INDONESIA DISSERTATION/THESIS PROJECT

IN35 The relationship between reef complexity and fish communities

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

The physical complexity of an ecosystem is a key driver of biodiversity and productivity. This complexity provides microhabitats for species to exploit, whilst also providing shelter from predation. Just as trees provide complexity to a tropical rainforest, scleractinian (hard) corals provide complexity to a coral reef by laying down calcium carbonate skeletons that over thousands of years produce the huge reef structures we see today. However, these corals grow incredibly slowly and are highly sensitive to environmental stress such as increased temperatures or ocean acidification. This has led to a global decline in coral abundance thanks to human induced climate change, and a subsequent phenomenon called reef flattening. Understanding the structural complexity of coral reefs is therefore of extreme importance.

However, quantifying structural complexity of underwater architecture is traditionally challenging, and has subsequently relied on particularly basic methods to estimate. The two most commonly used techniques have been chain-and-tape rugosity and Habitat Assessment Scores (HAS). For the former, a chain of known length is laid across the reef following the contours of the surface, and the final linear distance between the two ends is then measured. The complexity of the surface is then calculated as rugosity by dividing the distance between the ends with the actual length of the chain. The more complex the surface, the shorter the final distance between the two ends, whereas for a completely flat surface the two values would be the same. However, this method risks physically damaging the reef, but it also estimates complexity along a narrow strip of reef that is then applied to the wider reef area, which is unlikely to be an accurate representation. HAS is a passive observational alternative, whereby a diver visually characterises five aspects of the reef's complexity along a scale of 0 to 5, then adds up the scores to get a single HAS value. This is a widely used techniques, and avoids any physical damage to the reef, but it can suffer from observer bias as it relies on subjective decisions to be made by observers.

Technology is revolutionising the way scientists conduct research across disciplines by improving the accuracy and efficiency of data collection, moving towards automation to remove human error, or simply allowing previously impossible questions to be answered. This is particularly true for tropical marine ecology, which has historically relied on basic methods based around in water observations by divers, such as the examples above. In the case of habitat complexity, recent advances in underwater photography/videography and computing have led to the development of 3D modelling as a tool to allow areas of reef to be digitally reconstructed and the complexity measured mathematically to a high degree of accuracy. Operation Wallacea scientists in Honduras have developed their own 3D modelling method (see Young et al 2017) that uses low cost and readily available underwater video cameras (GoPro) combined with existing software to construct models that are accurate to approximately 1.5cm resolution. Once constructed, these models can be analysed in various ways to give a highly accurate estimate of structural complexity. This has the benefits of higher accuracy, but also means complexity is being measured across the entire reef area that has been modelled.

Initially, this method was used to model relatively small areas of reef (e.g. 2 x 2m quadrats). However, further development of the method combined with access to improved computing power, means that we are now starting to model larger areas of reef. This in turn is allowing us to incorporate 3D modelling into the long-term coral reef monitoring programmes run at our various sites. Students on this project in Indonesia will work as part of the reef monitoring team, but will focus specifically on the structural complexity of the reefs being surveyed. By combining complexity measurements with data on fish and/or benthic community structure students can explore the role of habitat complexity in driving patterns in associated biodiversity and abundance, both within reef sites and between them. For example, do reefs with more structural complexity have a higher abundance of reef building organisms such as scleractinian corals? Or do more complex reefs support higher numbers and species of fish? This project is diving based but will also involve intensive analysis back on land between dives.

Recommended Reading

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