MASTS Small Grant scheme: Final Report

Coral reefs and environmental niche construction: quantifying patterns and variability

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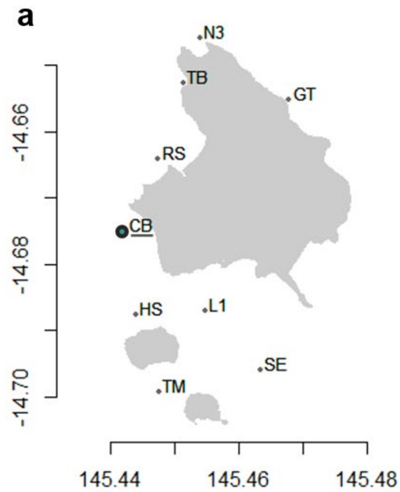
Coral reefs are one of the most biodiverse and threatened ecosystems in the world [1]. Scleractinian corals act as ecosystem engineers and build the three-dimensional framework that provides shelter and food for themselves and all the other species that inhabit the reef. Coral reefs are characterised by high diversity in terms of species, morphologies and demographic rates, harbouring in less than 1% of the oceans one third of known marine fish species [2].

Most research that deals with corals and environment is focused on assessing the plastic response of distinct species to environmental variation [3]. However, despite the role of corals as ecosystem engineers, the extent to which different morphologies or coral assemblages influence environmental conditions and provide varied niches for coral themselves and the associated flora and fauna is still unknown.

Corals build the physical structure of the reef, hence quantifying how the 3D structure of coral assemblages modify environmental conditions is important for three reasons. First, defining morphologies and assemblages that can buffer environmental conditions in ways favourable to coral fauna could be a uniquely useful tool for conservation actions such as reef restoration. Second, the *hidden* microscale environmental variation within reefs may explain species coexistence and hence part of the diversity and variability of the reef fauna. Third, the capacity to control environmental niches can have had evolutionary consequences that deserve more investigation [4], allowing a deeper understanding of coral evolutionary patterns.

The MASTS small grant allowed the purchase of data loggers which I used to quantify the natural variation of light and temperature niches within reef sites and to study their relationship with reef 3D structure. My study site was Lizard Island (Australia), where methods to obtain bathymetry, bottom reconstructions, and species characterization of coral assemblages have been developed by collaborators [7]. Photogrammetric techniques have been used to produce underwater reef maps of 9 morphologically different reef study sites (~130m^2) (Figure 1). To quantify environmental variability, dataloggers have been deployed to simultaneously measure temperature and light 30 to 50 locations at the bottom of each site for 24 hours (Figure 1).



code	reef site
N3	North Reef 3
GT	Gnarly Tree
SE	Southeast
L1	Lagoon 1
TM	Trimodal
HS	Horseshoe
CB	Corner Beach
RS	Resort
TB	Turtle Brach

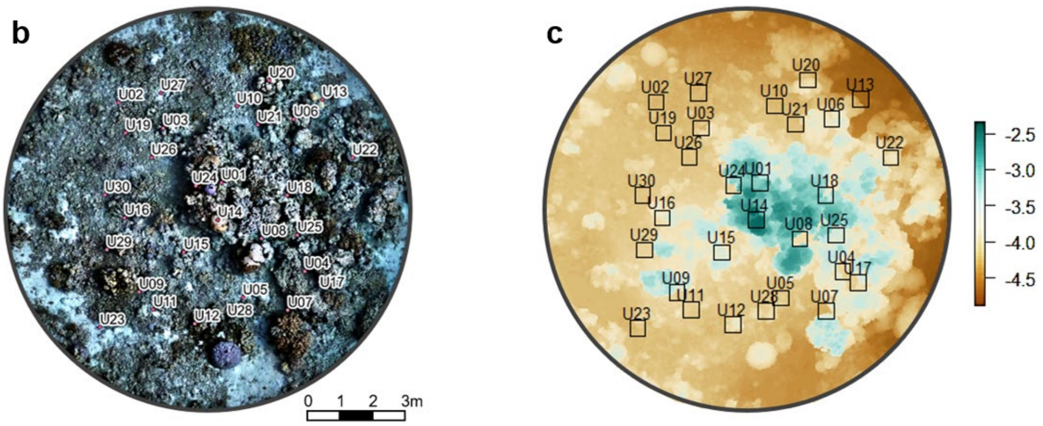


Figure 1 – Reef sites and 3D models of a site. a) On the left, the map shows the reef study sites around Lizard Island (Australia). On the right, codes for reef sites table. b) and c) are example of datalogger unit locations within Corner Beach (CB, highlighted and underlined a) in 2018. c) shows the position of each unit as annotated on the orthomosaic of the reef site. c) is the digital elevation model, where every pixel of the map represents elevation (depth) data. 50-cm side rectangles highlight the respective areas used for computing surface descriptors of the local reef for each unit at this scale (i.e., explanatory variables).

With my analysis, I assessed that: (i) while light varies a lot within reef sites, temperature variation is mostly driven by temporal fluctuation and is consistent within reef sites (Figure 2); (ii) reef structural traits, such us rugosity (R) and fractal dimension (D) influence light niches within reefs (Figure 3).

