reef fish populations in the Cayman Islands

Impactos de la reducción de la actividad humana debido al COVID-19 en las poblaciones de peces en las Islas Cayman

Impacts de la réduction de l'activité humaine due au COVID-19 sur les populations de poissons aux îles Cayman

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ABSTRACT

In the Cayman Islands, the oceans have been quiet for over a year due to the lockdown and closed borders resulting from the COVID-19 pandemic providing a unique opportunity to study how fish populations react when human activities are minimized, and the oceans are relatively “quiet”. In July 2020, when lockdown restrictions were initially lifted, we conducted in situ fish population surveys to estimate fish density, biomass and diversity at 5 sites in and around George Town Harbour, which acts as the cruise ship base for Grand Cayman. Surveys were repeated every other month through August 2021 and compared to baseline fish population data from AGGRA surveys completed pre-COVID in 2018. Fish abundance and diversity increased significantly in July 2020 compared to 2018 but began to gradually decline across all survey sites over the course of the survey period as local activities increased. The density and biomass of herbivorous species were also found to significantly increase after COVID yet remained at high levels throughout the study. These results indicate that fish populations were able to rebound when disturbance was removed, but even minimal levels of human activity had a negative impact on fish abundance and diversity. Understanding how fish populations respond to human activity, and therefore how/if their natural role in the reef ecosystem is interrupted or changed, can help support conservation and management strategies that aim to minimize loss to biodiversity through implementation of strategic development plans.

KEYWORDS: COVID-19, Human Impacts, quiet ocean, community composition, biodiversity

INTRODUCTION

Coral reefs are home to innumerable species, a fantastic diversity of marine life, and are valued on the order of hundreds of billions of dollars annually in goods and services (Moberg and Folk, 1999). Coral reefs and the fish that inhabit them, however, have been severely impacted by local stressors such as overfishing, coastal development, and pollution, as well as global stressor such as increasing sea water temperatures (Hughes et al. 2007; Heenan et al. 2017; Lachs and Onate-Casado 2020). Many Caribbean reef fisheries stocks are severely depleted, threatening the persistence of critical ecosystem functions such as herbivory and predation (McClanahan et al. 2011). As coral reefs and their associated fish stocks decline around the world, it becomes increasingly critical to find solutions to protect coral reef ecosystems for the future (Worm et al. 2008).

In 2020, the world was impacted by the COVID-19 pandemic, which resulted in numerous countries closing their borders and limiting daily activities of residents. In the Cayman Islands, mandatory island-wide civilian lockdown began in March 2020, with activities severely restricted for a period of 4 months followed by easing restrictions for the following 1.5 years. During this time, human activities on the ocean, including boating, fishing, diving, and tourism were extremely reduced, if not absent. These changes resulted in an unprecedented opportunity to investigate how fish populations would change when activity was reduced.

The Cayman Islands has been a major tourism destination in the Caribbean for the last several decades. The majority of this tourism is related to the cruise ship industry, where during high season we can see as many as 9 cruise ships at any time in the main harbor of George Town. Not only do the presence of these large vessels create engine noise, but tourists also engage in a variety of water-based activities while visiting Grand Cayman that may have a direct or indirect impact on fish populations. However, the ocean is not naturally quiet (Hildebrand 2009). Many organisms create sounds that are used for a variety of purposes including navigation, prey location, and mate identification. Human caused noise pollution often overlaps with the production and detection ranges of many marine organisms, thereby interfering with the ecology of these organisms. In fact, human caused sound can affect the physiology, behavior, and distribution of marine organisms (Ferrier-Pages et al. 2021). Locally, the ocean had almost no direct human impact between March and July 2020 and even though the Cayman Islands lifted many domestic restrictions from July onwards, the borders remained closed, and the booming international tourism industry was at a stand-still for nearly 2 years. On one hand, human impact has been reduced, yet human intervention can also be important (Lachs and Onate-Casado 2020). The aim of the present study was to determine if the community composition of fish populations located in the center of shipping and tourism activity changed overtime during a period of reduced human and cruise ship activity. Understanding how fish populations respond to human activity, and therefore how/if their natural role in the reef ecosystem is interrupted or changed will provide critical reef management

