CCMI

CENTRAL CARIBBEAN MARINE INSTITUTE

RESEARCH AND CONSERVATION REPORT 2017

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OUR SPONSORS

We would like to thank the following organisations and individuals for making our research possible:

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THE EUROPEAN UNION'S BEST 2.0 PROGRAMME
THE GUY HARVEY OCEAN FOUNDATION

Long-term Monitoring

Since 1999, CCMI has been conducting annual Atlantic Gulf Rapid Reef Assessment (AGRRA) surveys on Little Cayman making this record one of the longer records of coral reef health for the region. Data gathered through these surveys are essential to understanding changes in local reef ecology in relation to global and local factors.

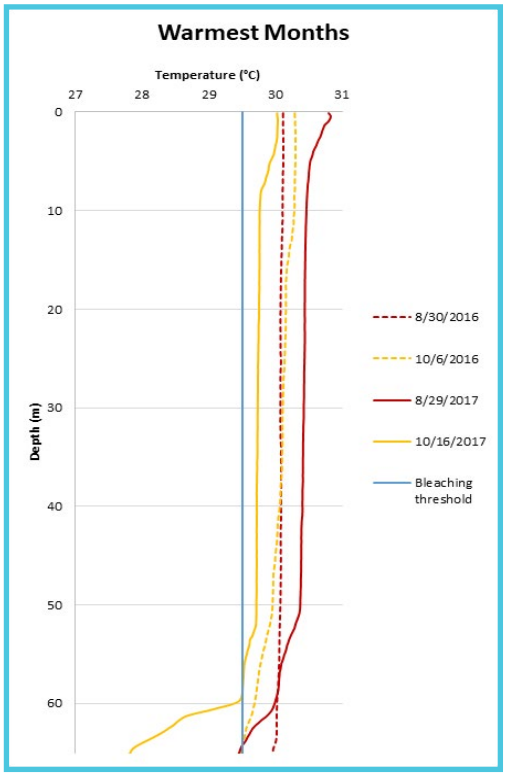
Corals across the three Cayman Islands and on a global scale were impacted by prolonged high ocean temperatures in 1998. For many years, we measured massive losses to the reefs, but in 2009, we began seeing a remarkable recovery on Little Cayman. By 2009, corals began recovering and we report that this positive trajectory is continuing through 2017 (Manfrino et al. 2012).

In 2017 our field teams recorded fish population biomass (numbers and sizes of fish) and diversity of the three the Cayman Islands for the first time, since our initial study in 1999. Wide ranging local human impacts are likely drivers of the highly variable fish populations that were reported.

Final analysis is in progress and results will be available by the end of Q1 2018. Differences in socioeconomics, multi-culturally driven taboos, education, and the capacity for enforcement of marine protected laws across the Cayman Islands all require unique approaches to marine conservation, as one size does not fit all. However, natural geographies and oceanographic setting are also responsible for some of the differences we note.

Throughout the year, the field team measures monthly sea water temperature and salinity (conductivity) using a 'Castaway' profiler to a depth of 180ft (60m) to record changes in shallow ocean heating. Ocean temperatures cool from November through February then heat up through October. Important conclusions include that corals at all depths down to 60m will 'experience' the longer-term trend of warming sea surface temperatures.

In addition, temperatures between August and October (Figure 1 below), which are typically the most stressful months for local reefs, were well above the bleaching threshold of 29.5 °C established for Little Cayman (van Hooidonk et al. 2012).



Improving Resilience

HERBIVOROUS FISH PROTECTION

In 2017, we received a three-year Darwin Initiative grant to determine which herbivorous fish are most essential to the health of our coral reefs. The variety of herbivorous fish on Cayman reefs forage on different algal species which play an important but often competitive role with corals. This project is a partnership between CCMI, the Cayman Islands Department of Environment, and the Smithsonian Institute, bridging local knowledge and global perspective to produce meaningful recommendations for the Cayman Islands and throughout the Caribbean, including draft Biodiversity Action plan.

