

# Moorea Coral Reef LTER

The Moorea Coral Reef (MCR) LTER program studies the coral reef ecosystem surrounding the island of Moorea, French Polynesia in the central South Pacific. Moorea Coral Reef LTER research is dedicated to understanding coral reef function and how this is affected by natural and human forces. In its first 15 years, MCR LTER has altered scientific paradigms regarding how coral reef ecosystems respond to disturbances such as hurricanes, chronic stressors from local human activities (eutrophication, fishing), and global change (ocean acidification, rising ocean temperature).

Moorea Coral Reef LTER has uncovered key attributes that govern contemporary reef community resilience and factors that will shape future communities in a warmer, more acidic ocean. Through conceptually-driven time series and process measurements, field and mesocosm experiments, and modeling, MCR researchers have developed a deep mechanistic understanding of ecosystem dynamics and functioning, and are positioned to forecast the effects of intensifying global change and the expanding human footprint on oceanic coral reef ecosystems.



Between 2008-2018:

**42** investigators

**14** institutions represented

**84** graduate students



Coastal

Principal Investigator:

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University of California,  
Santa Barbara

Est. 2004

Funding Cycle:

LTER III

NSF Program:

Geosciences /  
Division of Ocean Sciences /  
Biological Oceanography





# Key Findings

## **Ocean acidification (OA) is an emerging threat.**

Researchers at MCR LTER have been at the forefront of evaluating how OA will affect the structure and function of future reefs. The ecosystem engineers that structure coral reefs – stony corals and calcified algae – are uniquely threatened by low seawater pH. Using time series data to determine experimental conditions, researchers have tested for coral susceptibility to low seawater pH, the dependence of these responses on space, time, and functionality scales, and the implications for future coral reefs. [Products 1, 2]



## **Unprecedented resilience of coral communities.**

The diverse coral community on Moorea's outer reefs has repeatedly shown a remarkable ability to recover rapidly following massive

disturbances. In the last

decade, a predator outbreak and cyclone devastated coral across the seascape, yet recovery was more rapid than has been observed anywhere in the world. Moorea Coral Reef LTER researchers have gained critical insights into the processes, connectivities, and feedbacks governing coral reef resilience. This has provided the basis for general management strategies to help restore and strengthen coral reef community resilience. [1-3]

## **Coral reefs are vulnerable to disturbance-induced regime shifts.**

Reefs worldwide have abruptly and increasingly shifted from coral to seaweed dominated communities.

Experiments at MCR LTER revealed that a large disturbance can cause a coral reef to flip to seaweeds indefinitely. Experiments and models showed that multiple stable states (e.g. corals or seaweeds) can continue to thrive under the same levels of herbivory. They also discovered that the seaweed state is stabilized by the development of structural and chemical defenses that reduce the palatability of mature (but not juvenile) algae [6].

## **Microbes and the future of coral reef function.**

The powerhouse mutualism between the coral animal and its symbiotic dinoflagellate algae is the backbone of coral reef ecosystems. Moorea Coral Reef LTER research has produced counter-intuitive results, specifically that flexibility with respect to symbionts does not automatically make corals resilient – a finding that has had profound implications for understanding the susceptibility of coral colonies to stress. Similarly, MCR LTER researchers have shown that major feedbacks involving other microbes affect coral health, particularly bacteria key to the dynamic nutrient cycling on reefs. [7-8]







# Synthesis

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**Alternative futures for coral reefs.** The MCR LTER has played a global leadership role in synthetic efforts to understand the state of coral reefs and their future in warmer, more acidic oceans. The extraordinary resilience of Moorea’s reefs has motivated collaborations with the National Center for Ecological Analysis and Synthesis (NCEAS) to identify winners and losers among coral fauna, and more recently, synthesis work at the Powell Center to address reef “oases”. Multiple international efforts through the Okinawa Institute of Science and Technology have explored the roles of recruitment and connectivity in fueling reef

resilience. Core time series data on biological, physical, and chemical conditions around Moorea have been integrated in MCR-led syntheses. These projects addressed dynamic variation in seawater pH, the global threats of ocean acidification and their scale-dependence, reef resilience, and variation in coral growth rates [9].

**The global human footprint on coral reefs.** Moorea Coral Reef LTER investigators and MCR time series datasets have contributed to multiple synthesis projects on the relationship between coral reef biodiversity and human activities from regional to global scales [10].



## Data Accessibility

Since the site was established in 2004, the MCR LTER data repository has managed a publicly accessible online catalog of core data. Data are uploaded to the the Environmental Data Initiative (EDI) repository, including links between datasets and publications. Core data are also shared publicly in databases such as BioTIME (Dornelas et al. 2018. *Global Ecology and Biogeography*. 27: 760-786) and the Coral Traits Database (Madin et al. 2017. *Scientific Data*. 4: 170-174).

