CRAIG A. BOYS

# *Fish-Habitat Associations in a Large Dryland River of the Murray-Darling Basin, Australia*

*Thesis Submitted in Fulfillment of the Degree of Doctor of Philosophy*

*Accepted May 2007*

River and Floodplain Group
Faculty of Health Design and Sciences
University of Canberra
Canberra, ACT 2601

This thesis is dedicated to my brother David "Bonzo" Boys who taught me many things. Bonzo, by example, showed me what it really means to face adversity and repond with dignity, integrity, positivity and an unwavering respect for others. Bonzo you will be dearly missed by me and so many people, but never forgotten. The submission of this thesis is significant for me for so many reasons, but especially since it is the fulfilment of the last promise I made to you.

David "Bonzo" Boys

December 1975 – November 2005

UNIVERSITY OF CANBERRA


# Copyright in Relation to this Thesis

# Table of Contents

# Abstract

Many aspects concerning the association of riverine fish with in-channel habitat remain poorly understood, greatly hindering the ability of researchers and managers to address declines in fish assemblages. Recent insights gained from landscape ecology suggest that small, uni-scalar approaches are unlikely to effectively determine those factors that influence riverine structure and function and mediate fish-habitat associations. There appears to be merit in using multiple-scale designs built upon a geomorphologically-derived hierarchy to bridge small, intermediate and large spatial scales in large rivers. This thesis employs a hierarchical design encompassing functional process zones (referred to hereafter as zones), reaches and mesohabitats to investigate fish-habitat associations as well as explore patterns of in-channel habitat structure in one of Australia's largest dryland river systems; the Barwon-Darling River.

In this thesis, empirical evidence is presented showing that large dryland rivers are inherently complex in structure and different facets of existing conceptual models of landscape ecology must be refined when applied to these systems. In-channel habitat and fish exist within a hierarchical arrangement of spatial scales in the riverscape, displaying properties of discontinuities, longitudinal patterns and patch mosaics. During low flows that predominate for the majority of time in the Barwon-Darling River there is a significant difference in fish assemblage composition among mesohabitats. There is a strong association between large wood and golden perch, Murray cod and carp, but only a weak association with bony herring. Golden perch and Murray cod are large wood specialists, whereas carp are more general in there use of mesohabitats. Bony herring are strongly associated with smooth and irregular banks but are ubiquitous in most mesohabitats. Open water (mid-channel and deep pool) mesohabitats are characterised by relatively low abundances of all species and a particularly weak association with golden perch, Murray cod and carp. Murray cod are weakly associated with matted bank, whereas carp and bony herring associate with this mesohabitat patch in low abundance.

Nocturnal sampling provided useful information on size-related use of habitat that was not evident from day sampling. Both bony herring and carp exhibited a variety of

habitat use patterns throughout the diel period and throughout their lifetime, with temporal partitioning of habitat use by juvenile bony herring and carp evident. Much of the strong association between bony herring and smooth and irregular banks was due to the abundance of juveniles (<100mm in length) in these mesohabitats. Adult bony herring (>100mm length) occupied large wood more than smooth and irregular banks. At night, juvenile bony herring were not captured, suggesting the use of deeper water habitats. Adult bony herring were captured at night and occupied large wood, smooth bank and irregular bank. Juvenile carp (<200mm length) were more abundant at night and aggregated in smooth and irregular banks more than any other mesohabitat patch. Adult carp (>200mm length) occupied large wood during both day and night.

There is a downstream pattern of change in the fish assemblage among river zones, with reaches in Zone 2 containing a larger proportion of introduced species (carp and goldfish) because of a significantly lower abundance of native species (bony herring, golden perch and Murray cod) than all other zones. In comparison, the fish assemblage of Zone 3 was characterised by a comparatively higher abundance of the native species bony herring, golden perch and Murray cod. A significant proportion of the among-reach variability in fish assemblage composition was explained at the zone scale, suggesting that geomorphological influences may impose some degree of top-down constraint over fish assemblage distribution. Although mesohabitat composition among reaches in the Barwon-Darling River also changed throughout the study area, this pattern explained very little of the large-scale distribution of the fish assemblage, with most of the variability in assemblage distribution remaining unexplained. Therefore, although mesohabitat patches strongly influence the distribution of species within reaches, they explain very little of assemblage composition at intermediate zone and larger river scales. These findings suggest that small scale mesohabitat rehabilitation projects within reaches are unlikely to produce measurable benefits for the fish assemblage over intermediate and large spatial scales in the Barwon-Darling River. This indicates the importance taking a holistic approach to river rehabilitation that correctly identifies and targets limiting processes at the correct scales.