In the first phase, researchers surveyed 17 sites on the three islands. Only 316 urchins (*Diadema*) were identified at the 17 study sites. Urchins significantly reduce algae on the reef and a mysterious mortality in the 1980s nearly wiped out the entire population. The field team counted 2,848 fish. Fish biomass and communities in 2017 are remarkably different between Grand Cayman, Little Cayman (high fish biomass) and Cayman Brac (low biomass). Videos transects were recorded at each site so that a complete analysis of the benthic community could be compared between sites and between islands. Major differences between the islands include fewer and smaller fish on Cayman Brac, larger and more diverse fish on Little Cayman, and differences in the dominant herbivorous fish species between the islands. This data will help us elucidate the role the different fish play in maintaining a balance on the reefs.

In the second phase, the objective was to determine the diet of the various herbivorous fish species using two complementary methods of observation. Dr. Claire Dell led field observations to determine the diets and feeding (bite) rates of the 11 dominant species of herbivores on each of the three islands. Next, she conducted feeding assays by creating assemblages of different types of algae suspended on ropes that were placed on the reef with cameras recording the fish which came in to feed.

Over 70 hours of feeding assays have been recorded and reviewed. Dr. Dell is in the early stages of analysing the information gathered, but early findings point to redband parrotfish and Bermuda chub as being responsible for reducing two of the most problematic and dominant algae, *Lobophora* and *Dictyota.* In conducting these surveys, Dell also noted that a different algae, *Microdictyon*, was found to be smothering reefs on the north side of Cayman Brac, though it is rare throughout the rest of the Cayman Islands and the Caribbean. Her work is currently investigating what factors (nutrients, upwelling, lack of certain fish species) are driving the abundance of this netlike green algae.

This project was featured in the Darwin Initiative Newsletter for its important potential in maintaining biodiversity and providing protection against the effects of climate change, both the August 2017 edition and the November 2017 edition.

IMPROVING RESILIENCE cont

LOOKING AHEAD

In 2018, Dell will begin tagging herbivores to determine their movements and range to measure the extent of their potential impact toward reducing algae. Preliminary observations suggest that some individuals within a species are resident to a patch of reef only a few hundred square metres in size, while others are thought to roam kilometres every day. Knowing how far a species moves will inform recommendations to ensure they are adequately protected.

As of December 2017, an intern with CCMI and PhD candidate at the University of Florida, Lindsay Spiers, has expanded her research from Belize to the Cayman Islands. This research investigates the feeding preferences of herbivorous long-spined sea urchins, and the impact these animals have on reducing algae on coral reefs.

LABORATORY EXPERIMENTS ON FERTILIZATION RATES OF NASSAU AND TIGER GROUPER

Little Cayman is home to one of the last remaining grouper aggregation spawning sites in the region. In 2017, CCMI researchers conducted laboratory experiments as part of a collaboration with the Reef Environmental Education Foundation (REEF), the Cayman Islands Department of Environment and Scripps Oceanographic Institute to study the survival rate of the early life stages (embryos and larvae) of Nassau grouper and tiger grouper. An update on this project will be provided following the completion of analysis and review of results from this collaborative effort by all participating organisations.

Restoration

CORAL RESTORATION

Under the direction of Dr. Tom Frazer, coral restoration work in 2017 included the expansion and adaptation of the nursery structures, as well as the initiation of experiments to refine outplanting efforts to achieve greater long-term success.

Spawning of *Acropora cervicornis*, or staghorn coral, was recorded for the first time on Little Cayman in August of 2017. Researchers estimated that 52% of large and medium sized corals spawned and 25% of smaller fragments spawned. This spawning is a positive indicator that the coral being reared in the nursery are maturing and have the potential for contributing to the regional wild population.

In August 2017, a vast new expansion of the deep nursery took shape as the site for a research project for University of Florida master's degree student, Daniel Veras Mena. Daniel is a Fulbright Scholar from the Dominican Republic who designed a sponge/coral nursery just west of the deep nursery in 50ft of water. He is hoping to better understand interactions between *Acropora cervicornis* corals and sponges. The hypothesis is that corals might benefit from the metabolized organic material that is processed through the filtration system of sponges. The sponges, therefore, may provide a boost to corals. In this study, coral fragments are suspended either above the sandy substrate (control), above concrete blocks alone (structural control) or above concrete blocks to which sections of the yellow tube sponge *Aplysnia fistularis* have been attached.

