

Effects of sedimentation on the structure of a  
phaeophycean dominated macroalgal community

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## Declaration

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

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## Table of Contents

DECLARATION	I
TABLE OF CONTENTS	II
LIST OF FIGURES	V
LIST OF TABLES	VII
ABSTRACT	IX
ACKNOWLEDGEMENTS	XI
PREFACE	XIII
<hr/>	
Chapter 1	1
<i>Aspects of macroalgal biology</i>	<i>I</i>
<hr/>	
1.1 AN INTRODUCTION TO MACROALGAE	2
1.2 BIOGEOGRAPHY ON A WORLD SCALE	3
1.2.1 Diversity in context	3
1.3 BIOGEOGRAPHY IN SOUTHERN AUSTRALIA	4
1.3.1 Biodiversity and Endemicity	4
1.3.2 Trends across the continent	7
1.4 ALGAL DOMINATION OF SOUTHERN AUSTRALIA'S ROCKY SHORES	9
1.5 FACTORS SHAPING A MACROALGAL COMMUNITY	11
1.5.1 Substrate and water quality	11
1.5.2 Depth and wave exposure	12
1.5.3 The influence of light on productivity	13
1.5.4 Biotic interactions	14
1.6 MACROALGAL LIFE HISTORY STRATEGIES	16
1.6.1 Order Laminariales	16
1.6.2 Order Fucales	18
1.7 STABILITY AND THE EXISTENCE OF ALTERNATE STATES	19
1.8 CONCLUDING REMARKS	21
<hr/>	
Chapter 2	23
<i>State of the Environment, Gulf of St Vincent, South Australia</i>	<i>23</i>
<hr/>	
2.1 INTRODUCTION	24
2.2 NATURAL HISTORY OF GULF ST VINCENT WITH SPECIAL REFERENCE TO THE CITY OF ADELAIDE	25
2.2.1 Oceanography	25
2.2.2 Coastal erosion – shoreline recession and dune erosion	27
2.2.3 Biogeography	27
2.3 THREATS TO ADELAIDE'S COASTAL AND MARINE ENVIRONMENT	28
2.3.1 Coastal Development	29
2.3.2 Sewage and industrial pollution	30
2.3.3 Catchment modification & stormwater channelling	32
2.3.4 Resource exploitation	33
2.3.5 Introduction of feral species	34
2.3.6 Sedimentation	35
2.4 ECOLOGICAL CONSEQUENCES	36
2.4.1 Species decline and loss	36

2.4.2	Seagrass dieback	36
2.4.3	Degradation of macroalgal communities	37
2.5	AN OPPORTUNITY TO STUDY IMPACTS ON REEF ENVIRONMENTS	38
2.5.1	Importance of southern Australian reef systems	38
2.5.2	Creation of a sedimentation event	39
2.6	RATIONALE FOR THE STUDY	39
2.6.1	Specific aims of the study	40
<hr/>		
	Chapter 3	41
	<i>Population structure of canopy forming species in Gulf St Vincent</i>	41
<hr/>		
3.1	INTRODUCTION AND RATIONALE	42
3.1.1	Objectives	44
3.1.2	Layout of methods and results	44
3.2	PART A – MATERIALS AND METHODS	46
3.2.1	Field Program	46
3.2.2	Age structure of juvenile canopy forming macroalgae	48
3.2.3	Testing for autocorrelation along a transect	48
3.3	PART A - RESULTS	51
3.3.1	Autocorrelation along transect lines	51
3.4	PART B – MATERIALS AND METHODS	53
3.4.1	Characterisation of adult community structure	53
3.4.2	The relationship between adult and juvenile assemblages	53
3.5	PART B – RESULTS	55
3.5.1	Adult Community Structure at the quadrat scale	55
3.5.2	The relationship between adult and juvenile assemblages	59
3.6	PART C – MATERIALS AND METHODS	63
3.6.1	Modelling quadrats with co-dominant assemblages	63
3.6.2	Links between assemblages in space	63
3.7	PART C - RESULTS	66
3.7.1	Modelling assemblage states	66
3.7.2	Adult community structure at a larger scale – the relationship between neighbouring assemblages	67
3.8	DISCUSSION	69
3.8.1	The presence of autocorrelation in the data	69
3.8.2	The structure of a canopy covered macroalgal stand	70
3.8.3	Relationship between adults and juveniles	73
3.9	SUMMARY AND CONCLUSIONS	75
<hr/>		
	Chapter 4	77
	<i>Effect of elevated sediment deposition on algal recruitment</i>	77
<hr/>		
4.1	INTRODUCTION AND RATIONALE	78
4.1.1	An opportunity to study the effects of sedimentation	78
4.1.2	Impacts of increased sediments	82
4.1.3	Objectives of this chapter – testing for an impact	82
4.2	MATERIALS AND METHODS	84
4.2.1	Experimental design	84
4.2.2	Comparison of adult structure	86
4.2.3	Comparison of juvenile structure	86
4.3	RESULTS	88
4.3.1	Comparison of adults	88

