

Benthic diatom communities  
of coastal marine environments  
in the Windmill Islands, Antarctica

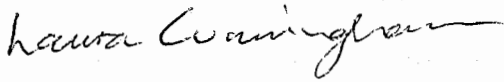
By

Laura Kay Cunningham, BSc. Hons.

Submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy,  
University of Tasmania, May 2003.

## Declaration

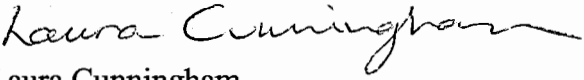
This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution and, to the best of my knowledge, no material previously published or written by another person except where duly acknowledged in the text of the thesis.

A handwritten signature in cursive script, reading "Laura Cunningham". The signature is written in dark ink and is positioned above the printed name.

Laura Cunningham

## Authority of Access

This thesis may be made available for loan and limited copying in accordance with the *Copyright Act, 1968*.

  
Laura Cunningham

## *Abstract*

This project examined the effects of ecological factors and anthropogenic contaminants on benthic diatom communities near Casey Station, in the Windmill Islands, Antarctica. Preliminary sampling indicated significant compositional differences occurred between diatom communities in bays immediately adjacent to Casey Station and those more distant. Subsequently, a more detailed appraisal of spatial variability in benthic diatom communities was undertaken. Significant differences in community composition were demonstrated for all scales examined, however, increased distances between samples typically corresponded to increased dissimilarity.

The influence of environmental factors on spatial variability was assessed using direct gradient ordination techniques. Grainsize, particularly the mud content, accounted for the majority of variation in diatom abundances explained by the measured environmental variables. Differences in light availability, water depth and grain-size explained 60% of the variation in community composition observed between locations. The remaining 40% of the variation in diatom community composition remains unexplained; potential causes include freshwater input, and chemical contamination.

A preliminary analysis of temporal variability in benthic diatom communities from the Windmill Islands is presented. Seasonal, short-term (100's of years) and long-term (1000's of years) changes in community composition were examined at several locations. Temporal variability of the diatom communities within Brown Bay was also assessed, in conjunction with metal and  $\text{Pb}^{210}$  data. Within one core, a shift in community composition was detected subsequent to the onset of chemical contamination. Some changes in species abundance exceeded the natural variability observed in control cores, and thus were attributable to chemical contamination.

Relationships between diatom abundances and concentrations of different metals within Brown Bay were examined using direct gradient analyses. Approximately 50% of the variation in the diatom community composition was related to metal concentrations. Further clarification of the interactions between metals, sediment grain-size and diatom community composition would be required prior to the development of predictive models. Direct gradient analyses also demonstrated a weak correlation between diatom community composition and hydrocarbon distribution.

Manipulative field experiments were used to demonstrate that the composition of diatom communities can be influenced by both metal and hydrocarbon contaminants at concentrations comparable to levels produced by station activities. This supports the conclusion that anthropogenic contaminants are responsible for some compositional differences observed in diatom communities, both within Brown Bay and between Brown Bay and reference locations.

## Acknowledgements

First and foremost, I would like to thank my parents and sister for their continued love, support and encouragement throughout this project, and indeed my life. Without their support, the trials and tribulations of this project would have seemed so much greater. Words cannot express how much I appreciate having these people in my life. In addition to the emotional support they have provided me with, I would also like to thank them for their practical assistance with the editing and proof-reading of this thesis.

Secondly, I would like to acknowledge the guidance and support of both my supervisors, Andrew McMinn (University of Tasmania) and Martin Riddle (Australian Antarctic Division). Their support and advice throughout this project was invaluable. Their expertise and their ability to impart some of this knowledge to me enabled me to tackle a PhD project in an area where I had no previous experience. I would also like to thank Donna Roberts for being an unofficial 'mentor'. Donna was a sounding board for ideas, a great listener and fellow coffee drinker when I needed to talk, and also provided both encouragement and practical assistance throughout this project.

A number of people from the Human Impacts Program at the Australian Antarctic program have contributed to this project, both directly and indirectly, and I would like to thank them all. Particular thanks to: Jonathan Stark for sharing his knowledge of experimental design and biostatistics as well as providing me with sediment samples; Ian Snape for helping me skirt the quagmire of geochemistry and providing me with results from chemical analyses; and Rebecca Scouller who not only shared Pb<sup>210</sup> data which forms a significant part of her own research, but who also sub-sampled and prepared for chemical analysis most of the cores used in this project. Thanks should also be extended to Sarah Richard who, when she could spare the time from her own work, assisted me in the field during the 1999/2000 austral summer.

I am also indebted to Julian Finn for his assistance during the 2000/2001 field season at Casey. His positive attitude and willingness to undertake all tasks asked of him, combined with his practical ability in regard to boating work made him an invaluable part of this project. I would also like to thank Mike Connor, Squizzy Taylor and Gary Mayo for volunteering a significant amount of their time to help me with field work undertaken during this season. Members of both the 53<sup>rd</sup> and 54<sup>th</sup> ANARE to Casey Station contributed in many different ways to this project, and I am grateful for all their assistance. Special thanks to Mick Eccles for providing communication support, even when this necessitated starting at 3 am. Further logistical support was provided through the Australian Antarctic Division, and I would like to thank the many people involved with this.

Finally, a Tasmanian University Strategic Scheme Scholar ship enabled me to undertake this project, whilst financial support for field research and associated expenses was provided via grants from the Antarctic Science Advisory Committee to Martin Riddle and Andrew McMinn.

## Table of Contents

Chapter 1	<i>General Introduction.....</i>	1
Chapter 2	<i>Diatom assemblages in surface sediments of the Windmill Islands .....</i>	39
Chapter 3	<i>A preliminary assessment of human impacts on benthic diatom communities from the Windmill Islands.....</i>	53
Chapter 4	<i>Spatial variability of diatom communities in the Windmill Islands .....</i>	69
Chapter 5	<i>The influence of environmental variables on benthic diatom communities from the Windmill Islands.....</i>	91
Chapter 6	<i>Temporal variability of diatom communities in the Windmill Islands .....</i>	127
Chapter 7	<i>Is there historical evidence of human impacts on benthic diatom communities within Brown Bay? .....</i>	173
Chapter 8	<i>Are benthic diatom communities within Brown Bay related to the distribution of heavy metals? .....</i>	195
Chapter 9	<i>A preliminary assessment of the relationship between hydrocarbon concentrations and diatom communities within the contaminated Brown Bay.....</i>	213
Chapter 10	<i>The effects of sediment contamination on the development of benthic diatom communities .....</i>	227
Chapter 11	<i>The influence of heavy metals and petroleum hydrocarbons on benthic diatom communities in the Windmill Islands: an experimental approach .....</i>	245
Chapter 12	<i>Synthesis.....</i>	273
References	<i>.....</i>	287