



HONDURAS DISSERTATION/THESIS PROJECT

HO24 Assessing the recovery of a keystone urchin species and its role in reef restoration

Dr Dan Exton | Head of Research | dan.exton@opwall.ac.uk

Herbivory is one of the most important processes on coral reefs, especially in recent decades with the widespread impacts of coastal development and eutrophication. Scleractinian (hard) corals, the ecosystem architects of these highly biodiverse and productive systems, are crucial to the health and function of a reef but grow extremely slowly. Comparatively, macroalgae grows quickly and therefore competes with corals and other benthic organisms for one of the most limited resources on a reef; space. Under natural conditions, macroalgal growth is restricted by the low nutrient content of most tropical coastal water, which is naturally highly oligotrophic, whilst macroalgal biomass is restricted by the feeding activity of herbivores. Unfortunately pollution from a range of sources has significantly increased nutrient availability on many reefs meaning there is now an increased pressure on herbivores to facilitate coral dominance in the benthic community. Where herbivory is insufficient, reefs become at severe risk of a phenomenon known as phase shifts, which describes the process whereby an ecosystem moves from one stable state to another, and in the context of coral reefs most commonly describes a move from coral to macroalgal dominance. These phase shifts ultimately lead to a loss in reef structure, and a collapse of the associated fish and invertebrate communities – a devastating impact which poses one of the greatest threats to coral reefs ecosystems.

In many parts of the tropics, herbivorous fish are the most abundant and therefore important for the process of removing macroalgae. In the Caribbean, however, the most important herbivores historically are sea urchins, specifically the species *Diadema antillarum*. These urchins each inhabit a home range of up to 4m² which they are able to completely graze in the space of around four days. When population densities of *D. antillarum* are high enough, as they should be naturally, they are able to consume the entire net primary productivity of the ecosystem. However, in 1983 a water-borne pathogen emerged which, within just one year, caused the mass mortality of *D. antillarum* throughout the Caribbean. Between 95-99% of all individuals were killed with some areas affected to the extent that local extinctions occurred. This mass mortality event caused significant deterioration in reef health almost immediately, with some reefs reporting an increase in macroalgal cover of 20% after only 5 days of disease outbreak.

Unfortunately, the recovery of *D. antillarum* populations has been minimal at best, with areas of highest recovery still over one order of magnitude lower more than 20 years after the mass mortality event occurred. This means that extremely low populations are the norm for reefs in the Caribbean, and resilience to phase shifts is low as a result. Reasons for a lack of recovery are varied, and only minimal research has focused on the issue, despite the importance of *D. antillarum* as a keystone species for Caribbean reefs and the high priority of phase shift prevention and recovery amongst regional governments and international conservation groups. This project will therefore focus on investigating the barriers to *D. antillarum* recovery on Caribbean reefs by using Honduras as a model system. The island of Utila is a popular dive tourism destination, but the health of reefs has

deteriorated as macroalgae replaces the vital coral community. Despite a handful of patches of relatively high population densities in extreme shallows, densities of *D. antillarum* are low on reefs around the island, making it an ideal representation of the Caribbean as a whole. In contrast, the extensive Banco Capiro reef system in Tela Bay on the Honduran mainland is home to one of the highest recorded post-disease *D. antillarum* population densities, making it a site of extreme interest to researchers attempting to address the urchin problem.

Students collecting data for their dissertations on this topic will collect baseline population density data on *D. antillarum* and other urchin species on study reefs around Utila and Tela Bay, as part of a long-term monitoring programme to identify changes in population dynamics. In addition, students can focus on one of several potential barriers to recovery, to assess which factors have contributed to the difference in population between the two sites. This can include levels of predation on *D. antillarum* individuals, benthic characteristics and food preferences which may affect the species' ability to survive on modern reefs, and evidence that the disease has persisted. Data will mostly be collected by SCUBA diving, although some snorkelling may be required for shallow habitat assessments.

Recommended Reading

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- Bodmer MDV, Wheeler PM, Hendrix AM, Cesarano DN, East AS, Exton DA (2017) Interacting effects of temperature, habitat and phenotype on predator avoidance behaviour in *Diadema antillarum*: Implications for restorative conservation. *Marine Ecology Progress Series* 566: 105–115
- Cramer KL, O’Dea A, Carpenter C, Norris RD (2018) A 3000 year record of Caribbean reef urchin communities reveals causes and consequences of long-term decline in *Diadema antillarum*. *Ecography (Cop)* 41: 164–173
- Cramer KL, O’Dea A, Clark TR, Zhao JX, Norris RD (2017) Prehistorical and historical declines in Caribbean coral reef accretion rates driven by loss of parrotfish. *Nature Communications* 8: 14160
- Hughes TP (1994) Catastrophes, phase shifts, and large-scale degradation of a Caribbean coral reef. *Science* 265(5178): 1547-1551
- Lessios HA (2016) The Great *Diadema antillarum* Die-Off: 30 Years Later. *Annual Review of Marine Science* 8:267–283
- Lessios HA, Robertson DR, Cubit JD (1984) Spread of *Diadema* mass mortality through the Caribbean. *Science* 226: 335-337
- Lewis SM, Wainwright PC (1985) Herbivore abundance and grazing intensity on a Caribbean coral reef. *Journal of Experimental Marine Biology and Ecology* 87: 215-228

- Maciá S, Robinson MP, Nalevanko A (2007) Experimental dispersal of recovering *Diadema antillarum* increases grazing intensity and reduces macroalgal abundance on a coral reef. *Marine Ecology Progress Series* 348: 173-182
- McClanahan TR, Kamukuru AT, Muthiga NA, Yebio MG, Obura D (1996) Effect of sea urchin reductions on algae, coral, and fish populations. *Conservation Biology* 10(1): 136-154
- Mumby PJ, Hastings A, Edwards HJ (2007) Thresholds and the resilience of Caribbean coral reefs. *Nature* 450: 98-101
- Rodríguez-Barreras R, Pérez ME, Mercado-Molina AE, Sabat AM (2015) Arrested recovery of *Diadema antillarum* population: Survival or recruitment limitation? *Estuarine Coastal Shelf Science* 163:167–174
- Rogers A, Lorenzen K (2016) Does Slow and Variable Recovery of *Diadema antillarum* on Caribbean Fore-Reefs Reflect Density-Dependent Habitat Selection? *Frontiers in Marine Science* 3:63