

Dynamics of refractory carbon in seagrass meadows

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Certificate of Original Authorship

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Preface

This thesis has been prepared in publication format, whereby each chapter represents a manuscript ready for submission to a peer-reviewed journal. Therefore, there will be a degree of redundancy across chapter introductions and methodologies. As of yet, no individual chapter has been accepted for publication in a peer-reviewed journal.

Therefore, the citations and manuscript follow ESA's Ecology Journal formatting for research articles, with the exception of Chapter 4, which is prepared as a note (results and discussion are combined).

Two published papers were produced in association with my PhD, but are not a part of this thesis. These two articles, which are sited within the thesis chapters, are attached as appendices at the end of the thesis.

Trevathan-Tackett, S.M, P.I. Macreadie, P. Ralph, and J. Seymour. 2014.
Detachment and flow cytometric quantification of seagrass-associated bacteria.
Journal of Microbiological Methods **102**:23-25.

Trevathan-Tackett, S. M., J.J. Kelleway, P.I. Macreadie, J. Beardall, P. Ralph and A. Bellgrove. 2015 (2015). Comparison of marine macrophytes for their contributions to blue carbon sequestration. *Ecology* **96**:3043-3057.

Table of Contents

Certification of Authorship	i
Acknowledgements	ii
Preface	iii
Table of Contents	iv
List of Illustrations and Tables	v
Abstract	xi
Introduction	1
Chapter 1: Assessing the organic composition of seagrasses for their capacity to contribute to long-term carbon sequestration: A global survey	17
Chapter 2: Microbial-driven seagrass remineralisation influenced by temperature and sediment chemistry	69
Chapter 3: Long-term microbial remineralisation of seagrass under natural field conditions	108
Chapter 4: Microbial priming effect as a mechanism for enhanced CO ₂ release in coastal sediments	139
Chapter 5: Small-scale seagrass habitat loss affects quantity and quality of sedimentary carbon	153
Synthesis, Conclusions and Outlooks	182
Literature Cited	204
Appendix Table 1 with Literature Cited	225
Appendix Publications (attached pdfs of articles, separate page numbering)	

List of Illustrations and Tables

Introduction

Figure I1: Conceptual model of the multi-variable approach used to investigate the dynamics of refractory carbon in seagrass meadows.....	6
Table I1: Review of seagrass decomposition studies and the variables and factors measured or analysed in each study.....	9
Table I2: Review of the seagrass decay rates (percent per day) under oxic and anoxic conditions.....	13

Chapter 1

Table 1.1: Summary of structural carbohydrate and fibre content reported from the literature for seagrass tissue types.....	21
Table 1.2: Summary of the seagrass samples collected.....	24
Figure 1.1: Map of seagrasses collected.....	29
Figure 1.2: Principal components analysis of TGA data for all samples shown by climatic region and tissue type.....	33
Figure 1.3: Representative thermograms for each tissue type.....	34
Figure 1.4: Proportion of thermal intervals (TI) of total organic matter (OM) and OM as percent of the total mass across all tissue types.....	35
Figure 1.5: Linear regressions of the strongest relationships (adjusted $R^2 > 0.09$) between TGA intervals and latitudes	37
Figure 1.6: Principal components analysis of molecular mixing model predictions from NMR analysis for seagrass tissue types	39
Figure 1.7: FTIR spectroscopy loadings for climatic zone and tissue type.....	41
Figure 1.8: Principal components analysis of FTIR analysis shown by climatic region and tissue type.....	42

Figure 1.9: PCA plots and Eigenvalues and Eigenvectors for molecular mixing model and thermogravimetry variables.....	44
Figure 1.10: Conceptual model describing the organic matter (OM) quality of seagrasses in different climatic regions, tissue types and taxa.....	53
Table S1.1: SIMPER table of significant PERMANOVA pairwise comparisons of thermogravimetric analysis (TGA) and molecular mixing model (MMM).....	56
Table S1.2: Summary of Principal Components Analyses (PCA) Eigenvectors from Chapter 1	60
Table S1.3: Raw spectral intensities of main ¹³ C-CPMAS NMR functional groups expressed as % of total spectral intensity for selected samples subsample.....	61
Figure S1.1: Principal components analysis of TGA data for tissue types.....	64
Figure S1.2: Seagrass organic matter quality from thermogravimetric analyses between temperate and tropical regions and across all bioregions.....	65
Figure S1.3: Seagrass organic matter quality from thermogravimetric analyses across families for leaf, non-photosynthetic above-ground tissue, rhizome, root.....	66
Figure S1.4: Principal components analysis of TGA for <i>Zostera</i> samples.....	67
Figure S1.5: Overlay of the average solid-state ¹³ C-CPMAS NMR spectra of each tissue type.....	68