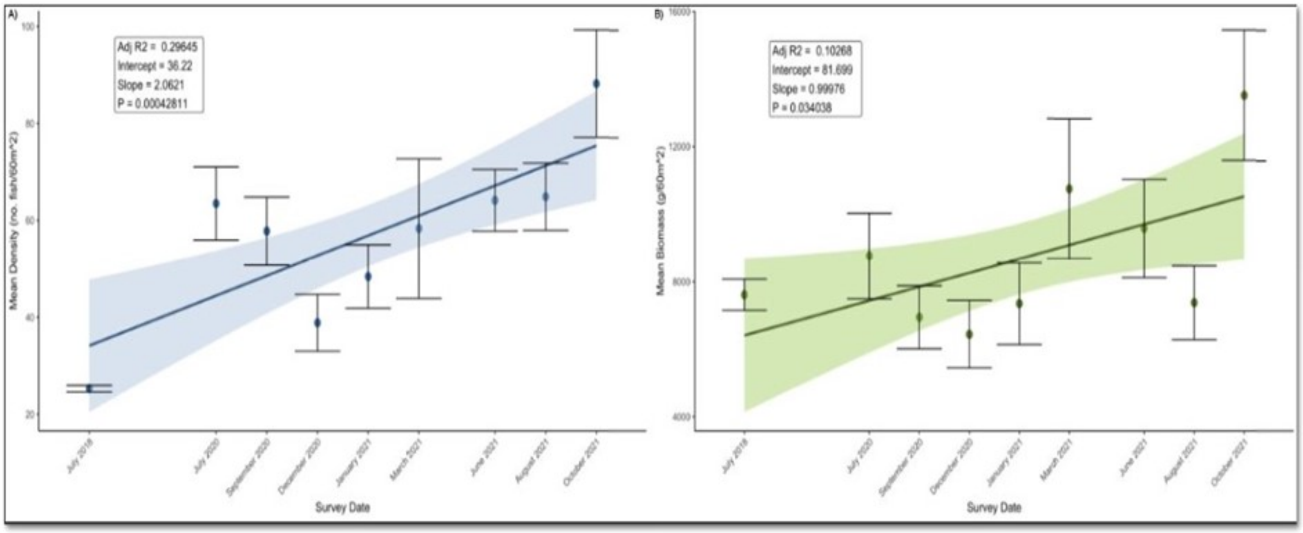

Figure 1. (A) Mean density (no fish/60m2) and (B) biomass (g/60m2) at surveyed sites from before COVID restrictions (July 2018) to after restrictions (July 2020 – October 2021) showing significant correlations over time (linear regression).

insight. While this study continues to be ongoing, here we present the initial results from surveys conducted through October 2021, at which point border restrictions remained in place.

METHODS

Beginning in July 2020, when lockdown restrictions lessened, we began a series of fish population surveys, with initial surveys occurring when the oceans had been untouched for an unprecedented period. Surveys were conducted at 4 sites in and around the typically heavily trafficked George Town harbour (Don Fosters, Eden Rock, Soto's Reef, and Fishpot Reef), and repeated roughly every two months thereafter until October 2021. At each site, all fish encountered with 1m of either side of a 30m transect ($60m^2$ total area) were identified to species and total length (TL) estimated to calculate density and biomass. Four to six surveys were conducted at each site. Results of these surveys were then compared to surveys conducted by CCMI in 2018 at three sites within the same area around George Town Harbour. The 2018, surveys were conducted as part of an island-wide AGRRA survey and thus the present data were filtered based on the AGRRA species list to normalize the survey methodology (www.agrra.org). Trends in mean fish density and biomass did not differ among sites and thus the effect of site was removed from further analyses. Mean fish density and biomass were therefore compared across time using linear regressions, with pre- and post- lockdown surveys (July 2018 vs. July 2020) compared using a paired t-test. Mean densities of main trophic groups (herbivores, carnivores, invertivores, omnivores, and planktivores) were compared across time using linear regressions. Density data met the assumptions of normality and variance, however biomass data were transformed by taking the square root to meet the assumptions ($p>0.05$; Shapiro-Wilks and Levene's Test). All statistical analyses and data visualization were performed in R v.4.1.3 (R Core Team 2022) with RStudio 2022.02.1 (RStudio Team 2022).

RESULTS & DISCUSSION

Mean fish density increased significantly from July 2018 to July 2020 ($P = 0.014$), suggesting a rapid response to reduced activities. Likewise, throughout the period of reduced activities, fish density continued to increase, showing a significant positive trajectory over time (Adj $R2 = 0.296$; $P < 0.001$; Fig. 1a). Mean fish biomass was also found to increase significantly over time (Adj $R2 = 0.103$; $P = 0.034$), however pairwise comparisons between July 2018 and July 2020 were not significant ($P > 0.05$) (Fig. 1b). These results indicate that there is a lag between increased density and increased biomass, which may be, in part, due to reliance on successful larval recruitment to replenish disturbed populations. In fact, recovery is strongly driven by larval recruitment patterns, which are documented to vary based on environmental conditions (Doherty 1991). It is possible, therefore, that an increase in recruitment during the period of reduced activity may have led to initial increases in mean density, which subsequently led to delayed increases in biomass as those recruits grew into larger size classes.

