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Biology and ecology of diadromous fishes in south eastern Australia

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Biology and ecology of diadromous fishes in south eastern Australia

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by

NATHAN G. MILES

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Dedicated to my wife, Kim for my hours of

neglect and time spent apart.

&

To my family, especially my late grandfather Geoff Rayner and

my recently passed grandmother, Jean Miles,

I hope I've made you all proud.

Certification

I, Nathan G. Miles, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy, in the Department of Earth and Environmental Science, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Nathan G. Miles

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The desire to learn more about fish has influenced my life in more ways than I ever could have imagined. My keen interest in fish and the natural environment led me to university and opened my eyes to the possibility that I could make a contribution to conservation of fish in Australia. Throughout this period a number of people have influenced me on my way and I thank them all for their advice and support over the years. It was not long after my move from the country to the coast, that I developed an interest in the coastal freshwater fishes and their unique and seemingly mysterious lifecycles. As a result, I embarked on the adventure that has built up to this thesis. It has not always been a smooth journey, with logistical, administrative and technological obstacles seeming to forever hamper my progress, but the highlights have far outweighed the stumbles, and the past three and a half years have yielded so many memorable experiences, from the numerous nights talking around the camp fire to the excitement of finally finding an elusive species. As I look back over the past years I feel an overwhelming sense of gratitude to all the people, organisations and of course the fish, that have helped, guided and inspired me along the way. Thank you.

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Abstract

Diadromous fishes are a frequent but poorly understood component of coastal riverine fish communities in Australia. Many of Australia's coastal riverine fish, including diadromous species, have undergone declines in abundance and distribution since European settlement. Fish that were once plentiful are now generally rare or appear to be extinct in some catchments or parts of their range. However, as a group, diadromous fish species have complex lifecycles, the details of which have not been well investigated. The various environments and habitats used by diadromous fish are also under threat, through poor land practices, land reclamation and river regulation. The current study aimed to fulfil a number of gaps in the current knowledge of diadromous fishes in Australia. The primary objective was to examine the current distribution, abundance and biology of diadromous fish species of south eastern Australia.

As information on diadromous fishes in Australia was limited, an extensive review of the literature has been conducted as a basis for identifying knowledge gaps. From this review, it was estimated that 33 Australian fish species display diadromous lifecycles, of which only seven have information available for most life stages (*Lates calcarifer*, *Macquaria novemaculeata*, *Galaxias maculatus*, *G. brevipinnis*, *G. truttaceus*, *Geotria australis* and *Mordacia mordax*). Diadromy in Australian fish species is dominated by amphidromy (45.5%) and catadromy (42.4%), with only a small proportion of the diadromous species anadromous (12.1%). The geographical distribution of diadromy in Australia showed that the highest species richness occurred in the north east and south east of the continent, with lowest species richness in the south west. Latitudinally, northern latitudes of Australia are dominated by amphidromy, the central latitudes by catadromy and the southern latitudes have relatively even numbers of all three

diadromous types. The lack of information on diadromous fishes and the high level of environmental degradation and river regulation in south eastern Australia highlight the urgent need for further research on diadromous species in this region.

Diadromous fishes use a range of marine and freshwater environments at different life history stages. As a result, a variety of fish sampling methods were trialled and their efficiency in catching a wide range of species and fish sizes in marine and freshwater environments was assessed. The examined methods included: seine net, scoop net, fyke net, plankton nets, light traps and fish traps. Each method proved useful for capturing certain fish species and fish sizes. Overall, the seine net caught the greatest number of individuals and species, and this method was also time efficient for catching and sorting the catch. As a result, seine nets were adopted for all of the larger scale studies that were conducted in the current research. The broadscale study (Chapter 4) conducted over a large spatial scale also incorporated scoop nets, bait traps and multi panel gill nets, as these provided a range of active and passive methods which allowed rapid assessment of fish at each site. The more detailed study (Chapter 5) aimed to examine a wide range of fish sizes and life stages over larger temporal scales, and used all the methods that were trialled in the pilot study, as the use of these methods ensured that the entire lifecycle of diadromous species could be sampled.

