Dynamics of refractory carbon in seagrass meadows

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Certificate of Original Authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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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.

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Synthesis, Conclusions and Outlooks

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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 CO_2 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.