HONDURAS DISSERTATION/THESIS PROJECT

HO30 Behaviour of the long-spined sea urchin, a keystone Caribbean coral reef herbivore

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

It was only after an unidentified pathogen caused a mass mortality event, killing an estimated 98% of all individuals, that the true ecological importance of the sea urchin *Diadema antillarum* to Caribbean coral reefs was understood. This mass mortality affected the entire Caribbean, all but wiping out this species on coral reefs throughout the region. Unfortunately, *D. antillarum* are important herbivores on Caribbean reefs, playing a vital role in ensuring macroalgal biomass is minimised allowing corals to thrive, and are now considered to be a keystone species. Corals are the ecosystem architects of coral reefs, but they grow extremely slowly. Macroalgae on the other hand are able to grow extremely quickly, but the naturally nutrient poor tropical seawater has historically limited their growth, while herbivory has maintained their standing biomass. Overfishing of reefs has led to greatly reduced herbivory rates, while coastal pollution has increased nutrient concentrations, and these factors have combined to leave coral reefs under threat of macroalgal overgrowth, in what is known as a phase shift from one stable ecological state to another.

Unfortunately, the recovery of *D. antillarum* populations has been minimal at best, with areas of highest recovery still over one order of magnitude lower over 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. Many theories have been proposed to explain why recovery has been so limited, but as yet no definitive answer has been reached. These have included barriers to recruitment due to an asynchronous reproductive strategy, as well as predation and competition. However, research by Operation Wallacea scientists over recent years has begun to rule out many of these previously proposed theories, and has led to an increasing belief that a lack of structural complexity on Caribbean reefs is leaving *D. antillarum* vulnerable to predation, which in turn leads to continued population suppression.

D. antillarum are a naturally cryptic species, meaning they hide within the framework of the reef while not foraging for food. This logically requires a sufficiently complex reef structure to accommodate high densities. However, various natural and anthropogenic impacts are reducing the structural complexity of reefs through a process known as “reef flattening”, as the calcifying organisms responsible for reef growth (i.e. corals) are increasingly replaced by non-calcifying organisms (e.g. macroalgae). Currently we have very little understanding of the preferences of *D. antillarum* towards reef structure, and therefore what role reef flattening is playing in the continued suppression of their abundance. It has been hypothesised that construction of artificial reef systems will provide individuals with the shelter they require to avoid predation, which in turn could potentially facilitate population recovery. Developing our understanding of *D. antillarum* habitat preferences will therefore help us to design bespoke structures that maximise the efficacy of future conservation initiatives.

This project could be entirely laboratory based, or include elements of SCUBA diving, depending on the questions being asked and the specific preference of the student. Individual *D. antillarum* can be collected from the reef, either by the student or our team of divers, and returned to the research centre where a small wet lab will be available including tank facilities. In the lab, preference experiments can be set up to observe whether *Diadema* exhibit any choices in terms of habitat preference. There are a large number of questions that could be addressed throughout the course of this study including examination of crevice size preferences, shape and structure preferences, and material preferences. Projects including diving could aim to model the microhabitats being used by *D. antillarum* in situ to explore whether an “ideal” structural form exists which could be artificially replicated in a laboratory situation. In the world of urchin physiology and behaviour there are a huge number of unknowns that could potentially have large impacts for future conservation management strategies; students who sign up for this project will be involved with research that has real-world practical implications for the future of Caribbean reef systems.

Recommended Reading

Bellwood DR, Hughes TP, Folke C, Nyström M (2004) Confronting the coral reef crisis. Nature 429: 827-833

Bodmer MDV, Rogers AD, Speight MR, Lubbock N, Exton DA (2015) Using and isolated population boom to explore barriers to recovery in the keystone Caribbean coral reef herbivore *Diadema antillarum*. Coral Reefs 34(4): 1011-1021

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

Hughes TP (1994) Catastrophes, phase shifts, and large-scale degradation of a Caribbean coral reef. Science 265(5178): 1547-1551

Lessios HA (2005) *Diadema antillarum* populations in Panama twenty years following mass mortality. Coral Reefs 24: 125-127

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