Unfortunately, Hurricane Irma produced large waves along the north shore of Little Cayman where the nurseries are maintained. Divers were immediately dispatched to assess the coral nurseries and while the shallow nursery showed some structural failure repairs were made quickly. The deep nursery and sponge garden had minimal structural damage. Thanks to a Rapid grant from the IFAW (International Fund for Animal Welfare), swift action by the CCMI team meant the nursery has been 'repaired' and a contingency budget was activated for this very purpose, to help rebuild damaged frames and reattached corals to the nursery structures.

LOOKING AHEAD

In 2018, nursery-reared coral will be outplanted onto the wild reef in an experiment to evaluate and better understand factors which impact long-term survival rates. Researchers will study the impact of outplanting corals in plots with varying density to evaluate which conditions are most conducive to growth and success. The research team is also continuing to develop and refine 2-dimensional and 3-dimensional mapping techniques for outplant and nursery sites to improve monitoring.

Protecting Biodiversity

INVASIVE LIONFISH MANAGEMENT

The IUCN European Commission's BEST (Voluntary Scheme for Biodiversity and Ecosystem Services in Territories of European Overseas) Initiative awarded a grant to fund an 18-month study led by Dr. Alli Candelmo to improve lionfish management by using an innovative acoustic telemetry design to study their movements in Little Cayman, Cayman Islands.

The overall goal of the project is to identify new ways to limit the ecological and economic impacts of invasive lionfish both locally and regionally. Acoustic tags were surgically implanted by Dr. Candelmo in 30 lionfish during the first of two tagging phases. Data gathered from these tags regarding horizontal and vertical movement patterns of these lionfish will inform future management plans.

Initial results from the first phase of lionfish tagging have strong site fidelity and are not moving great distances on the continuous deep reef wall. They are staying with 200m horizontally of where they were first tagged. However, many lionfish are making regular vertical movements to depths beyond recreational dive limits. This is important from a management perspective, as it suggests that regular culling of areas can still be effective in controlling lionfish populations at depths inaccessible to recreational divers.

Another unexpected but exciting result is evidence that lionfish appear to be subject to predation from native predators at rates much higher than previously suspected. Acoustic data indicates that between (14-32%) of tagged lionfish were preyed upon up to 3 months post-tagging. Nurse sharks are thought to be the primary predator, as the project team encountered difficulties with these native predators on numerous tagging dives.

Finally, project staff created a publicly accessible lionfish culling web map using the ArcGIS online platform, which is now embedded in the CCMI website. This interactive platform provides the most up-to-date culling information (e.g. average catches, date of last cull per site, etc.) for local stakeholders.

PROTECTING BIODIVERSITY cont

This web map can also serve as a template for other small Caribbean islands with community culling programmes. Please click here to view interactive web map.

Evidence of regular vertical migrations by lionfish on steep reef walls is good news for managers. It is possible that the deep dives discovered may be associated with spawning activity, which was previously thought to happen much shallower. Regular culling of areas may help to control lionfish populations that frequent depths inaccessible to recreational divers. Furthermore, the fact that native predators may be helping to control lionfish population serves to highlight the importance of conserving these species.

LOOKING AHEAD

CCMI researchers are in the process of analysis of final results from this project. We will also be disseminating relevant information regarding the project via presentations and webinars to regional stakeholders in 2018.

Publications

PRESENTATIONS/POSTERS/ABSTRACTS

1. Kathryn Lohr, David Suggett, Emma Camp, Aimee Cook McNab, Carrie Manfrino and Joshua Patterson. (2017) The Role of Reef Zone and Light Acclimation in the Performance of Corals Under Restoration. 147th American Fisheries Society, Tampa, Fl, Aug-2, 2017. Presentation.

2. Butkowski, D., Sparke, T., & Candelmo, A. (2017) Coordinating lionfish removal efforts using a publicly accessible web map. 70th Gulf and Caribbean Fisheries Institute, Merida, Mexico, Nov 6-10, 2017. Poster.

