Trophic Structure and the Importance of Terrestrial Wetland Producers for Aquatic Food Webs in Tropical Australian Estuaries

Thesis submitted by

Kátya Gisela dos Santos ABRANTES BSc (Hons)

for the degree of Doctor of Philosophy
in Marine Biology
within the School of Marine and Tropical Biology
James Cook University

Townsville, February 2008

STATEMENT OF ACCESS

I, the undersigned, the author of this thesis, understand that James Cook University will make this thesis available for use within the University Library and, via the Australian Digital Theses network (unless granted an exemption), for use elsewhere.

I understand that, as an unpublished work, a thesis has significant protection under the Copyright Act and;

I do not wish to place any further restriction on access to this work.

ELECTRONIC COPY OF THESIS FOR LIBRARY DEPOSIT

I, the undersigned, the author of this work, declare that the electronic copy of this thesis provided to the James Cook University Library is an accurate copy of the print thesis submitted, within the limits of the technology available.

STATEMENT ON SOURCES

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

ABSTRACT

Estuaries support a great density and diversity of life and are traditionally considered to be important nursery areas for a variety of species, providing abundant and essential food supply and refuge from predation for juveniles of several fish and invertebrate species. However, to date no study has provided unequivocal evidence supporting this paradigm. In fact, recent studies based on the analysis of stable isotopes have shown that the importance of estuarine terrestrial wetland habitats such as mangroves and salt marsh in supplying energy to animals in adjacent aquatic habitats is not as significant as once thought. The objective of the present thesis is use stable isotopic analysis to clarify the importance of terrestrial wetland productivity as a source of energy for estuarine communities in the Australian Wet and Dry Tropics and to study the processes of energy flow taking place in these systems. Overall, material of terrestrial wetland origin was found to be incorporated into estuarine food webs in Tropical Australia. However, this importance is dependent on several physical and ecological factors including productivity of the different habitats, type and extension of wetland vegetation and connectivity.

In a first study, stable isotope analysis of carbon and nitrogen were used to analyse processes of energy flow and assess the extend to which carbon fixed by terrestrial plants is incorporated into adjacent aquatic food webs in two intermittently connected estuarine pools in the Ross River floodplain in North Queensland, Australia. The two pools differed in surrounding vegetation as one was surrounded by mangroves and the other by the salt couch *Sporobolus virginicus.* Since $\delta^{13}C$ values of C3 mangroves (low $\delta^{13}C$) are very different from those of the C4 salt couch (high $\delta^{13}C$), it was possible to determine the importance of terrestrial wetland producers by comparing isotope values of consumers between sites. The IsoSource model was also used to clarify the importance of the different potential sources to consumers. An incorporation mangrove and *S. virginicus* material was detected for several fish and invertebrate species at both sites, indicating that carbon of terrestrial origin is incorporated in the estuarine food

web. A linear negative relationship between $\delta^{13}C$ and $\delta^{15}N$ was also detected for primary producers, primary consumers and secondary consumers at the *Sporobolus* pool. This relationship was similar for the different trophic levels and was found to be useful to calculate trophic positions. A food web of ~3.5 trophic levels was found at both pools.

In a more detailed study, $\delta^{13}C$ and $\delta^{15}N$ analysis was used to determine the extent to which carbon of terrestrial origin is important for nutrition of juveniles of four penaeid prawn species, and to detect and describe ontogenetic variations in diet. These species were selected because penaeids are known to depend on estuarine wetland habitats such as mangroves and salt marsh at their juvenile stage. Although an incorporation of mangrove and salt marsh carbon was detected, it was not of a major importance for any species, and autochthonous sources seemed more important. Ontogenetic shifts in diet were detected for *Penaeus* (*Fenneropenaeus*) *merguiensis*, *Metapenaeus bennetae* and *Penaeus esculentus*, and corresponded to an increase in mean trophic level as well as to changes in the ultimate sources of energy.

In a broader scale study, the incorporation of terrestrial wetland productivity in estuarine food webs was studied in four open estuarine systems in Tropical Australia. These included a near-pristine system in the Wet Tropics (Deluge Inlet), two impacted systems in the Wet Tropics (Victoria and Half Moon Creeks), and a near pristine system in the Dry Tropics (Blacksoil Creek). Incorporation of mangrove derived carbon was detected for Deluge Inlet and Victoria Creek and incorporation of carbon of sugarcane origin was also detected for fish from Victoria Creek. The degree of incorporation of mangrove carbon into estuarine food webs seemed to relate directly to the type and extent of mangrove vegetation adjacent to the estuary. Trophic structure differed between estuaries, but in all areas a constant trophic length with about four trophic levels was detected. Stable isotope results also suggest a high level of omnivory and diet overlap between fish species at Deluge Inlet, Half Moon Creek and Blacksoil Creek, but not for the agriculture impacted system of Victoria Creek, which can be a reflection of the great level of anthropogenic impact in this area.

