CARBON STORAGE IN TIDAL WETLANDS OF SOUTHEAST AUSTRALIA

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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. 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.

Signature of Student:

Date: 27th January 2017

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PREFACE

THESIS BY PUBLICATION

This is a thesis by publication. Consequently, there will be some repetition and redundancy of text particularly in the introductory, methods and reference sections of the various chapters. Chapters are formatted according the final publication format of the relevant journal for chapters which have already been accepted for publication (Chapters 2 and 5) or in the format required under submission for review for chapters yet to be published (Chapters 3 and 4). The introductory (Chapter 1) and conclusion (Chapter 6) chapters are not currently intended for separate publication and are therefore presented in a generic format.

PUBLICATIONS ARISING FROM THIS THESIS:

Kelleway, J.J., Saintilan, N., Macreadie, P.I., & Ralph, P. (2016). Sedimentary factors are key predictors of carbon storage in SE Australian saltmarshes. *Ecosystems*. doi:10.1007/s10021-016-9972-3

Kelleway, J. J., Saintilan, N., Macreadie, P. I., Skilbeck, C. G., Zawadzki, A., & Ralph, P. J. (2016). Seventy years of continuous encroachment substantially increases 'blue carbon' capacity as mangroves replace intertidal salt marshes. *Global Change Biology*, 22, 1097-1109. doi:10.1111/gcb.13158

ANCILLARY PUBLICATIONS COMPLETED DURING CANDIDATURE:

Trevathan-Tackett, S. M., Kelleway, J. J., Macreadie, P. I., Beardall, J., Ralph, P., & Bellgrove, A. (2015). Comparison of marine macrophytes for their contributions to blue carbon sequestration. *Ecology*, 96(11), 3043-3057.

Osland, M. J., Day, R. H., From, A. S., McCoy, M. L., McLeod, J. L., & Kelleway, J. J. (2015). Life stage influences the resistance and resilience of black mangrove forests to winter climate extremes. *Ecosphere*, 6(9), art160. doi:10.1890/ES15-00042.1

Macreadie, P.I., Nielsen, D.A., Kelleway, J., Atwood, T., Seymour, J., Petrou, K., Connolly, R.M., Thomson, A.C., Trevathan-Tackett, S., and Ralph, P.J. (Accepted 1/12/2016) Can we manage coastal ecosystems to sequester more blue carbon? Frontiers in Ecology and the Environment.

Macreadie, P.I., Trevathan-Tackett, S.M., Baldock, J.A., Kelleway, J.J. (2017) Converting beach-cast seagrass wrack into biochar: a climate-friendly solution to a coastal problem? *Science of the Total Environment,* 574, 90-94.

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ABSTRACT

Saltmarshes and mangroves are among the most productive and most at risk ecosystems to the impacts of human activity and climate change, globally. Along with seagrasses, these coastal vegetated ecosystems have been termed 'blue carbon' habitats due to their capacity to accumulate and store C. Consequently, there is interest in the processes which govern C accumulation and storage in these ecosystems and their potential to mitigate climatic change. While previous research has indicated high C stocks and accumulation in saltmarshes, there is substantial spatial variability in saltmarsh C. An understanding of the factors behind this variability is required to better inform regional and global C management. Within the study region of southeast (SE) Australia, this thesis therefore aims to: quantify and characterise saltmarsh C stocks; determine the role of geomorphic and vegetation factors in C accumulation and storage; assess variations in quantity and character of C with sediment depth and in relation to environmental change.

Analysis of sediment cores collected from 18 sites revealed mean (± SE) belowground C stocks of 164.45 ± 8.74 Mg C ha^{-1}, comparable to global values. Stocks were more than two times higher in fluvial (226.09 ± 12.37 Mg C ha^{-1}) relative to marine (104.54 ± 7.11) geomorphic sites, but did not vary between the saltmarsh vegetation structures tested. Vegetation type, however, was determined to play an important role in surface accumulation with mid- (19 month) and short-term (6 d) measures showing faster C accumulation in upper marsh rush saltmarsh relative to both succulent and grass lower marsh assemblages. Additionally, the encroachment of saltmarsh by high biomass mangrove trees and shrubs was shown to bring about substantial increases in C storage in both biomass and belowground C stocks. While there were general trends of decreasing C content with sediment profile depths, this was not always the case. The preservation of deep mangrove roots (in both contemporary

saltmarsh areas as well as areas currently under mangrove encroachment) and/or remnant stable C sources (including char) were both responsible for peaks in C density down profile.

This thesis improves our understanding of the processes influencing coastal wetland C storage, with implications for the prioritisation of planning policies and on-ground activities which aim to maximise the benefits from wetland protection and restoration. Such initiatives have the potential to increase overall C storage, thereby presenting a negative feedback to global warming, while also presenting other ecosystem service benefits.