4.3.2	Juveniles	92
4.4	DISCUSSION	98
4.4.1	Comparisons based on the adult stand	99
4.4.2	Comparisons based on juveniles assemblages	100
4.4.3	Impact of the dispersed sediment plume on canopy forming macroalgae	102
4.5	SUMMARY AND CONCLUSIONS	105
<hr/>		
Chapter 5		106
<i>Temporal change in adult and juvenile communities</i>		<i>106</i>
<hr/>		
5.1	INTRODUCTION	107
5.1.1	Likely affects of the sediment plume	108
5.1.2	Temporal variability in environmental phenomena	108
5.1.3	Differences between localities that may confound analysis	110
5.1.4	Objectives of this chapter	111
5.2	MATERIALS AND METHODS	113
5.2.1	Summaries of climate data	113
5.2.2	Temporal comparisons	113
5.3	RESULTS	116
5.3.1	Climatic variation	116
5.3.2	Temporal comparisons based on the one year juvenile cohort	118
5.3.3	Temporal comparisons based on adult assemblage	122
5.4	DISCUSSION	128
5.4.1	Coherent patterns of temporal variation in macroalgal structure	129
5.4.2	Different temporal trajectories	132
5.4.3	The impact of the dispersed sediment plume	135
5.5	CONCLUSIONS	137
<hr/>		
Chapter 6		138
<i>Summary and conclusions</i>		<i>138</i>
<hr/>		
6.1	BACKGROUND	139
6.2	SUMMARY OF KEY FINDINGS	142
6.3	STABILITY AND SUCCESSION WITHIN MACROALGAL STANDS	144
6.4	WHAT REMAINS TO BE DONE	148
<hr/>		
References		150
<hr/>		
Appendix I		173
<i>Age determination in canopy forming macroalgae</i>		<i>173</i>
<hr/>		

