Comparing Reef Monitoring Methods for Subtropical Coral Reefs in South Africa

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Background

Structural characteristics of coral reefs underlie a great deal of the variation in ecosystem processes, niche availability and patterns in community composition. Monitoring these structural characteristics is informative for understanding the dynamics of these biodiverse habitats in the face of global change. For the last 25 years, the high-latitude coral reef communities of Sodwana Bay, on the east coast of South Africa, have been extensively monitored by analysing two-dimensional (2D) photos of the reef substratum by means of photo-quadrat digitisation and the point-based software, Coral Point Count (CPCe). This is one of the longest running continuous coral monitoring programmes in the world and the method used was state-of-the-art when instituted and has provided a wealth of information on reef community composition and dynamics. Recent advances in photographic technology, computing power and programming have provided new methods that might add new dimensions to this programme, particularly three-dimensional (3D) information. Structure from Motion (SfM) photogrammetry produces exactly this, through construction of digital 3D models of areas that allow measurements of aspects of physical structure. This provides an opportunity to explore some of the variability in reef communities and interactions. The question arises, how does the method compare to the current monitoring methods in terms of accuracy and efficiency? Are the additional structural metrics worthy of inclusion and do they justify the effort? This study's objectives include: a) evaluating and comparing each method's ability to survey an artificial reef; b) extending this to the current monitoring sites to determine if greater efficiency in the method might allow expansion of the area monitored; and c) assessing and comparing measures of structural complexity and community composition between a newly recolonised area of reef with an established reef community to investigate the interaction of coral community composition with reef structural characteristics.

Methods

An artificial reef, constructed from basic 3D shapes was surveyed using photogrammetry, photo-quadrat digitisation and random point counts. Several metrics were measured, including surface area, volume, perimeter of the shapes and percentage cover for comparison with manually calculated geometries (ground-truthed values). SfM photogrammetry involved capturing images along transects boustrophedonically, followed by the construction of 3D models using Agisoft Photoscan. Metrics were then extracted from this model in Agisoft and GIS software. For comparison of this approach with photo-quadrat digitisation and CPCe analysis, images were taken along transects using photo-quadrats, and were stitched together and digitised for metric extraction in GIS software as well as overlaid with random points within CPCe for analysis of community composition. The accuracy of measurements, their ability to provide relevant metrics, and the cost and effort of implementation were compared between methods. Each of these methods was used to survey the four fixed transects at the

Nine-mile Reef monitoring site and four alternative sites within the reef complex for method assessment. Lastly, triplicate 10-m transects were surveyed using photogrammetry and photo-quadrats in a recently senesced patch of reef undergoing recolonisation, and in an adjacent established reef community, in order to compare structural complexity and percentage coral community composition between the two states of succession.

Results

Here we present a detailed comparison of methods to develop an enhanced protocol for monitoring coral reef communities, encompassing as many useful variables as can be achieved. We show that the digital area analyses were far more time-consuming and laborious in both the SfM photogrammetry and photo-quadrat methods in comparison to CPCe due to the need for image digitisation. We demonstrated that the 3D approach however, may necessitate more computer processing, dependent on several factors, including the intended spatial scale at which the monitoring efforts are to be employed, and the aims of the study. CPCe provided a fast, simple method for collecting community composition data, but provided only an instantaneous snapshot of this, with no other ecologically valuable information on processes such as coral mortality or recruitment. Photogrammetry could thus make a valuable contribution to the current long-term monitoring protocol used on South African coral reefs, and its measurements were found to have an accuracy comparable to the current digitisation method. SfM photogrammetry has the advantage of providing several more structural metrics such as rugosity, height and slope, but was marginally more costly in terms of the equipment and software required for computer processing. The structural characteristics measured were found to vary between the recolonising reef patch and adjacent stable community, and were associated with the coral community composition at each site.

Conclusion

This study thus identified an appropriate strategy for supplementary monitoring techniques on the Sodwana Bay coral reefs, and photogrammetry proved its utility in quantifying differences between a recolonising area of reef and an adjacent established community. This 3D approach therefore has the advantage of providing additional information on the reef profile, while having the disadvantage of more processing demands. A final determination of whether the cost-benefit ratio for the photogrammetry technique justifies its inclusion in monitoring protocols, depends on its ability to provide relevant metrics to meet study objectives without greatly increasing cost, either financially or in man-hours.

Potential themes:

Critical habitats and Coastal and marine technologies supporting management