The distribution and abundance patterns of diadromous and riverine fishes were investigated over large spatial scales, by sampling at 47 sites in 17 catchments between 2004 and 2005. A total of 13 269 fish from 31 species were recorded and these were dominated in number by native freshwater fishes (10 252 fish, 8 species), when compared with introduced freshwater fishes (1 570 fish, 3 species), marine fishes (777

fish, 10 species) and diadromous fishes (670 fish, 10 species). Although diadromous fish were only recorded in limited abundance, they were important in that they constituted: a large number of species to the assemblages; larger sized fish to the community; and, key species to reproductive, trophic and behavioural guilds. In particular, diadromous fish made up the majority of carnivorous species which feed on allochthonous inputs and they also contributed to herbivorous and omnivorous guilds. Multivariate analyses (MDS and ANOSIM) significantly delineated fish assemblages based on marine and coastal bioregions, river size, estuary type and river reach. SIMPER revealed that a range of freshwater, introduced, marine and diadromous fish contributed to these differences in the fish communities. *Galaxias maculatus*, *Gobiomorphus australis*, *Potamalosa richmondia* and *M. novemaculeata* were the diadromous species which most often contributed to these differences.

The temporal and spatial variability of diadromous fish assemblages were examined in more detail in the Shoalhaven and Clyde Rivers. Differences in fish assemblages were influenced spatially by the longitudinal gradients throughout the catchment and by the migrational patterns and recruitment of diadromous fishes. Temporal variation in diadromous fish assemblages were also complicated by the lifecycle of diadromous fishes as many species have migrating larvae, juveniles and/ or adults which mean they can be present in the stream throughout all seasons but in different life stages. As a result, diadromous fish assemblages in the Shoalhaven and Clyde Rivers exhibited complex spatial and temporal patterns which reflected their lifecycles and migratory requirements. Longitudinal changes in diadromous fish assemblages in the Shoalhaven River were also influenced by the presence of Tallowa Dam. Fish communities below this structure were more similar to those further downstream, but diadromous fishes

were also affected by cold water pollution below this structure. The abundance of diadromous fish were also negatively correlated with distance from the tidal limit, but were generally positively correlated with instream habitats such as woody debris and undercut bank.

The migratory history of five species were examined through otolith microchemistry. In order to ensure that otolith Sr:Ca and Ba:Ca values in wild fish were the result of ambient salinities, a manipulative experiment was conducted. Fish were held in various salinities and temperatures for a period of up to 62 days. The resulting Sr:Ca values showed patterns which reflected that of the salinity regime. However, for some species the Ba:Ca values did not appear to reflect changes in salinity. Transects across otoliths from wild caught fish also revealed distinct variations in otolith Sr:Ca values, with patterns that indicated a diadromous lifecycle in freshwater mullet (*Myxus petardi*) and striped gudgeon (*Gobiomorphus australis*). Freshwater herring (*Potamalosa richmondia*), Cox's gudgeon (*Gobiomorphus coxii*) and bullrout (*Notesthes robusta*) displayed less obvious patterns in Sr:Ca values, perhaps reflecting more complex patterns of movement between marine and freshwater environments. Although, some of these species were previously thought to be diadromous, the current study suggested that, for some species, the type of diadromy (or range of movements) may differ from those previously documented. The most important finding was the apparent amphidromous lifecycle of *M. petardi*, in at least for these populations from the Shoalhaven and Clyde Rivers.

This research provided new information on the biology and status of a number of diadromous fish species of south eastern Australia. Of particular importance was the

collection of new information about *M. petardi* and *P. richmondia*, including the capture of larvae and juveniles from brackish water. These data supported the diadromous lifecycles, which were indicated by otolith microchemistry. Age estimates confirmed longevity in *P. richmondia* (~10 years) and *M. petardi* (~5 years) and from the specimens of *N. robusta* that were examined it appears that they have longevity in excess of five years. This study also highlighted an apparent decline in distribution and abundance of *Prototroctes maraena* and *Pseudaphritis urvillii* on the NSW south coast, which may be a cause for concern. More research is required to determine the status and threats for these species, in particular.

The current study has provided important new information about the distribution and abundance patterns, as well as the biology, for a number of diadromous species in this region. It has also highlighted the need for further research and management of this important group of fish.