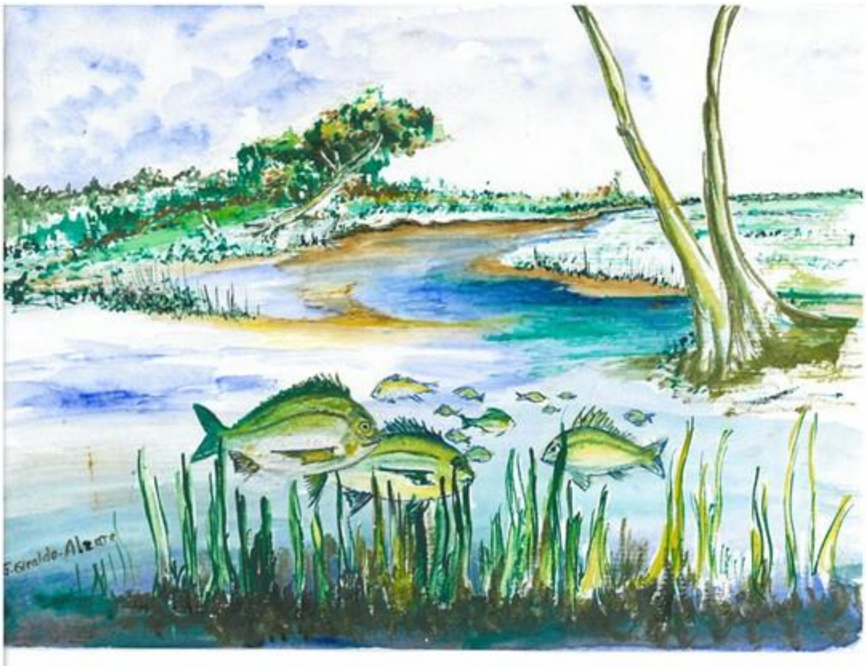
Population Structure and Movement of Black Bream

(*Acanthopagrus butcheri*)

in South Australian Estuaries Based on Otolith Chemistry



Ana Judith Giraldo

Presented for the degree of Doctor of Philosophy

School of Biological Sciences

University of Adelaide

July 2015

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

Ana Judith Giraldo

July 2015

Cover image: Black bream ecosystem (watercolour by Gustavo Giraldo & Judith Giraldo)

"This is what knowledge really is. It is finding out something for oneself with pain, with joy, with exultancy, with labour, and with all the little ticking, breathing moments of our lives, until is ours which is rooted in the structure of our lives"

Thomas Wolfe (1900-1938)

Table of Contents

Abstract

The elemental concentration of otoliths provides an opportunity to discriminate among fish living in different habitats, and to estimate population connectivity, life history variation and potential movements. Understanding temporal patterns of recruitment and connectivity of estuarine fish populations, as well as life history variation is fundamental to elucidating population dynamics and informing effective management and conservation efforts. Estuarine associated species utilise sheltered habitats for growth and feeding, but also face fluctuating environmental conditions. Estuaries may be temporally variable sinks or sources of juveniles and have fish moving to other areas. Otolith chemistry provides a tool to reconstruct origins and quantify connectivity between juvenile and adult populations, as well as investigate movements of fish throughout their life history.

The overall aim of this study was to assess connectivity and partial migration within black bream (*Acanthopagrus butcheri*) populations in South Australia. The key objectives were to: (1) Determine spatial and temporal variation in otolith elemental signatures to assess their usefulness for determining connectivity of black bream populations; (2) Retrospectively trace subadult fish from the Fleurieu Peninsula (FP) and Kangaroo Island (KI), South Australia, to their juvenile regions to gain an understanding of movements; and (3) Determine the proportion of migrant and resident life history types within estuarine populations and if these different contingents reflect a hybrid fish genotype.

I examined spatial and temporal variability in otolith chemistry of juvenile 0^{+} black bream to discriminate fish living in different estuaries. Fish were sampled in up to 12 estuaries on KI (7 estuaries) and the FP (5 estuaries) annually over a five year period (2007–2011). Otoliths were examined to determine if individual estuaries or groups of estuaries differed in chemical concentrations (signatures or tags), and to examine inter-annual variation in chemical tags. Tags differed among individual estuaries and in some cases adjacent estuaries shared similar chemical tags. Differences in chemical tags were detected among all estuaries in two of the year comparisons. Similarities in otolith tags were detected for five of the seven estuaries in 2010 and 2011. Grouping estuaries with similar chemical tags enhanced the classification accuracy of fish to estuaries and therefore the ability to discriminate stock structure based on otolith chemistry. Temporal differences in chemical tags were detected among years for several estuaries; however, there were no clear trends in the differences between years. The results highlight that black bream from different estuaries or groups of estuaries have unique chemical tags that can be used to trace cohorts of fish. Such differences can be used to estimate connectivity, population movements, and the function of estuaries as nursery areas for this species in subsequent years.

Otolith chemistry was then used to reconstruct origins and to quantify connectivity between juvenile and adult components of black bream populations. Trace element composition of juvenile black

bream otoliths from broad areas representing estuaries from each of KI and FP were quantified for each of four years (2007-2010) and used as baseline data to retrospectively trace the juvenile region of 1 to 3^+ year black bream. Such an approach was possible because there were differences in otolith element concentration of young-of-year black bream among broad areas. Through LA-ICP-MS analysis of the juvenile region of subadult (1 to 3^+ year old) black bream, I was able to estimate the proportion of juvenile fish that recruited from these two regions through time, as well as temporal patterns of connectivity between KI and FP. My results suggest variability among cohorts of the same age, among age classes within a cohort and between regions in terms of self-recruitment. These results highlight the variable nature of connectivity among populations and recruitment to adult populations suggesting that management and conservation efforts may need to consider such variability.