Chapter 2

Figure 2.1: Seagrass mass loss during three months of decomposition and the associated decay rates.....	80
Table 2.1: Percent of macromolecular compound losses from decaying seagrasses predicted from ¹³ C-CPMAS NMR spectra.....	81
Figure 2.2: MDS plot of bacterial OTUs grouped by tissue, time and temperature.....	83
Figure 2.3: Taxonomic shifts of bacterial community at class-level related to decomposition time and temperature.....	85

Figure 2.4: Proportion of genera within Alpha- and Deltaproteobacteria for leaves, rhizome/root and sediment through time and with temperature treatments.....	86
Figure 2.5: Statistical Analysis of Metagenomic Profiles (STAMP) of predicted metagenomes from PICRUSt analysis for differences in metabolic pathways between tissue types.....	88
Table S2.1: Summary of Analysis of Covariance (ANCOVA) statistics.....	95
Table S2.2: Summary table of Analysis of Similarity (ANOSIM) statistics.....	96
Table S2.3: Raw spectral intensities of main ¹³ C- CPMAS NMR functional groups expressed as % of total spectral intensity for each tissue and treatment throughout incubation period.....	97
Figure S2.1: Temperature recorded over the course of 1 year (May 2013 – May 2014) in a <i>Zostera muelleri</i> meadow in Fagan’s Bay, Central Coast, Australia.....	100
Figure S2.2: Seagrass elemental C:N ratios, carbon and nitrogen content.....	101
Figure S2.3: Solid-state ¹³ C- CPMAS NMR spectra of mass loss through decomposition normalised to organic C loss.....	102
Figure S2.4: Diffuse reflective mid-infrared spectroscopy.....	103
Figure S2.5: Oxygen and total sulphide microsensors profiles for 23°C, no nutrient treatments.....	104
Figure S2.6: Abundance of bacterial cells associated with seagrass litter.....	105
Figure S2.7: Alpha diversity statistics for the eubacterial communities.....	106
Figure S2.8: Statistical Analysis of Metagenomic Profiles (STAMP) of predicted metagenomes from PICRUSt analysis for differences in metabolic pathways throughout decomposition.....	107
 <u>Chapter 3</u>	
Table 3.1: Grain size and C _{org} stocks of the Brisbane Waters Estuary sites.....	117
Figure 3.1: Elemental and stable isotope characteristics of the sediments from the Brisbane Waters Estuary.....	118

Figure 3.2: Box plots of organic matter contribution predictions for the top 20 cm of sediments.....	120
Figure 3.3: Proportion of mass remaining of leaf and rhizome/root biomass after two years of decomposition.....	122
Figure 3.4: Elemental content of leaf and rhizome/root biomass throughout decomposition.....	123
Table 3.2: Decay rates ($k = d^{-1}$) predicted by single-, double- and triple-component decay models for leaves and rhizome/roots from each site.....	124
Figure 3.5: MDS plot of the significant shifts in rhizome/root organic matter (OM) quality throughout decomposition.....	126
Figure 3.6: MDS plot of bacterial community shifts for each tissue type and sediment throughout decomposition.....	128
Figure 3.7: Bacterial communities from seagrass and sediments at different sites and throughout decomposition.....	129
Figure S3.1: C:N ratios and $\delta^{13}C$ signatures for the plant reference collected at each of the three sites from this study.....	136
Figure S3.2: Decay models fitted to leaf mass loss data.....	137
Figure S3.3: Decay models fitted to rhizome/root mass loss data.....	138

Chapter 4

Figure 4.1: Cumulative microbial respiration of control and amended treatments for surface and deep sediments.....	147
Figure 4.2: Average respiration rates of control and amended treatments for surface and deep sediments.....	148
Figure 4.3: Estimated contributions of labile (LOC) and refractory (ROC) organic carbon sources to respiration.....	149
Figure 4.4: Organic matter quality of 0-1 cm and 29-30 cm sediments using thermogravimetric analysis.....	151

