Employing 3-D coral reef remote sensing to predict fish biomass

April 16 2019, by Michelle Horton

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Coral reefs offer many tropical fish a vibrantly encrusted locale of refuge – a respite from the intense pressures of the sea – providing an opportunity for protection, nutrition and even reproduction. At the mercy of a warming ocean due to climate change, reefs are experiencing more frequent and damaging coral bleaching events, leaving fish (and other ocean dwellers) with barren accommodations in areas once ripe with life.

Research published this week in *Remote Sensing in Ecology and Conservation* employs a new approach of combining two-dimensional and three-dimensional remotely sensed seascape models to more accurately identify complex reef structure, and the populations of fish living within them. Creating cost effective and accurate spatial methods of identifying coastal "hotspots" is an essential step in the creation of effective management plans for marine protection and conservation.

"Mapping and placing value on reef areas that represent important biodiversity hotspots are important for coastal communities that rely on healthy reef fish populations for food, tourism and culture. This information can help to inform urgently needed management actions to sustain healthy reefs and healthy coastal communities," said research lead Lisa Wedding, Stanford Center for Ocean Solutions research associate and recently appointed associate professor at the University of Oxford, School of Geography and the Environment.

For a more accurate depiction of these underwater habitats, the team took a multi-faceted approach. To inform their models, the divers conducted standard underwater visual fish surveys at 625 transect study sites along the Main Hawaiian Islands, tallying the type and length of each fish species viewed. These nearshore locations varied in habitat types (such as coral reef and sea grass beds), marine conservation efforts (studying areas in and outside of marine-protected areas) along with mixed human impacts and shoreline exposures.

They then harnessed satellite data to create 2-D habitat maps at each site. While used widely in the past, using 2-D satellite data for coral reef mapping has limitations, as only planimetric (or horizontal) areas of habitats are accounted for rather than the total complex 3-D structure. In the case of coral reefs, elaborate habitat configurations indicate higher potential for biodiversity, a chief indicator of a healthy ecosystem.

The team turned to a technology called light detection and ranging (LiDAR), a remote sensing tool that uses light in the form of a pulsed laser to measure variable distances. This allowed them to create 3-D models, bringing to life the true complexity of the coral reef seafloor. Equipped with this information, the researchers were able to create predictive models of the reef fish community, based on the collected habitat data. Surprisingly, the most effective model was a combination of the 2-D and 3-D LiDAR satellite data, which most accurately predicted coral reef fish diversity, biomass and density.

"We found that 2-D characterization of the seafloor does not capture the intricate relationships between reefs and fish communities, and the application of LiDAR in this work helps to advance seascape ecology theory and application in the third dimension," said Wedding.

Seascape ecology is an emerging applied science that focuses on understanding the consequences of spatial patterns in the ocean and is the topic of a new book, *Seascape Ecology*, edited by Simon J. Pittman, co-authored by Lisa M. Wedding, and published by Wiley.

The researchers also noted that marine protected areas consistently experienced higher fish diversity and biomass. Meaning management of fisheries plays a fundamental role in marine conservation and should not be overlooked. This also suggests that creating marine protected areas where complex 3-D reef structures exist may be key in establishing more resilient ocean ecosystems, able to recover more quickly from future bleaching events or other damaging forces.

"Understanding the seascape from a 3-D perspective offers great potential to advance our knowledge of coral reefs," Wedding said. "LiDAR remote sensing allows us to capture the intricate 3-D vertical structure of coral reefs and understand where habitats have high conservation value to inform future ocean planning efforts. Our research supports the design of marine protected areas in these locations, which should be a management priority, as habitat complexity can enhance reef resilience and recovery."

Looking forward, the Stanford Center for Ocean Solutions plans to collaborate with the University of Oxford and Arizona State University to scale-up this novel remote sensing approach to map coral reef risk and resilience in Palau. The technique supports management of more resilient species and provides a more rapid approach to monitoring coral reef health, allowing managers to better allocate resources for bleaching events and coral recovery.

More information: Lisa M. Wedding et al. Remote sensing of three-dimensional coral reef structure enhances predictive modeling of fish assemblages, *Remote Sensing in Ecology and Conservation* (2019). DOI: 10.1002/rse2.115

Provided by Stanford University

Citation: Employing 3-D coral reef remote sensing to predict fish biomass (2019, April 16) retrieved 28 April 2024 from https://phys.org/news/2019-04-d-coral-reef-remote-fish.html