Patterns of recovery are also documented to differ among species, where slow-growing, larger-bodied species are much slower to recover than fast-growing, small-bodied species (Abesamis et al. 2014). Among the trophic groups examined in the present study, only the herbivores were found to have a significant positive correlation over time (Adj $R2 = 0.319$; $P < 0.001$), indicating that increased

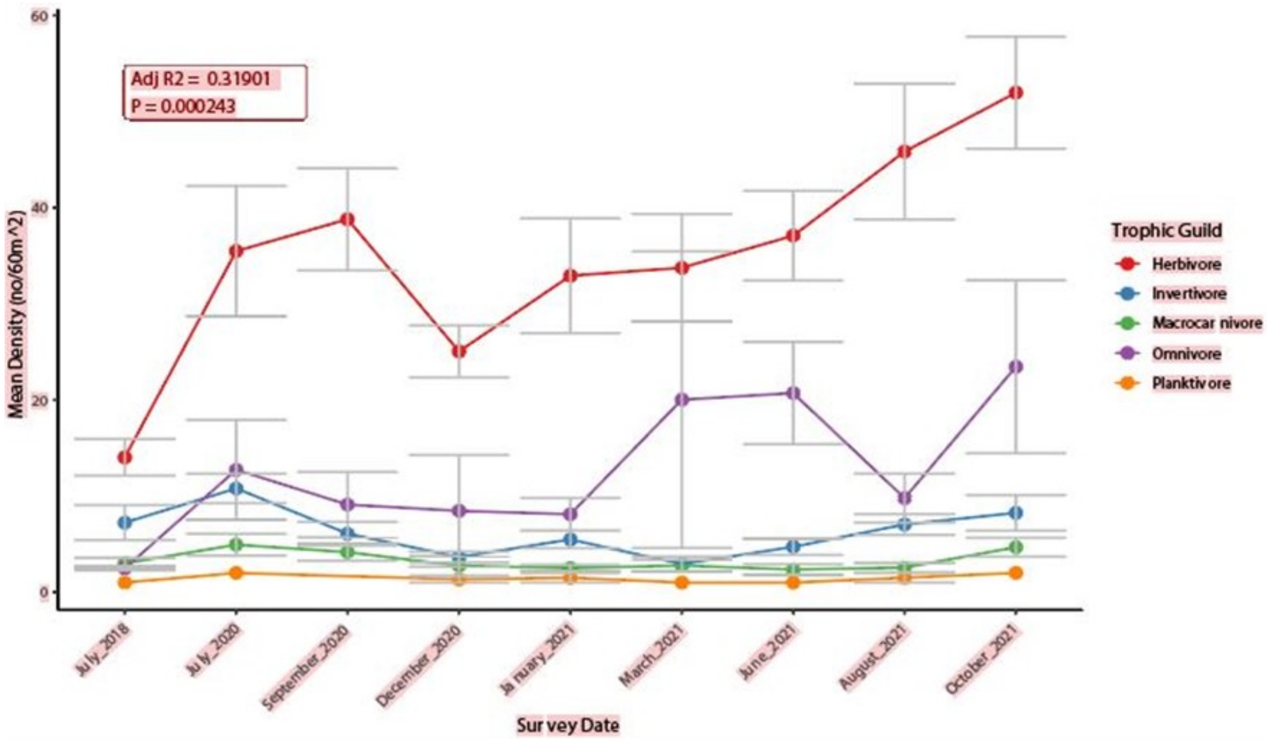

Figure 2. Mean density (no fish/60m2) of various trophic guilds at surveyed sites from before COVID restrictions (July 2018) to after restrictions (July 2020 – October 2021) showing significant correlations over time for herbivores (linear regression).

overall fish density is likely driven by increases in the density of herbivorous species. This result conforms with previous studies that have shown a more rapid recovery by herbivores, particularly parrotfishes, compared to other trophic groups, which is consistent with their shorter lifespans, faster growth, and higher turnover rates (Abesamis et al. 2014). It is likely, therefore, that the present population is still in the early stages of recovery, as larger-bodied higher trophic groups have yet to respond to the reduced disturbance. Previous studies assessing recovery times of disturbed fish stocks suggest that while the influence of reduced disturbance can be detected within several years, comprehensive recovery of reef fish biomass takes decades to achieve (MacNeil et al. 2015). Similarly, our results suggest that comprehensive recovery of the fish populations examined here has not yet been achieved and will likely take several years.

Although comprehensive recovery may take decades to achieve, the increase in herbivorous species suggest that specific ecosystem functions can be restored within a shorter time-frame (MacNeil et al. 2015). Herbivores are integral to health and persistence of coral reef, promoting coral recruitment and reducing negative interactions with macroalgae. Coral reefs with high densities of herbivores are also documented to maintain higher coral cover compared to reefs with fewer herbivores (Jackson et al. 2014). The increase in herbivore density over time found in this study, therefore, suggests that even short-term periods without disturbance can positively impact the ecosystem and increase coral reef resilience.

CONCLUSION

Overall, our results indicate that fish populations have the capacity to responded immediately when water-based activities are removed. However, the continued increases in densities and the lag in recovery of biomass suggest that full recovery will take several years but will continue to occur as long as disturbances remain minimal. Herbivores were the most impacted trophic group with significant increases in density over time. Increased densities of herbivores in association with reduced water-based activities related to COVID may, therefore, result in healthier reefs as algal consumption by herbivores will increase as their abundance increases, enabling our corals to thrive. Taken together these results suggest that reducing human activities on corals reefs can have a positive impact on the ecosystem and should be considered in strategic management plans.

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