## List of Figures

Figure 1.1 Major currents around southern Australia (after Jeffrey <i>et al.</i> 1990).	5
Figure 1.2 Marine biogeographic provinces of Australia (based on Womersley 1984).	7
Figure 2.1 Map showing the location of Adelaide within Gulf St Vincent.	24
Figure 2.2 Problematic locations along Adelaide's metropolitan shoreline.	30
Figure 3.1 Map of the study area showing the location of reefs.	46
Figure 3.2 Mantel correlogram based on combined data from all sites.	52
Figure 3.3 Mantel correlograms for each site.	52
Figure 3.4 Number of adult canopy individuals ( $n\ m^{-2}$ ) for each genus.	55
Figure 3.5 Composition of the identified assemblage states.	57
Figure 3.6 Graphical representation of quadrat data in species space.	58
Figure 3.7 NMDS ordination of one-year-old canopy forming taxa.	60
Figure 3.8 Average numbers of juvenile macroalgae under each canopy type.	61
Figure 3.9 NMDS ordination of real and modelled quadrat data.	66
Figure 4.1 Aerial photo showing the large plume created by the dredge.	81
Figure 4.2 Map of the study area showing the location of reefs.	84
Figure 4.3 Average number of adult individuals ( $n\ m^{-2}$ ) at each site.	89
Figure 4.4 Composition of each site in terms of the four assemblage states.	89
Figure 4.5 Canonical correlation based on adult canopy composition.	90
Figure 4.6 Canonical correlation using two-year cohort under a VLA canopy.	92
Figure 4.7 Average number of two-year-old individuals ( $n\ m^{-2}$ ).	93
Figure 4.8 Canonical correlation using one-year cohort under a VLA canopy.	94
Figure 4.9 Average number of one-year-old individuals ( $n\ m^{-2}$ ).	95
Figure 4.10 Canonical correlation using new recruits under a VLA canopy.	96
Figure 4.11 Average number of current season recruits ( $n\ m^{-2}$ ).	97

Figure 5.1 Southern Oscillation Index (SOI) data 1960 – 2002.	109
Figure 5.2 Problematic locations along Adelaide’s metropolitan shoreline	110
Figure 5.3 Map showing fetch lengths at the study site for different wind directions.	114
Figure 5.4 Average monthly sea temperatures at Pt Stanvac, South Australia.	116
Figure 5.5 Total monthly precipitation for the Adelaide area (Adelaide Airport).	117
Figure 5.6 Relative Exposure Index (REI), 1990 – 2000 for the study area.	118
Figure 5.7 Density of one-year-old juveniles under VLA canopies.	119
Figure 5.8 Canonical correlation of one-year-old juveniles under a VLA canopy.	120
Figure 5.9 Average number of adult canopy individuals at each site.	122
Figure 5.10 Total number of VLA type quadrats surveyed over the four years.	123
Figure 5.11 Average proportion of quadrats belonging to each community type.	123
Figure 5.12 Canonical correlation of adult assemblages for each year of the study.	126
Figure 6.1 Basic transition state model.	146
Figure 6.2 Transition state model using a spatial context.	147

## List of Tables

Table 1.1 World comparison of algal biodiversity (based on Womersley 1990).	4
Table 1.2 Endemicity in southern Australian macroalgae (based on Womersley 1990).	6
Table 1.3 Definitions of distributional range (Womersley 1959).	8
Table 1.4 Distribution of algal flora in southern Australia (based on Womersley 1990).	9
Table 1.5 Properties of stability (based on Grimm 1996).	19
Table 2.1 Christies Beach WWTP 2001-02 annual discharges (SA Water 2002).	31
Table 3.1 Description of the reefs used in the first part of this study.	47
Table 3.2 Juvenile macroalgae age / size class parameters.	48
Table 3.3 NPMANOVA testing for site differences in macroalgal canopy composition.	56
Table 3.4 Pair wise <i>a posteriori</i> comparison between sites.	56
Table 3.5 Tests of association between canopy forming genera.	57
Table 3.6 The relationship between the abundance of adult and juvenile plants.	59
Table 3.7 Mantel test of association between distance matrices.	60
Table 3.8 Observed versus expected frequency for neighbouring patch configurations.	68
Table 4.1 Description of the treatment reefs used in the study.	85
Table 4.2 Canopy forming taxa found commonly in the study area.	88
Table 4.3 Significance tests of canonical correlation in Figure 4.5	90
Table 4.4 NPMANOVA testing for differences between sites.	91
Table 4.5 Significance tests of canonical correlation in Figure 4.6	93
Table 4.6 Significance tests of canonical correlation in Figure 4.8	95
Table 4.7 Significance tests underpinning canonical correlation in Figure 4.10	96
Table 5.1 Asymmetrical ANOVA model for use with the Beyond BACI analysis.	115
Table 5.2 Significance tests of canonical correlation in Figure 5.8	121
Table 5.3 Beyond BACI analysis, examining changes in adult assemblages.	124

