MEDIATION OF GLOBAL CHANGE BY LOCAL BIOTIC AND ABIOTIC INTERACTIONS

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DECLARATION

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Laura Falkenberg and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

Laura J. Falkenberg
September, 2012

Cover image: An area of turf-forming algae (dominated by *Feldmannia* spp.) that has colonised much of the free space created by a disturbance within an area of kelp canopy (*Ecklonia radiata*) on the metropolitan Adelaide coastline.
Photo: Sean Connell.

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ABSTRACT

Variation in environmental conditions is a pervasive feature of natural systems that has profound consequences for the structure of ecological communities. As a result of altered local conditions produced by human urbanisation, shifts in marine habitats from kelp forests to mats of turfing algae are increasingly common. Forecasting whether such ecological change will be accelerated or reversed as a function of modified global conditions is a new form of ecological enquiry. Throughout this thesis, I assessed the conceptual model that while cross-scale abiotic stressors can combine to have interactive effects, management of local conditions can counter-balance this change. My experimental manipulations were intended to test the hypotheses that; 1) cross-scale factors (i.e. local and global) will have interactive effects that increase the probability of expansion of turfs but not kelp, and, 2) management of local conditions (e.g. presence of biota, nutrient enrichment) will dampen the effects of global change on turfs (e.g. forecasted CO_2).

Change in ecological communities is anticipated where altered environmental conditions have contrasting effects on interacting taxa that determine their composition and relative abundances. Experimental enrichment of CO_2 and nutrients influenced biomass accumulation of turf and kelp differently, with turf responding positively to enrichment of both resources while kelp responded to enrichment of nutrients but not CO_2. These responses likely reflect resource limitations experienced by the algae, as stoichiometry indicated turf was co-limited by CO_2 and nutrients while kelp appeared to be limited by nutrients but not CO_2. Simultaneous enrichment of these factors would, consequently, be anticipated to facilitate the expansion of turf algae at the expense of established kelp canopies.

Considerable attention has focused on the influence of altered conditions on single taxa in isolation, yet such approaches only elucidate direct response(s). In natural systems, these responses may be mediated by indirect effects resulting from interactions with other taxa. I assessed the model that biotic interactions

(i.e. competition and herbivory) can counter the abiotic drivers of change. Experimental tests revealed the presence of kelp inhibits the synergistic positive effects of stressors (i.e. CO_2 and nutrient enrichment) on their turf competitors, likely due to the modification of physical conditions (i.e. light availability). Similarly, rates of herbivory increased to counter the positive effects of stressors on turfs under enriched CO_2 (i.e. increased grazing of turfs by gastropods). This increase in herbivory was attributable to the changes in stoichiometry of algal turfs under the greater availability of this resource. Together, these results indicate potential for indirect effects, mediated by species interactions, to counter the direct influence of altered environmental conditions.

Where biotic controls are absent, however, such modification of resource availabilities may increase the probability of the expansion of novel habitats. I considered the hypothesis that where human activities combine to synergistically benefit turfs (as occurs where CO_2 and nutrients are enriched), removal of one factor alone may enable further change to be slowed or recovery hastened. Experimental tests that reduced the locally-determined factor (i.e. reducing nutrients under continued CO_2 enrichment) substantially slowed further expansion of turf algae, but the legacy of nutrient enrichment was not entirely eradicated. This result indicates that although management of local environmental conditions may substantially reduce the effects of entrained global change, some effects could be enduring.

In summary, there was broad support for the conceptual model that cross-scale abiotic stressors can combine to interactively affect algal communities, but that such change can be countered by management of local conditions, both biotic (i.e. retaining the processes of competition and herbivory) and abiotic (i.e. removing pollutants). These results represent progress in ecological tests of hypotheses regarding global climate change as they incorporate comprehensive sets of abiotic and biotic community drivers. Further, this thesis contributes new knowledge regarding the anticipated responses of marine communities to local through global scale pollution, and the potential for local conditions to mitigate the effects of global change.

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Chapter 2

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Chapter 3

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Appendix A

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