THE BIOLOGY, ECOLOGY AND CONSERVATION OF WHITE'S SEAHORSE *HIPPOCAMPUS WHITEI*

by

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July 2014

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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ABSTRACT

Seahorses are iconic charismatic species that are threatened in many countries around the world with several species listed on the IUCN Red List as vulnerable or endangered. Populations of seahorses have declined through over-exploitation for traditional medicines, the aquarium trade and for curios and through loss of essential habitats. To conserve seahorse populations in the wild, they are listed on Appendix II of CITES, which controls trade by ensuring exporting countries must be able to certify that export of seahorses is not causing a decline or damage to wild populations. Within Australia, seahorses are protected in several states and also in Commonwealth waters.

The focus of this study was White's seahorse *Hippocampus whitei*, a medium-sized seahorse that is found occurring along the New South Wales (NSW) coast in Australia. The species is listed as 'data deficient' on the IUCN Red List and there is little research information available to assist in the conservation of the species. Research on *H. whitei* was undertaken from 2006-2009 and primarily focused on determining the species' life history parameters, its distribution and relative abundance, habitat preferences and site fidelity, and response to marine protected area (MPA) protection and habitat modification. Research primarily occurred within Sydney Harbour and Port Stephens.

Field surveys found that *H. whitei* is endemic to coastal estuaries along 300 km of NSW coastline. It is a medium-sized seahorse (max L_T 162 mm) that displays rapid

growth (Port Stephens: females L_∞ = 149.2 mm and K = 2.03 per year and males L_∞ = 147.9 mm and K = 2.52; Sydney Harbour: females L_∞ = 139.8 mm and K= 1.28 and males L_∞ = 141.6 mm and K=1.22), becomes sexually mature at approximately 6 months, and can live for up to 5 years in the wild. The species displays life-long monogamy with several pairs observed breeding over three consecutive breeding seasons, and strong site fidelity with seahorses remaining at the same site for up to 56 months for males and 49 months for females. Adult male and female *H. whitei* exhibited a significant preference for sponge and soft coral *Dendronephthya australis* habitats whilst juveniles had a strong preference for gorgonian *Euplexaura* sp. habitat. *Hippocampus whitei* in Port Stephens were significantly less abundant within the no-take MPA and there was a negative correlation with predator abundance.

Long-term monitoring of *H. whitei* in Port Stephens found that populations declined over a period of six months for no apparent reason; however, they recovered within three years. A manipulative experiment undertaken on protective swimming nets in Sydney Harbour found *H. whitei* had a positive association with epibiotic growth and proximity to the sea floor. An experiment on the effects of flash photography found it had no significant effect on movements, behaviour, or site persistence of *H. whitei* and concluded that flash photography by divers is a safe and viable survey technique for this species. The information obtained from this study should contribute towards a reassessment of the species under the IUCN Red List and also provides the necessary data to ensure adequate management of the species within NSW waters.

PREFACE

The contents within this thesis constitute my own work with several of the chapters having previously been published or are currently under review. As this thesis is based on chapters made up of published papers, there will be some repetitiveness across each of the chapters. References and formatting are based on the *Journal of Fish Biology* format. The development and implementation of each of the research projects within this thesis were of my own doing; however, I have had assistance from co-authors for various components of this study which I have outlined below.

Chapter 3 has been published as "Harasti, D., Martin-Smith, K., and Gladstone, W. (2013) Population dynamics and life history of a geographically restricted seahorse, *Hippocampus whitei*. *Journal of Fish Biology* **81**, 1297-1314." All the diving work for this study was undertaken by myself and my two co-authors, my PhD supervisors, provided advice on the study design and guidance in the preparation of the manuscript.

Chapter 4 has been submitted to *Journal of Fish Biology* and is currently being considered for publication. Both co-authors provided advice and guidance in writing up this research. Professor Gladstone provided advice on the study design to determine habitat preferences whilst Dr Martin-Smith provided advice on monitoring seahorse movements using a towed GPS system.

Chapter 5 is in process of being submitted to a journal for consideration for publishing. All of the monthly monitoring for this four year study was undertaken by myself with both my co-authors *Martin-Smith and Gladstone) contributing to the study with assistance with the study design and guidance on the writing of the manuscript.

Chapter 6 has been published as "Harasti, D., Glasby, T., and Martin-Smith, K. (2010) Striking a balance between retaining populations of protected seahorses and maintenance of swimming nets. *Journal of Aquatic Conservation: Marine and Freshwater Ecosystems* **20**, 159-166. Dr Glasby provided advice in the development of the study design and statistical analysis for the manipulative experiment. Dr Martin-Smith provided the data that he had collected previously on seahorses at Clifton Gardens that was incorporated into this manuscript whilst I was responsible for the establishment of the experimental study and subsequent diving surveys.

Chapter 7 was a collaborative study with Beth Moore and Dr Hamilton from the California Academy of Sciences and was supported with funds from the Sea Life Conservation Fund (Sydney Aquarium). The project development, tissue sample collection and final write up were undertaken by myself. Beth Moore was responsible for the genetic analysis and provided advice on the written description of the methods and results. Dr Hamilton provided advice on the study design and provided comments on the chapter.

Chapter 7 has been published as "Harasti, D and Gladstone, W. (2013). Does underwater flash photography affect the behaviour, movement and site persistence of seahorses?" *Journal of Fish Biology* **83**, 1344-1353. Professor Gladstone assisted with this project by providing guidance on statistical analysis and preparation of manuscript. Dr Keith Martin-Smith also provided feedback on a draft manuscript that helped improve the publication.

ACKNOWLEDGEMENTS

I dedicate this thesis to my father, Dennis Harasti, who passed away unexpectedly in 2005, aged 52, and my grandfather, Taffy Williams, who passed away in 2013, aged 80.

This PhD project arose from a meeting with Dr Keith Martin-Smith whilst he was working on seahorses at Clifton Gardens in Sydney Harbour. I'm very grateful that Keith took me on board as a student and he has provided excellent guidance, friendship and encouragement since this research commenced.

Professor William (Bill) Gladstone has provided excellent support as my university supervisor, first through the University of Newcastle and now at University of Technology Sydney. Bill has always provided great feedback on the drafts that I have sent and I'm very grateful of his supervision which has helped improve my research and made me a better scientist.

Thanks to Dr Tim Glasby who provided assistance with statistical analysis and filled a great role of 'unofficial supervisor'. Thanks for always responding to my stats questions at such short notice and helping me work through some of the more complicated analyses. You have made me think a lot more about the importance of planning the statistical analysis prior to rushing off and commencing any new study in the future.

I'm grateful to Pam and Chris Norman, former owners of Pro Dive Nelson Bay, who provided great support throughout the duration of the diving surveys and hundreds

of air-fills. Thanks to the Sea Life Conservation Fund (Sydney Aquarium) who provided some funding assistance for the research undertaken on the Manly net and the genetics study. My colleague and friend Chris Gallen provided great assistance with helping develop the GIS maps for the various chapters.

I'm very grateful of the support that my family has provided, especially my Mum who has been forever strong since Dad passed away. Finally, this thesis would not have been possible without the amazing support from my partner Suzanne. Outside of the fact that her excel wizardry has been of great benefit to me, especially since she taught me pivot tables, she has performed wonders in raising our two little boys (William and Ben) over the past 4 years. Thank you for being so understanding, loving and supportive, especially over the past 6 months whilst I was finishing the write up, and ensuring that I had enough 'quiet' time to finally get this thesis completed.

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