Chapter 5

Figure 5.1: Down-core variation in organic matter and organic carbon for each plot through time.....	161
Table 5.1: Table for OM, C _{org} and stable isotope and elemental statistical analyses over time.....	162
Figure 5.2: Thermograms for the sediment mass loss and rate of change with increasing temperatures.....	165
Figure 5.3: Stable isotope and elemental signatures of sediments in comparison with reference organic matter.....	166
Figure 5.4: Stable isotope and elemental signatures of sediment samples that significantly changed through time.....	167
Figure 5.5: Box plots of the five possible contributions of OM calculated by the mixing model for the samples with significant changes in stable isotopes and C:N through time.....	168
Figure S5.1: Historical time lapse of the seagrass meadows at the Johnson's Beach site from Google Earth [®]	173
Figure S5.2: Differences in % organic matter down-core for each treatment throughout the experiment.....	174
Figure S5.3: Remnants of hollow, decaying rhizome tissue from <i>Thalassia testudinum</i> kill plot.....	175
Figure S5.4: Histogram of the dry bulk density values for all sediment depths and the depths analysed of C _{org}	176
Figure S5.5: Box plots of predicted organic matter sources for sediments from Bare plots.....	177
Figure S5.6: Box plots of predicted organic matter sources for sediments from <i>Halodule wrightii</i> control plots.....	178
Figure S5.7: Box plots of predicted organic matter sources for sediments from <i>Halodule wrightii</i> kill plots.....	179

Figure S5.8: Box plots of predicted organic matter sources for sediments from *Thalassia testudinum* control plots..... 180

Figure S5.9: Box plots of predicted organic matter sources for sediments from *Thalassia testudinum* kill plots..... 181

Synthesis, Conclusions and Outlooks

Figure C1: PCA of the bacterial communities from the short-term laboratory and long-term field decomposition data sets (Chapters 1 and 2)..... 184

Figure C2: Comparison of the classes driving the differences in bacterial communities during initial, early and late-stage seagrass decomposition..... 185

Figure C3: Relationship between latitude and decay rates of seagrass..... 188

Table C1: R (refractory) index calculated from thermogravimetric analysis for fresh tissues from the international study (Chapter 1) and the long-term decomposition study (Chapter 3)..... 190

Figure C4: Modified conceptual model for seagrass decomposition based on the new insights derived from this thesis..... 197

Figure C5: Conceptual design illustrating the processes affecting refractory carbon accumulation and remineralisation with decomposition, the microbial priming effect and habitat loss..... 203

Appendix

Appendix Table 1: Review of literature that reports refractory organic matter as structural carbohydrates and fibre content for above-ground and below-ground seagrass tissues. 225

Abstract

The protection and rehabilitation of natural landscapes in order to enhance their role in carbon sequestration is currently a hot topic for scientists and policymakers looking for solutions to reduce atmospheric CO₂ levels. Blue carbon ecosystems (seagrass, mangrove, saltmarsh) have recently been found to match or even exceed the capability of terrestrial ecosystems to sequester carbon. In seagrass habitats, seagrass carbon alone can account for half of the carbon in the top 10 cm of sediment. Litter quality, often measured as refractory carbon content, is one of the main factors that can influence the sequestration and storage of refractory carbon. Yet to-date, there has been little attempt to understand what factors help or hinder refractory carbon preservation in seagrass sediments.

The aim of this thesis was to unravel the processes and factors that influence, and even optimise, the preservation of refractory carbon in seagrass meadows beginning with the refractory carbon content in seagrass tissues, its persistence (or remineralisation) during decomposition and finally, its preservation in sediments and the mechanisms that provoke further remineralisation after burial. To accomplish these aims, a multi-variable approach was taken, which involved assessing the main and interaction effects of biological, chemical and environmental/physical variables on refractory carbon remineralisation and storage.

The results from this thesis revealed that the processes that affect refractory carbon dynamics in seagrass meadows are complex. It was shown that, while inherent refractory carbon content in the tissues can promote sequestration, decomposition was a strong influence on the persistence of refractory carbon. Anoxic conditions and structural complexity of the tissues promoted refractory carbon preservation and were dependent on the microbial communities present. Sheath and stem tissues were considered to be important carbon contributors due to their high refractory carbon content and chance of *in situ* burial. Temperature and the availability of labile organic matter and inorganic nutrients enhanced decay in the short-term under oxic conditions, while physical disturbance and habitat loss caused losses of sediment refractory carbon over the course of months to years depending on the type of disturbance.

In light of these results, a new conceptual model was developed for seagrass decomposition and have highlighted several important avenues of future blue carbon research, including the functional roles of microbes (bacteria, fungi and protists) in carbon remineralisation via bioinformatics and enzymes kinetics, as well as the conversion, or ‘up-cycling’, of labile carbon to refractory carbon within microbial biomass.