In a final study, the seasonality in importance of autochthonous and allochthonous carbon for aquatic communities in six intermittently connected estuarine areas of the Australian Dry Tropics was investigated. Results varied between sites, depending of site-specific ecological conditions. The hydrology regime was a major factor controlling the sources of energy in these areas, controlling the amount of terrestrial material available to aquatic animals throughout the year and allowing the presence of an energetic connectivity between the terrestrial and aquatic environments. An important seasonal variation in the main sources of energy was detected in two systems, where a greater incorporation of carbon of terrestrial origin was present after the wet season. Hence, aquatic food webs may rely alternatively on autochthonous and allochthonous sources of energy, depending on the season. Trophic organization, including level of omnivory, diet overlap and trophic length, was also found to differ between systems and seasons due to differences in species composition, resource availability, connectivity, and type and level of environmental disturbances. While trophic length seems to be similar between open estuarine areas, with food webs having ~4 trophic levels, in intermittently connected areas trophic length was more variable between systems, with between 3.2 and 4 trophic levels.

ACKNOWLEDGEMENTS

I am extremely grateful to my supervisor Marcus Sheaves for all scientific guidance, invaluable support, for sharing his wisdom and above all for his friendship throughout this journey. Thanks for everything! I would also like to thank my co-supervisor John Collins for his encouragement and for sharing his knowledge on invertebrate ecology. I am also very thankful to Ross Johnston for his invaluable support over the years, in especial for his assistance with the fish collections. This study would not be what it is without you.

This PhD was funded by the Foundation for Science and Technology, Ministry of Science and Technology, Portugal, to which I am forever grateful. I would also like to thank the WWF Education for Nature (EFN) Program for the grants received in 2003 and 2004, which allowed me to start exploring the world of stable isotopes. I also thank the CRC for Coastal Zone, Estuary & Waterway Management for funding of both field trips and laboratorial analyses.

A big thank you to Rene Diocares from Griffith University in Brisbane for all the samples promptly analysed through the years. I am also very grateful to Andy Revill from CSIRO Marine Laboratories in Hobart for his help with the analysis of stable isotope samples and especially for introducing me to a mass spectrometer and showing me how little pelletised samples transform themselves into numbers in an Excel file.

I would also like to thank Nanette Hooker from James Cook University for the immeasurable help with plant identifications, and John Morrison and Simon Wever for the help with the aquarium experiments. To my friend Mariana Nahas for her help weighing and encapsulating samples, and for her friendship throughout the years. To Janine Sheaves for the invertebrate identifications, but most importantly for all the fun times, lamingtons, lollies and balloons shared.

Thanks to the nematode girl Pakamas Thinphanga for her companionship, for all the coke and procrastination material shared, and especially for the lunchtime company that kept me sane for so long. I miss eating 2-min noodles in the veranda already… Thank you so much for your friendship!

To my first officemate Ann Penny for all the fun we had at the office, in the lab and during field trips, and for all she taught me about Queensland, fish, fishing, fisherman and a few other North Queenslandic matters. For teaching me how to say “mate” properly. Thanks mate!

To the lab people who made the estuarine lab such a special place in so many ways: Marcus, John, Pakamas, Ross, Ann, Janine, Ron Baker, Leanne Currey, Christina Kulfan, Karen Tsui, Liliana Ortiz-Guerra and Matthew Knott. And a special thanks for the Duck brothers. I will forever treasure the times spent in that lab, a lab that for so many years was a home to me.

To Adam Barnett for all his love and encouragement, especially during the last stages of thesis write-up.

And most importantly, I would like to thank my parents Carlos and Guida Abrantes for all the love and support throughout my life, even when I had no income (or any prospects of having one) and had the crazy dream of going to Australia for a PhD. Thanks for teaching me that the most important richness I can ever have is inside my brain. And that the sky is the limit. To them I dedicate this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

STATEMENT ON SOURCES DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

All research procedures reported here received the approval from the Animal Ethics Committee, James Cook University.

---------- ----------

(Kátya Abrantes)