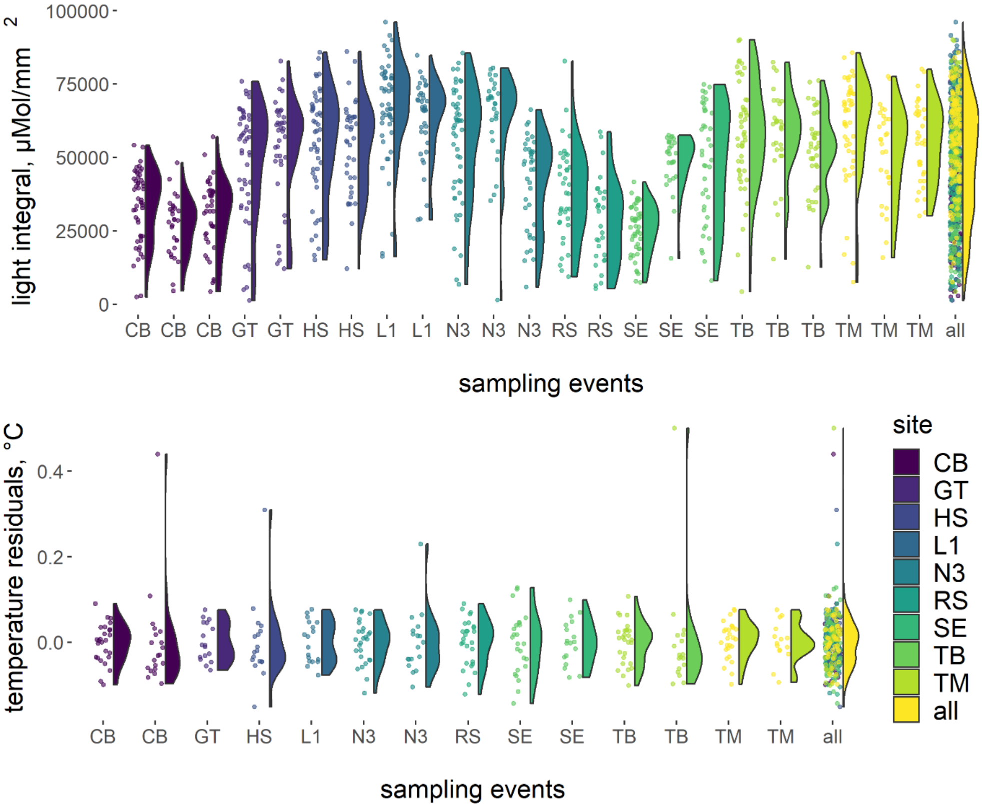


Figure 2 - Light daily integrals and temperature residuals distributions among sampling events. Samplings are color-coded by site. On the right, in yellow, the overall variable distributions. Most temperature residuals are within temperature sensor precision.

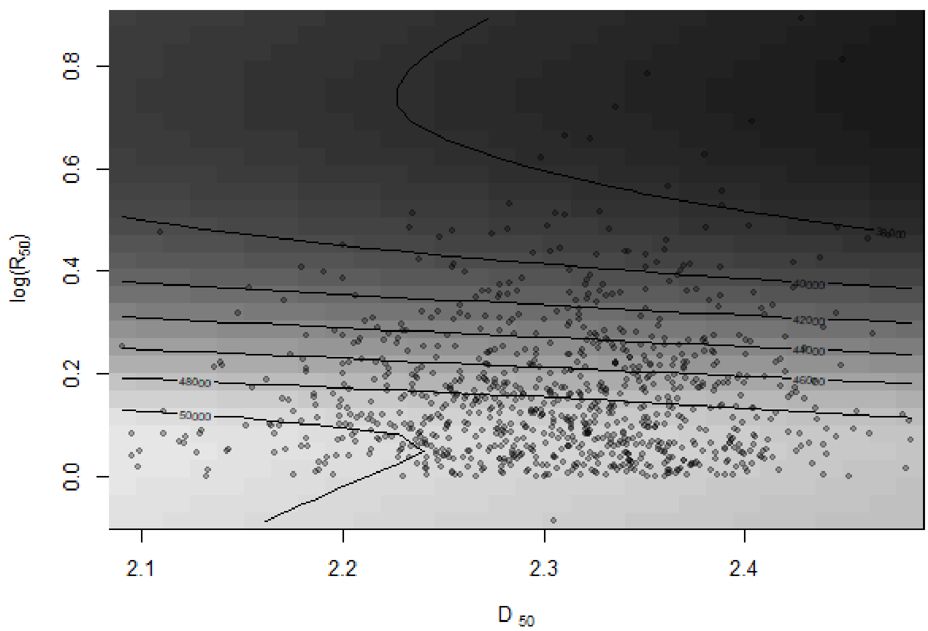


Figure 3 – Light prediction on the habitat complexity plane. Predictions of light based on habitat complexity surface descriptors (D – fractal dimension, R – surface rugosity), obtained with a smoothed predictor fit. Dots are observed data.

This data is the foundation of a chapter of my PhD thesis and will soon be turned into a manuscript for submission in peer-reviewed journals. Preliminary results of my experiment were presented at the European Coral Reef Studies conference in Oxford in December 2017. My PhD project is part of a broader international research programme (Putting the Extended Evolutionary Synthesis to test) that also provided communication and dissemination opportunities with the involved institutions and the general public.

References

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