Table 5.4 Significance tests of canonical correlation in Figure 5.12	127
Table 5.5 Climatic conditions and their likely effects on macroalgal assemblages	131
Table 5.6 Environmental parameters that potentially influence inter-site variability.	134
Table I.1 Juvenile macroalgae age / size class parameters.	174

## Abstract

Macroalgae are abundant on shallow temperate reef environments, often forming complex communities that comprise several strata. In southern Australia, these assemblages are dominated by large canopy forming taxa from the Orders Laminariales and Fucales. The presence of subtidal furoid macroalgae differentiates these communities from that elsewhere, and emphasises the need for local studies rather than relying on generalisations made elsewhere.

Like most natural systems, temperate reefs are often threatened by human activity with degradation reported from many locations in close proximity to urban settlements. The work presented in this thesis involves an examination of the temporal and spatial variability in the structure of macroalgal communities from reefs along the Adelaide (South Australia) metropolitan coast. The work looked specifically at the effects of a dispersed sediment plume, resulting from the 1997 beach sand-replenishment dredging program, on shallow sub-tidal reef systems.

An examination of the structure of canopy forming phaeophycean macroalgae in Gulf St Vincent (South Australia), noted large amounts of both spatial and temporal heterogeneity. Notwithstanding, this variation was not random, but demonstrated considerable structure that could be linked to a number of important underlying processes. In particular, macroalgal assemblages appeared as a mosaic of patches, each of which comprised a high-density state clearly dominated by a single genus (*Cystophora*, *Sargassum*, or *Ecklonia*), or alternatively a lower density mixed assemblage (Variable Low Abundance, VLA).

Macroalgal community structure appeared to be driven by biotic interactions at small scales (metres), such that patches comprised of different species of algae in high density states rarely abutted one another. Instead, VLA assemblages frequently formed a buffer being situated between these mono generic patches. In terms of successional processes, the high-density states appeared to be relatively stable whereas the VLA state, at least in some systems, was transitory. This finding was supported by the absence of intermediary high-density states (e.g. a mix of *Cystophora* and *Ecklonia*) implying that state changes must occur via the VLA state following some form of disturbance.

Larger scale patterns appeared to be driven by environmental variation, with factors such as wave exposure influencing habitat suitability for individual species and thereby

affecting community composition. These phenomena were examined in terms of life history strategies that tend to promote stability, and which are common in late successional taxa.

The importance of properties enhancing stability and the role of disturbance was investigated experimentally using a dispersed sediment plume, which entirely engulfed two reefs<sup>1</sup>, as a pulse impact. This disturbance was of particular relevance given that degradation of macroalgal communities in close proximity to the City of Adelaide has been, at least in part, attributed to the effects of elevated levels of sediment. Follow up surveys revealed that the sedimentation from the plume had primarily affected newly recruiting individuals, with few juveniles surviving to one year of age. Over the following few years, the effect of this recruitment failure cascaded into the adult stand.

In broader terms, unfavourable climatic conditions prior to the start of the study, including a particularly severe El Niño event, had a widespread effect on local assemblages, causing high levels of both adult and juvenile mortality. As such, at the commencement of the study, macroalgal communities across the study area were in the process of recovery. This was observed at control sites over the duration of the study. In contrast, recruitment failure at the sediment-affected sites retarded the recovery process, exacerbating the problems associated with prior unfavourable climatic events and leaving them in a degraded state.

This study demonstrated that macroalgal assemblages are equipped (under natural conditions) to handle ‘normal’ environmental fluctuations (such as inter-annual variability). However, the additional stress associated with certain anthropogenic impacts has the potential to push them over the limit, causing degradation. The loss of canopy macroalgae reduces the structural complexity of the system, leading to a concomitant reduction in their ability to recover. As such, these findings are of particular relevance to those charged with the responsibility for managing near-shore marine environments.

