

RETHINKING COLLABORATION FOR CORAL REEF SCIENCE

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The narrative that scientific advancement requires effort from one dedicated individual, the “mad” scientist cutoff from the help of others, is being replaced by new generations of scientists. This new wave of scientists is adept in communication, cooperation, and allocation of unique skills to solve a unified problem. This type of collaboration is reflected as an increase in the average number of authors per paper within all disciplines (Mallapaty 2018), establishment of national and international research centers, and a rise of Big Science, in which the scale and comprehensiveness of research projects have increased (Price 1963; Westfall et al. 1993). Indeed, scientific collaboration is widespread and growing.

Coral reef science presents a unique case for collaboration between highly varied disciplines due to the overwhelming network of biota and the complex interactions with humans and climate, from local to global scales. Current and future collaborations are further placed under the pressure of a “timer,” since it is expected that the majority of coral reefs will experience annual severe bleaching by the mid-2050s (van Hooidonk et al. 2016). To adapt to this, collaboration encompassing coral reefs cannot just include working across different laboratories to publish scientific papers, but must incorporate a holistic approach beyond academia that heeds the complex and highly interconnected nature of reefs. Studying the reef system requires precise cooperative planning and allocation of international resources to achieve unified and agreed upon goals. We identified two forms of collaboration that have shown to be promising avenues to improve understanding and conservation of reefs: collaboration within scientific research and collaboration of scientists with local coral reef communities.

BIG SCIENCE PRESENTS OPPORTUNITIES FOR CORAL REEFS

The ticking clock on coral reef ecosystems as we know them requires extra diligence in coordinating research efforts around primary understanding and how to directly implement our

findings. Each scientific action must be well planned and pointed towards a common goal, similar to those described by the recent Convention on Biological Diversity (UNEP 2019). In this plan, the unique approach of each scientific laboratory should be viewed as a unique puzzle piece that describes one (or several) of the key parameters of a reef system. The wide array of approaches to understand reefs can be seen as a reflection of the multitude of interactions that affects the coral holobiont itself (Czieielski et al. 2019). Approaches can be broadly categorized by discipline, such as sociopolitical science, economics, geology, ecology, chemistry, and climate. Variation within these broader disciplines can then be defined at the research group level by the unique approach to the reef system, i.e., the shape and area of coverage of the puzzle piece. How can we most effectively put these puzzle pieces together to build a full action plan to maximize benefit to the reefs and use resources most effectively?

We propose that to start this process as a community, we must establish committees to lay out the most immediate and important scientific goals that enable reef preservation worldwide. Committees of broad disciplines (ecology, chemistry, etc.) would have several community-nominated (with consideration of diversity and inclusion initiatives to avoid selection bias) and elected principal investigators whose research interests represent the discipline well. Committee meetings would take the form of an informal working group that could fit well into preexisting meetings, such as a Gordon or NCEAS (National Center for Ecological Analysis and Synthesis) conference. Before meeting, these committees would be responsible for sending out online surveys and communicating with scientists within their discipline to assess discipline level goals. These goals would then be formulated and communicated with the committees of other disciplines to establish overarching scientific goals and beneficial collaborations for our understanding and conservation of coral reefs. A 4-yr recurring report written by committee members with clearly defined goals for the scientific community would then serve as a framework for researchers moving forward. Formulation of these committees and dissemination of collaborative goals could be generated as a component of a preexisting organization, such as the International Coral Reef Initiative, with an emphasis on scientific goals for required understanding

of reef systems. As we have all seen from the COVID-19 pandemic, a large degree of scientific work can be completed online and this could be done just the same. While the exact form of collaboration between research groups may vary, it seems clear that increased communication and community defined goals for knowledge are necessary if we are to support global coral reef preservation moving forward.

MEANINGFUL ENGAGEMENT AND INCLUSION OF LOCAL COMMUNITIES

Perhaps the most often acknowledged but least applied form of collaboration in reef science is with local communities that live on or near coral reefs. Many of these communities have a deep empirical and historical knowledge of the function of their reefs over time whereas scientific research is typically restricted to short visits (<1 yr) with brief to no temporal coverage. For modern understanding, local communities reside on reefs year-round and are in a unique position to greatly strengthen understanding of reef systems by conducting year-round observations and studies, particularly for understudied and remote reefs. Consultation of local people for traditional ecological knowledge provides high temporal coverage understanding of the reef and has been used for management strategies (Thornton and Scheer 2012), but a gap still remains between current scientific studies and local communities, creating a scientific inequity. If we are to have the most complete understanding of coral reefs and provide scientific equity to all groups involved with reefs, there needs to be meaningful teamwork with local peoples in research projects.

Local community inclusion must extend beyond a relay of information on what foreign scientists are doing on their reefs and needs to include elements such as reciprocal training (Baines 1992), community-based monitoring (Obura et al. 2002), comanagement (Fernandez-Gimenez et al. 2006), and long-term partnership (Moller et al. 2009). Offering work-for-pay opportunities and including local communities from the very beginning of projects would establish inclusion and scientific equity and would garner participation for year-round research of coral reefs. Employing local collaboration practices in rural reefs, where there is no well-established research station would also aid in filling the large gaps in our knowledge of understudied reefs (Fisher et al. 2011). Local community inclusion sets up a tone of shared

responsibility to protect indispensable natural resources. One such example comes from a partnership between scientists and communities in Palau in which sedimentation stress to coral reefs was alleviated by designing taro fields to better trap sediment and moving them higher up in the watershed to protect the reefs (Richmond 2014). The benefits are immediate and long-lasting once ties are established. Local community inclusion sparks discussions of reef health and changes on an international scale and beyond the scientific community. With such a small amount of time left to preserve reef health, we must gather and incentivize the efforts of everyone that is willing to help.

Collaboration to improve our understanding and protection of coral reefs worldwide is not only an exercise in large scale teamwork to achieve a goal, but an exercise of inclusion of diverse views and establishing trust across borders and backgrounds. Large-scale scientific collaboration, once established, will produce greater products than the sum of the efforts involved. Meaningful partnership between diverse scientific interests and local communities living with the reefs will facilitate a unified approach to protect reefs globally and lead to increased coastal resilience and climate mitigation strategies of at-risk regions. The underlying effort and success of developing a well-informed society lies in everyone's commitment to communicating and cooperating across sectors and disciplines, with some levels of sacrifice for a common unified goal being paramount. As a scientific community we must exercise our social skills as much as possible, and work with people far outside our disciplines if we are to ensure a future of coral reefs worldwide.

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