3. von Reumont, J., Hetzinger, S., Garbe-Schönberg, D., Manfrino, C., Dullo, C., 2017, Tracking interannual to multidecadal-scale climate variability in the Atlantic warm pool using central Caribbean coral data, GeoBremen, 26.-28.9. 2017, Bremen, Germany (Poster)

4. DeBuysser, J., Butkowski, D., & Candelmo, A. (2017) Catch Them If You Can: Assessment of invasive lionfish (*Pterois volitans*) behavior on Little Cayman, Cayman Islands to aid culling efficiency. Association for the Sciences of Limnology and Oceanography: Mountains to the Seas Conference. Honolulu, Hawaii. Feb 25 - Mar 3, 2017. Poster. [REU Intern]

5. DeBuysser, J., Butkowski, D., & Candelmo A. (2017) Catch Them If You Can: Assessment of invasive lionfish (*Pterois volitans*) behavior on Little Cayman, Cayman Islands to aid culling efficiency. Whitman College Undergraduate Conference. Walla Walla, WA. April 12, 2017. Presentation. [REU Intern]

6. Gulick AG, Johnson RA, Bolten AB, Bjorndal KA (2017) Greener Pastures: Insight into green turtle foraging behavior and grazing plot dynamics. 37th Annual Symposium on Sea Turtle Biology and Conservation: International Sea Turtle Society. Las Vegas, NV.

7. Johnson RA, Gulick AG, Bolten AB, Bjorndal KA (2017) Green turtles and blue carbon: Effects of grazing on seagrass meadow carbon dynamics. 37th International Sea Turtle Symposium. Las Vegas, NV.

8. Johnson RA, Gulick AG, Bolten AB, Bjorndal KA (2017) Green turtles and blue carbon: Effects of grazing on seagrass meadow carbon dynamics. 102nd Ecological Society of America Meeting. Portland, OR.

9. Johnson RA, Gulick AG, Bolten AB, Bjorndal KA (2017) Blue carbon and green turtles: Effects of grazing on seagrass meadow carbon dynamics. Association for the Sciences of Limnology and Oceanography All Scientists Meeting. Honolulu, HI.

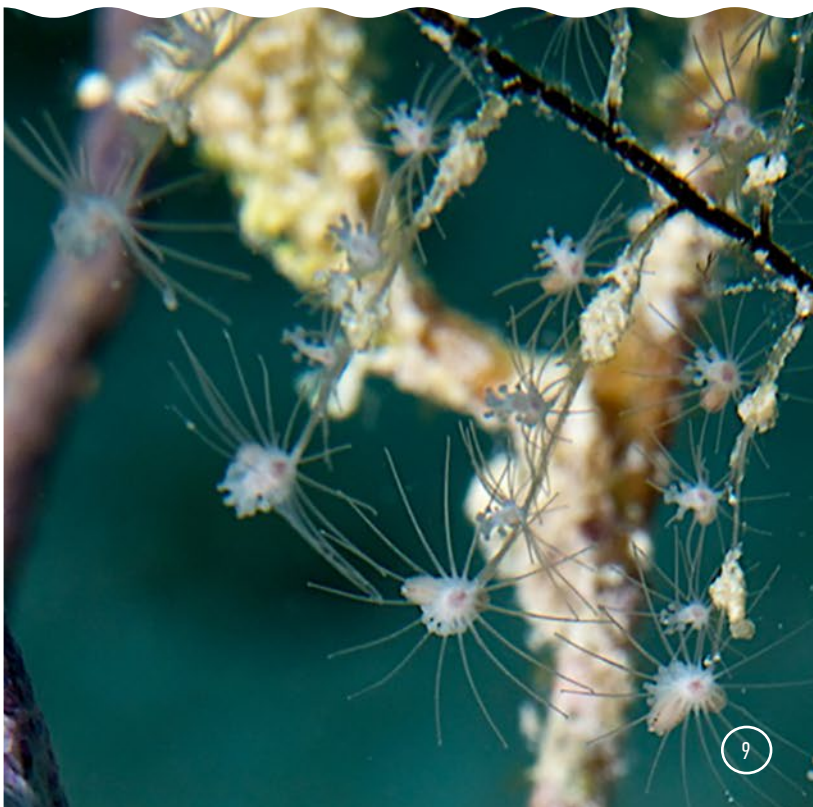
10. Hearne EL, Gulick AG, Johnson RA, Candelmo A, Bolten AB, Bjorndal KA (2017) Preliminary analysis of green turtle grazing on primary producer diversity in Caribbean seagrass meadows. 102nd Ecological Society of America Meeting. Portland, OR.

