Coral reefs from a fish-eye perspective, low-cost 3D-mapping for anyone

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Coral reefs worldwide are subjected to multiple threats ranging from climate change to habitat destruction and overfishing. To effectively manage these highly complex ecosystems, it is necessary to understand fish-habitat interactions and find ecological indicators that are both relevant and measurable. The 3D-structure (rugosity), of coral reefs is tightly linked with fish abundance, species richness and functional diversity. Highly complex reefs can boost ecosystem services, and display high resilience and recovery abilities in case of disturbances. Several methods exist to quantify rugosity on reefs, such as visual estimations and chain-tape measurements. In this study, we use and evaluate the new technique of digital 3D-mapping using structure from motion computational algorithms from underwater photos. We also show how the technology can be used in management and monitoring of coral reefs. 3D-models were created from 1x2 m squares and 25x2 m transects positioned on coral reefs in the Bazaruto archipelago, Mozambique. Filming was conducted with GoPro cameras, and modelling was done by using free and open photogrammetry software and a home pc with a medium-end graphics card. This shows that the method is available for rural, low-tech and low-budget environments. Complexity was measured as 3D-model area per square meter. The 3D-models resulted in increased accuracy, resolution and relevance with the actual 3D-structure, compared to traditional chain-tape-measurements. Fish abundance and species richness data was also collected along the 25m transects and bite rates of important herbivorous fishes were estimated from the filmed square plots. This was combined with the 3D-modelled rugosity data to describe the effect of coral complexity on fish assemblages and herbivory. With a suite of potential management applications, the structural models are useful as a reference of the state of the reef, to be used in monitoring to detect future and ongoing coral reef change and subsequent impact on fish communities.