Partial migration, where some members of a population migrate showing life history profiles of salinity habitats was evaluated in six estuarine populations of black bream from KI, using otolith Ba:Ca ratios. Profiles of Ba:Ca across otoliths were used to broadly determine fish habitat use (freshwater, estuarine, marine) and assign euryhaline or stenohaline status. In addition, we evaluated whether migratory fish may represent hybrid fish between black bream and yellowfin bream (*Acanthopagrus australis*) using an eight locus microsatellite library. Partial migration was observed in all six estuarine populations, although for most estuaries there were greater numbers of migratory fish than resident fish. Hybrid fish were found in five of the six estuaries and comprised both migratory and resident fish. Both resident and migratory fish spent most time in marine waters, but migratory fish also moved to estuarine and freshwaters. Similar patterns were also seen for hybrid fish. The data highlight the different migratory behaviours of subadult individuals and show that hybrid bream had reached estuaries previously thought to be inhabited by pure black bream. Complex migratory patterns may allow populations to persist under adverse environmental conditions and in systems subject to change.

Otolith chemistry data provided greater insight into patterns of connectivity between broad geographic regions and life history variation of black bream in South Australia. The variable nature of connectivity among populations and recruitment to adult populations suggests that conservation efforts will be more complex than protecting a single region. However, the temporally variable contribution of recruits and broad scale connectivity between juvenile regions suggests that no one region acts as a single ‘source’ of recruits, potentially safeguarding the species against the loss of functional nursery habitats. In the same manner, the ability of black bream populations to possess a suite of movement behaviours (likely in response to different conditions) may be beneficial in a dynamic environment such as an estuary since it allows the persistence of populations when faced with increasing habitat degradation. Overall, these findings infer that the adoption of a flexible life history strategy likely enhances species resilience to fluctuating environmental conditions and potentially adverse impacts.

Acknowledgements

Thanks to all involved in the course of this project.

I am deeply grateful to Professor Rob Hill for his encouragement for me to undertake the journey of a PhD in my late forties at the University of Adelaide. Something that was unimaginable after 25 years of being out of a University System.

A number of organisations provided funding, support and scholarship for this project: The Faculty of Sciences of the University of Adelaide, the Australian Research Council Linkage Project (ARC Project No LP100100153), the Kangaroo Island Natural Resource Management Board. The University of Adelaide also provided administrative, library and other support.

I owe a great debt to Bronwyn Gillanders, my principal supervisor, who provided guidance and unconditional support on academic and personal matters during the project. Bronwyn helped me build confidence in my professional and personal development; enlightening me with her knowledge and someone I can trust. Special thanks to Travis Elsdon and Chris Izzo, my second supervisors, for shaping my thoughts towards new methods and technologies, essential to the betterment of this project. Travis's assistance in guiding me through the complexities of access to funding for the project is also greatly appreciated. The support of Bronwyn, Travis and Chris through various stages of this project also allowed me to improve my English writing skills such that this thesis is reasonably legible and this is gratefully acknowledged.

Thanks to Salvador Herrando–Perez for daily support as a colleague and friend. He was a tireless force of positivity and courage introducing me to the "joys" of statistics via R.

Finally, I would like to thank my family, my children (Kat and Camilo) and my husband Glen whose quiet support of my voyage allows me to keep on navigating until the end.

Chapter Acknowledgements

The collection of fish was approved through a Ministerial exemption (Section 59) from Primary Industries and Regions South Australia and a University of Adelaide Animal Ethics permit (S-30-2002).

Chapter Two

This work was funded by an ARC Linkage and Discovery grant and the Kangaroo Island Natural Resources Management Board. Thanks to Benjamin Wade for technical assistance at the laser (Adelaide Microscopy). We acknowledge Michelle Picard for comments on an early draft of the manuscript. Thanks to Patrick Reis-Santos, Antonio Di Franco, Camilo Mejia and Glen Wingate for assistance in the field. Helpful comments on the final draft were provided by Christopher Izzo and Camilo Mejia.

Chapter Three

Advice on preparation of otolith for analysis of elemental composition was provided by Travis Elsdon. Technical assistance of the ICP-MS and imaging equipment was provided by Benjamin Wade (Adelaide Microscopy). Camilo Mejia, Kathleen Wingate, Patrick Reis-Santos, Glen Wingate, Tony Gayer and Antonio Di Franco assisted with collection of fish. Helpful comments on the final draft were provided by Camilo Mejia and Glen Wingate.

Chapter Four

Technical assistance of the ICP-MS and imaging equipment was provided by Benjamin Wade (Adelaide Microscopy) and also Patrick Reis-Santos, Melita de Vries and Tom Barnes. Assistance with collection of fish was provided by the students and teachers of Kangaroo Island Community Education. David Roberts (University of Wollongong) analysed the samples for evidence of hybridisation. Helpful comments on the final draft were also provided by Ian Riley, Camilo Mejia and Glen Wingate.

Antechamber Bay, Kangaroo Island