11. Hsia, S., Ouellette, G., Kerans, C., & Manfrino, C. (2017) Caves, Carbonates and Climate: Karst Landscape Development through Environmental Forcing, Little Cayman Island. University of Texas at Austin Jackson School of Geosciences Research Symposium, Austin, Texas, Feb 3, 2017. Poster. [REU Intern]

12. van Hartesveldt, N., & Foster, G. (2017). Potential avenues for expediting recovery of long-dead Acropora palmata skeletons. AGU Chapman Conference on Extreme Climate Event Impacts on Aquatic Biogeochemical Cycles and Fluxes, San Juan, Puerto Rico. Jan 22-27, 2017. [REU Intern]

13. Candelmo, A., Sparke, T., & Butkowski, D. (2017) Movement of lionfish along a deep reef wall. 70th Gulf and Caribbean Fisheries Institute, Merida, Mexico, Nov 6-10, 2017. Presentation.

14. Yamazaki, A., Hetzinger, S., von Reumont, J., Manfrino, C., Tsunogai, U., Sano, Y., Watanabe, T., 2017, Decline in 20th century Caribbean nitrogen fixation archived by annual resolution coral record, GeoBremen, 26.-28.9. 2017, Bremen, Germany (Talk)



PUBLICATIONS cont

PUBLICATIONS

1. Drury, Crawford; Schopmeyer, Stephanie; Lirman, Diego; Goergen, Elizabeth; Bartels, Erich; Nedimyer, Ken; Johnson, Meaghan; Maxwell, Kerry; Galvan, Victor; Manfrino, Carrie. Genomic patterns in *Acropora cervicornis* show extensive population structure and variable genetic diversity. ECOLOGY AND EVOLUTION; AUG 2017; 7; 16; p6188-p6200, Database: Science Citation Index.

2. Lohr Kathryn E., Smith David J., Suggett David J., Nitschke Matthew R., Dumbrell Alex J., Woodcock Stephen, Camp Emma F. (2017) Coral Community Structure and Recruitment in Seagrass Meadows. Frontiers in Marine Science 2017; Volume 4. DOI=10.3389/fmars.2017.00388. ISSN=2296-7745.

3. Banks, S. & Foster, K. (2017) Baseline levels of *Siderastrea siderea* bleaching under normal environmental conditions in Little Cayman, Open Journal of Marine Science, 7, 142-154, DOI: 10.4236/ojms.2017.71011.

4. Hearne EL+, Gulick AG, Johnson RA, Candelmo A, Bolten AB, Bjorndal KA. Preliminary analysis of green turtle grazing on primary producer diversity in Caribbean seagrass meadows. *In preparation.* Journal TBD.

5. Johnson RA, Gulick AG, Bolten AB, Bjorndal KA (2017) Blue carbon stores in tropical seagrass meadows maintained under green turtle grazing. Scientific Reports 7:13545. DOI:10.1038/s41598-017-13142-4.

6. Johnson, R.A, A.G. Gulick, A.B. Bolten, and K.A. Bjorndal. Sediment resuspension and erosion are not affected by green turtle grazing in shallow Caribbean *Thalassia testudinum* seagrass meadows. *In preparation.*

7. Lohr, K. E., McNab, A. A., Manfrino, C., & Patterson, J. T. (2017). Assessment of wild and restored staghorn coral Acropora cervicornis across three reef zones in the Cayman Islands. *Regional Studies in Marine Science*, 9c, 1-8. DOI: 10.1016/j.rsma.2016.11.003.

8. Peach, K. E., Koch, M.S., Blackwelder, P.L., Manfrino, C., (2017) Calcification and photophysiology responses to elevated pCO2 in six Halimeda species from contrasting irradiance environments on Little Cayman Island reefs, *Journal of Experimental Marine Biology and Ecology*, 486, 114-126. 55 DOI: 10.1016/j.jembe.2016.09.008.

9. von Reumont, J., Hetzinger, S., Garbe-Schönberg, D., Manfrino, C., Dullo, C., subm., Tracking interannual to multidecadal-scale climate variability in the Atlantic warm pool using central Caribbean coral data: *manuscript submitted to Paleoceanography and Paleoclimatology.*