CORAL RESILIENCE UNDER GLOBAL CHANGE

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAIʻI AT MĀNOA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

OCEANOGRAPHY

MAY 2016

By

Christopher P. Jury

Dissertation Committee:

Robert J. Toonen, Chairperson
Eric H. De Carlo
Kathleen C. Ruttenberg
Jeffrey C. Drazen
Megan J. Donahue

Keywords: coral, reef, calcification, ocean acidification, climate change

ABSTRACT

Corals and reef ecosystems appear to be highly sensitive to environmental change, especially ocean acidification and climate change. In spite of this apparent sensitivity, however, corals have a long evolutionary history and have survived through many episodes of global change in the geologic past. This paradox of apparent sensitivity combined with resilience makes reef-building corals an ideal platform to examine the responses of organisms, populations, and ecosystems to rapid, global change. First, the environmental and biological drivers of reef building over geologic time are reviewed and thresholds are identified in rates of environmental change beyond which a reef crisis is likely to result. Next, the chemical drivers of coral calcification are examined. Rather than direct dependence on aragonite saturation state, as has often been assumed, coral calcification is shown to be co-dependent on dissolved inorganic carbon and seawater pH. These results alter predictions of reef responses under ocean acidification and climate change and suggest that high latitude areas may provide reefs with refuges under global change, consistent with responses in the geologic record. Next, the influence of reef geochemistry on seawater chemistry is considered as a possible mechanism to provide local refugia from ocean acidification on coral reefs. Under the most extreme scenarios considered, changes in reef geochemistry can provide corals and other calcifiers with a partial refuge from ocean acidification, but at the expense of a collapse in reef-scale calcification. Finally, the potential for corals to adapt or acclimatize to anthropogenic global change are examined through a combination field and experimental approach. Here I show the first evidence that corals can mount an adaptive response to both ocean acidification and climate change over the decadal timescales relevant to global change, but that there are still limits to the scope for

adaptation. With substantial cuts in anthropogenic carbon dioxide emissions, this work predicts that many coral species and many coral reefs could adapt and survive under moderate acidification and warming, but reefs are predicted to suffere severe declines under worst-case global change scenarios. Together, these results show that corals and coral reefs have the capacity to respond to moderate levels of global change, they indentify possible refugia for corals during periods of reef crisis, and give hope that reducing human impacts on coral reefs offers a feasible pathway toward effective coral reef conservation over coming decades.