The variable nature of flow-pulse dynamics in the Barwon-Darling River creates a shifting habitat mosaic that serves to maintain an ever-changing arrangement of habitat

patches. The inundation dynamics of large wood habitat described in this thesis highlights the fragmented nature of mesohabitat patches, with the largest proportion of total in-channel large wood remaining unavailable to fish for the majority of the time. At low flows there is a mosaic of large wood habitat and with increasing discharge more potential large wood habitat becomes available and does so in a complex spatial manner. What results in this dryland river is a dynamic pattern of spatio-temporal patchiness in large wood habitat availability that is seen both longitudinally among different river zones and vertically among different heights in the river channel. Water resource development impacts on this shifting habitat mosaic.

Projects undertaking both fish habitat assessment and rehabilitation need to carefully consider spatial scale since the drivers of fish assemblage structure can occur at scales well beyond that of the reach. Fish-habitat associations occurring at small spatial scales can become decoupled by process occurring across large spatial scales, making responses in the fish assemblage hard to predict. As rivers become increasingly channelised, there is an urgent need to apply research such as that conducted in this thesis to better understand the role that in-channel habitats play in supporting fish and other ecosystem processes. Habitat rehabilitation projects need to be refined to consider the appropriate scales at which fish assemblages associate with habitat. Failure to do so risks wasting resources and forgoes valuable opportunities for addressing declines in native fish populations. Adopting multi-scalar approaches to understanding ecological processes in aquatic ecosystems, as developed in this thesis, should be a priority of research and management. To do so will enable more effective determination of those factors that influence riverine structure and function at the approariate scale.

# List of Figures

# List of Tables

# Acknowledgements

This PhD project was supervised by Associate Professor Martin Thoms of the eWater CRC (formerly the CRC for Freshwater Ecology) at the University of Canberra and Doctor Peter Gehrke of CSIRO Land and Water. Both have made significant contributions to my development as a riverine ecologist and I thank these two for their time, effort and guidance. During my candidature I was supported by a three year postgraduate scholarship from the CRC for Freshwater Ecology which included a stipend and financial assistance with operating costs and professional development courses.

This project was largely funded by a MD 2001 FishRehab Program grant as part of a Natural Heritage Trust (NHT) agreement between the Department of Agriculture, Fisheries and Forestry Australia (AFFA), the NSW Department of Primary Industries (Fisheries) and the CRC for Freshwater Ecology. Many of the findings in this thesis form the basis of a technical report prepared for AFFA (Boys *et al.* 2005). I'd like to thank Dr Graeme Esslemont and Dr Bob Creese for their contribution to this report.

The collection and handling of all fish was carried out under permit P01/0059 as covered by section 37 of the Fisheries Management Act 1994. All work was conducted under the conditions stipulated in NSW Fisheries Animal Care and Ethics permit 1 / 4.

The Aquatic Ecosystems Research Unit at NSW DPI provided substantial in-kind support in the form of staff and resources such as electrofishing boats. Particular thanks must go to technicians at the Port Stephens Research Centre who assisted with field sampling and database management: Simon "Wombat" Hartley, Tony "Chook" Fowler, Chris "Show-bags" Gallen, Roger Laird, Andrew Scardino, Jason Thiem, Thomas Rayner and Scott Norris. Gregory West designed and provided much assistance with the software package used to map in-channel habitat (Snag Mapper©). I am also very appreciative of the efforts of Robert "Noddy" Cossart and Gary Reilly from the University of Canberra who provided volunteer support with diel sampling and habitat surveys. Dr Graeme Esslemeont assisted with the coordination of many of the physical

habitat surveys with the assistance of Shannon Brennan, Louisa Davies, Vic Hughes, Ian Maddock, Ann Moore, Matt O'Brien and Melissa Parsons from the University of Canberra. Thankyou to the rest of the River and Floodplain Group at the University of Canberra for all the beers and coffees. A honourable mention must go to my roomies Mark "Maxy" Southwell and Victor "Steak" Hughes. I would like to acknowledge the friendly assistance of various landholders who allowed access to their properties and occasional accommodation.

Very special thanks must go to Dr Lee Baumgartner of NSW Department of Primary Industries. Not only did Lee provide profound comments on manuscript drafts, but his support and friendship got me through numerous periods of dis-elusion. I am also appreciative to Dr Stephen Balcombe, Dr Dean Gilligan, Dr Bob Creese, Dr Heinrich Stefanik, Dr Steve Kennelly and three anonymous reviewers who all provided valuable comments on the Boys and Thoms (2006) manuscript and therefore indirectly improved this thesis. Thankyou to Kris Kleeman for assistance in preparing Figure 3.1.

To my beautiful wife Karina. You have been my greatest asset throughout this PhD. Not only have you given me the gift of a beautiful son (and another on the way), but I will never forget the support, patience and encouragement you have provided me during what have been some difficult times for us both. Your role as a PhD widow is now at an end. As for Max David Boys, who would have thought that a person in the first six months of their life could be such an important catalyst for getting this thesis finally finished. So thankyou Max, you are making your old man proud already. You have given me a huge dose of perspective. After all, I can make my own people now!

Mum, Dad and Sharon, your combined strength through difficult times has helped me immensely.