Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

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BSc (University of Hawaii at Hilo, 2012)

“Coral Symbioses Under Stress: Spatial and Temporal Dynamics of Coral-Symbiodinium Interactions”

Department of Biology

Monday, November 26, 2018
2:00 P.M.
Clearihue Building
Room B007

Supervisory Committee:
Dr. Julia Baum, Department of Biology, University of Victoria (Supervisor)
Dr. Steve Perlman, Department of Biology, UVic (Member)
Dr. Ryan Gawryluk, Department of Biology, UVic (Member)
Dr. Brian Starzomski, School of Environmental Studies, Uvic (Outside Member)

External Examiner:
Dr. Tracy Ainsworth, School of Biological, Earth and Environmental Sciences,
The University of New South Wales

Chair of Oral Examination:
Dr. Dr. George Simandl, School of Earth and Ocean Sciences, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies
Abstract

Coral reefs, the planet’s most diverse marine ecosystems, are threatened globally by climate change and locally by overfishing and pollution. The dynamic partnership between coral and their endosymbiotic algae (Symbiodinium) is the foundation of all tropical reef ecosystems. Symbiodinium provide coral with nutrients for growth, but stress can break down this symbiosis, causing coral bleaching. There are also life-history tradeoffs amongst Symbiodinium types - some provide coral with more nutrition, while others are better able to cope with environmental stressors. Although these symbioses are believed to be a critical element of reef resilience, little is known about how local and global stressors alter these partnerships. In this thesis, I combine synthetic literature reviews and a meta-analysis, with field research, molecular analyses, bioinformatics, and statistical analyses to investigate environmentally-driven mechanisms of change in coralsymbiont interactions with the aim of advancing understanding of how corals will adapt to the stressors they now face.

First, I conducted a review of coral-Symbiodinium interactions, from molecules to ecosystems and summarized the current state of the field and knowledge gaps. Next, I conducted a meta-analysis of coral bleaching and mortality during El Niño events and created an open-source coral heat stress data product. I found that the 2015-2016 El Niño instigated unprecedented thermal stress on reefs globally, and that, across all El Niño events, coral bleaching and mortality were greater at locations with higher long-term mean temperatures. I provided recommendations for future bleaching surveys, and in a related perspectives piece, highlighted the importance of survey timing during prolonged coral bleaching events.

The latter three empirical chapters are based on my six field expeditions to Kiritimati (Christmas Island). Taking advantage of the atoll’s natural ecosystem-scale experiment, I tagged, sampled and tracked over 1,000 corals across its chronic human disturbance gradient. Since corals can uptake Symbiodinium from the surrounding environment, I first investigated the effect of local disturbance and winter storm waves on Symbiodinium communities in coral, sediment, and seawater. Greater variability in Symbiodinium communities at highly disturbed sites suggests that local disturbance destabilizes symbiont community structure. Since local disturbance influences Symbiodinium communities and coral-associated microbial communities, I next examined the covariance of coral-associated Symbiodinium and microbial communities for six coral species across Kiritimati’s disturbance gradient.

Most strikingly, I found corals on Kiritimati that recovered from globally unprecedented thermal stress, experienced during the 2015-2016 El Niño, while they were still at elevated temperatures. This is notable, because no coral has previously been documented to recover from bleaching while still under heat stress. Only corals protected from local stressors exhibited this capacity. Protected corals had distinct pre-bleaching algal symbiont communities and recovered with different algal symbionts, suggesting that Symbiodinium are the mechanism of resilience and that protection governs their communities.

Together, this research provides novel evidence that local protection may be more important for coral resilience than previously thought, and that variability in symbiotic and microbial communities provides a potentially flexible mechanism for corals to respond to both local and global stressors.