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<sup>1</sup> The plume was created accidentally during a dredging operation for beach sand replenishment of Adelaide’s eroding shoreline.

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## Preface

Macroalgal communities are prominent inhabitants of the near-shore marine environment at temperate latitudes. In southern Australia, assemblages are often dominated by large canopy forming phaeophycean taxa from the orders Laminariales and Fucales. Together they are major primary producers and create important habitat complexity. Yet the ecology and sensitivities of these communities' remain poorly understood.

Recent surveys of macroalgal-dominated reefs have identified a loss of canopy forming species from the northern part of Adelaide's metropolitan coastline. This impact has been attributed to declining water quality in the region; a stance supported by the more voluminous work on local seagrass communities. However, while seagrass decline has primarily been linked to eutrophication and stormwater discharge, macroalgal communities are also likely to have been affected by increased levels of sediment.

### **Pretext for this work**

During November 1997, offshore dredging for beach sand replenishment led to the creation of a large sediment plume that was observed in close proximity to a number of metropolitan reefs, south of Adelaide. The scale of this event presented a unique opportunity to examine the effect of this disturbance on the resident macroalgal communities. In particular, the most likely impact of the sediment plume would be to affect recruiting individuals through a reduction in suitable hard substrate and by smothering propagules. However, in order to address this issue, it was first necessary to develop an understanding of the inherent structure of the system.

This thesis represents an attempt to understand some of the important structural components of brown algal dominated macroalgal communities. The dynamic nature of the system is considered and used as a framework for investigating spatial and temporal changes in structure under natural conditions and in response to environmental perturbation.

### **Specific aims of the research**

The first objective of this study was to examine of local assemblages in order to create a framework that will enable a degree of prediction. Furthermore, it will address the

dynamic processes that give rise to assemblage structure, thereby providing a level of explanation. The use of this procedure will allow for the subsequent testing of a specific disturbance in a robust manner. Specific aims are:

*AIM: To build an understanding of how local canopy dominated macroalgal systems are structured, and whether knowledge of the current state of a patch can be used to determine past or future states.*

*AIM: To quantify the relationship between adult canopy structure and the underlying juvenile assemblage.*

*AIM: To construct a model that effectively describes assemblage structure.*

*AIM: To determine how the reefs in the study area change through time.*

The second objective of this study was to distinguish the effect of the sediment plume as the signal of interest from the influence of other environmental phenomena.

*AIM: To investigate the impact of elevated sediment levels as a pulse disturbance on the recruitment of canopy forming genera of macroalgae.*

*AIM: To identify the longer term effects of the sediment impact.*

### **Thesis structure and layout**

This thesis attempts to embrace some of the complexity displayed by canopy dominated macroalgal systems and explain some of the important components of structure. Using a sediment plume as a case study, the effect of a pulse disturbance is tracked as it propagates through time.

Chapter 1 provides a background and literature review of current knowledge on macroalgal communities. Included here is a description of the uniqueness of South Australia's marine biota and life history treatises for each of the dominant canopy forming genera present in the study area.

Chapter 2 introduces the Gulf St Vincent environment and discusses some of the threats to ecosystem health. Following this, a description of a sediment plume resulting from sand

dredging for beach replenishment is used as the basis for a natural experiment into macroalgal dynamics.

Chapter 3 describes local reef structure based on 4 selected reefs within Gulf St Vincent and explores some of the patterns observed.

Chapter 4 specifically addresses the impact of the sediment plume on algal recruitment dynamics. This is done through a spatial investigation comparing a number of control and impact sites.

Chapter 5 broadens the study, places the state of macroalgal communities in context with other environmental perturbations, and introduces a temporal component. The longer-term effects of the initial disturbance are then placed in the context of the overall state of macroalgal communities.

Chapter 6 summarises the major findings of this research and provides a synthesis of the results in the context of the relevant literature. It also serves to highlight future research initiatives, which would greatly improve knowledge of macroalgal dynamics.