## Partnerships

University of California, Santa Barbara (UCSB) | California State University Northridge (CSUN) | UC Office of the President



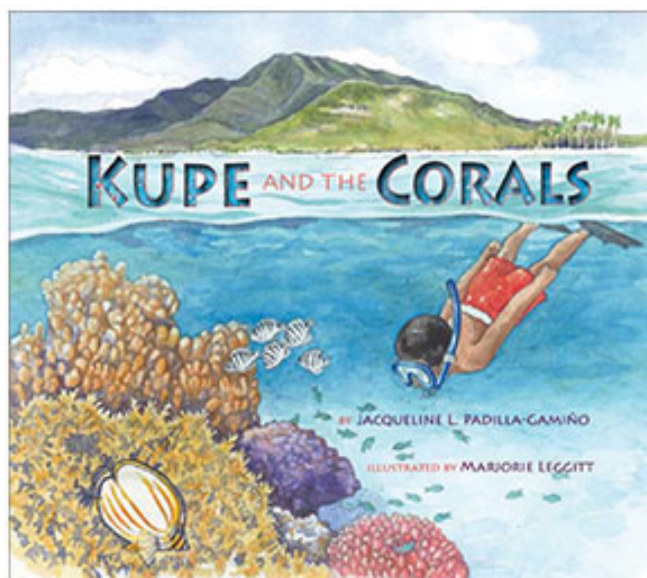
# Broader Impacts

**From the classroom to the reef.** Each year, undergraduate students mentored by MCR LTER investigators and graduate students (192 since 2008) spend three months conducting subtidal research, working with oceanographic instruments and sensors, and learning the logistics of field operations. Surveys indicate that >90% of these students go on to pursue advanced degrees in the environmental sciences.

**Building science literacy.** The MCR LTER Research Experience for Teachers (RET) program enables grade 3-12 teachers in California to increase their marine science knowledge through sponsored teacher workshops. Since 2008, 7 teachers have worked directly with MCR researchers, and 3 participated in a two week oceanographic cruise around Moorea.

**Magnet school partnership.** Since 2005, the MCR LTER Schoolyard Program has partnered with teachers and 1,500+ students at Washington Elementary STEM Magnet School in Pasadena, CA (student body 87% socioeconomically disadvantaged; 36% English language learners). Investigators work with teachers to develop classroom materials based on MCR science and data. Each year, 5<sup>th</sup> grade

students from Washington Elementary visit UC Santa Barbara for a science exploration day that includes hands-on learning at the REEF (Research Experience and Educational Facility), presentations, and active learning exercises led by MCR LTER graduate students.



**Kupe and the Corals.** The children's book, *Kupe and the Corals*, tells the story of a young Tahitian boy who, after capturing a coral larva one night, begins a voyage of scientific and cultural discovery. The book has been published in English, Spanish, French, Hawaiian, Tahitian, and Paumotu for use throughout southern California, Hawaii, and French Polynesia.

## Top Products

1. Comeau, S et al. 2015. Ocean acidification accelerates dissolution of experimental coral reef communities. **Biogeosciences**. doi: 10.5194/bg-12-365-2015
2. Comeau, S et al. 2016. Framework of barrier reefs threatened by ocean acidification. **Global Change Biology**. doi: 10.1111/gcb.13023
3. Holbrook, SJ et al. 2018. Recruitment drives spatial variation in recovery rates of resilient coral reefs. **Scientific Reports**. doi: 10.1038/s41598-018-25414-8
4. Edmunds, J et al. 2018. Density-dependence mediates coral assemblage structure. **Ecology**. doi: 10.1002/ecy.2511
5. Adam, TC et al. 2011. Herbivory, connectivity, and ecosystem resilience: response of a coral reef to a large-scale perturbation. **PLOS ONE**. doi: 10.1371/journal.pone.0023717
6. Schmitt, RJ et al. 2019. Experimental support for multiple attractors on coral reefs. **PNAS**. doi: 10.1073/pnas.1812412116
7. Putnam, HM et al. 2012. Endosymbiotic flexibility associates with environmental sensitivity in scleractinian corals. **Proceedings of the Royal Society B – Biological Sciences**. doi: 10.1098/rspb.2012.1454
8. Nelson, CE et al. 2013. Coral and macroalgal exudates vary in neutral sugar composition and differentially enrich reef bacterioplankton lineages. **ISME Journal**. doi: 10.1038/ismej.2012.161
9. Edmunds, PJ et al. 2016. Integrating the effects of ocean acidification across functional scales on tropical coral reefs. **Bioscience**. doi: 10.1093/biosci/biw023
10. Cinner, JE et al. 2016. Bright spots among the world's coral reefs. **Nature**. doi: 10.1038/nature18607

Photo credits: MCR LTER; Russell Schmitt (bottom page 2); Marjorie Leggitt (above)