The Ecology of Three Species of Wrasse (Pisces: Labridae) on Temperate Rocky Reefs of New South Wales, Australia

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I hereby certify that the work embodied in this thesis is the result of original research and has not been submitted for a higher degree to any other University or Institution.

Signed: ..........................................................

(Jason Kyle Morton)
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Abstract

In temperate New South Wales, most fish species in the family Labridae have not previously been investigated with available knowledge restricted primarily to photographic identification guides providing brief notes on species distribution, habitat preferences and identification. This information is inadequate for assessing the impact of labrid harvesting on rocky reef systems and for making informed management decisions for the protection of these fishes. Therefore, this study aimed to fill some of the significant gaps in the understanding of labrid assemblages associated with rocky reefs of temperate eastern Australia. This was accomplished by concentrating primarily on three species - *Ophthalmolepis lineolatus*, *Notolabrus gymnogenis* and *Pictilabrus laticlavius* - which are abundant and co-occur in shallow waters (<20 m) on the central coast of New South Wales. The methods used in this study included SCUBA surveys of labrid assemblages; *in situ* observations of labrid behaviour on SCUBA; and acquisition of labrid specimens for the extraction of intestines, gonads and otoliths, and for measurements of fish weight and length.

Labrids were found to be the most species rich family in the study region and were the most abundant of all non-planktivorous fishes. Overall, a higher number of labrid species and a higher number of labrid individuals occurred in sponge garden habitat (15-22 m depth) compared to fringe (3-7 m) and barrens (8-15 m), owing to greater densities of *O. lineolatus*, *Austrolabrus gymnogenis* and *Eupetrichthyes angustipes*. The common labrids, *N. gymnogenis*, *Achoerodus viridis* and *P. laticlavius*, occurred at higher densities in fringe habitat due mostly to a higher representation of juveniles in this habitat. The effect of habitat on labrid assemblages was subject to small-scale variation between sites (separated by hundreds of metres) and experienced temporal changes due primarily to a substantial increase in the abundance of recruits coinciding with late summer and autumn (April-May).

Behavioural observations revealed that the three focal species differed substantially in their spatial structure. *O. lineolatus* were found to be temporary reef residents using home ranges in excess of 2500 m$^2$ for periods of up to 1 year before permanently emigrating outside these temporary home ranges. In contrast, *N. gymnogenis* exhibit strong site fidelity to reef patches of less than 600 m$^2$ in which they remain for periods
in excess of 2 years. Reef patches are shared by up to at least 10 juvenile and female individuals and a single, highly territorial male in a mating system suggestive of resource defence polygyny. An understanding of the spatial structure of *P. laticlavius* was constrained by its cryptic behaviour, but behavioural observations suggest this species is home ranging and establishes temporary territories for the purpose of feeding and/or reproduction. Intensive ethological observations allowed for the description and quantifying of several major behaviours in which all species typically engaged including encounters and interactions with other fishes, lying, use of shelter, side-swiping, bending, gaping, cleaning by clingfishes (Gobiesocidae) and colour change. The occurrence of these behaviours often demonstrated substantial differences among species (e.g. lying, shelter and bending) and/or experienced shifts with ontogeny (e.g. interactions and area usage). These trends generally remained consistent at different times of the day and periods of the year, and at both locations.

Dietary analyses revealed *O. lineolatus*, *N. gymnogenis* and *P. laticlavius* are generalist carnivores feeding on a variety of benthic invertebrates including polychaetes, amphipods, decapods, gastropods, bivalves, polyplacophorans, echinoderms and cirripedes. Differences in the volumetric contribution of prey items in the guts of each species showed that food resources are partitioned among species and observations of foraging behaviour demonstrated a partitioning of microhabitats used for feeding. Ontogenetic shifts in diet and feeding microhabitats demonstrate that food resources are further partitioned within a species. However, overall morphological and behavioural similarities within a species results in greater competition occurring among individuals of the same species than among individuals of different species. This was reflected in higher rates of intra-specific interactions compared with interactions between labrid individuals of different species. Observations of feeding episodes revealed the bite rates of all species were typically unaffected by the time of day and period of year in which sampling occurred, but a location effect occurred for *O. lineolatus* and *P. laticlavius*. A reduction in bite rate with ontogeny occurred for *N. gymnogenis*.

The population structure of the three species suggests each exhibits the typical labrid reproductive strategy of protogynous hermaphroditism. *O. lineolatus* and *N. gymnogenis* are both monandrous species, but the occurrence of some *P. laticlavius* males at small sizes and young ages suggests this species may be diandrous.
Abstract

Similarities occurred between *O. lineolatus* and *N. gymnogenis* in the size/age at which individuals sexually matured (c.a. 180 mm, 2 years) and changed sex (c.a. 280 mm, 4.6 years), but these events occurred at substantially smaller sizes (95 and 138 mm, respectively) and younger ages (<0.9 and 1.9 years, respectively) in *P. laticlavius*. Sectioned otoliths were used to determine that the longevity of *O. lineolatus*, *N. gymnogenis* and *P. laticlavius* was at least 13.4, 9.6 and 4.8 years, respectively. Ages were validated using marginal increment analysis. Timing of reproduction in each species was asynchronous with peaks in the reproductive activity occurring in late summer to early autumn (February-March) for *O. lineolatus*, mid winter (July) for *N. gymnogenis* and mid spring to early summer (October-December) in *P. laticlavius*.

Information gained on the spatial structure, behaviour, diet, life history, growth and demographics of *O. lineolatus*, *N. gymnogenis* and *P. laticlavius* has revealed that, despite belonging to the same family, the ecological significance of each species is distinct, the susceptibility of each species to over-harvesting is different and that ‘blanket’ management strategies are inappropriate for this diverse family. It is recommended that this research acts a precursor for designing future studies aimed at these and other temperate labrids of Australia to more fully appreciate the ecology of these fishes, for predicting the foreseeable consequences of labrid exploitation and for making more informed decisions for the protection of these fishes.
Chapter 1:

Introduction
1.1 Research problem

Labrids, known commonly as wrasses, are frequently captured by recreational and commercial fishers, which are known to contribute to significant reductions in labrid densities and the mean size of individuals in some areas (Edgar and Barrett 1997, 1999; Jones 1999; Gladstone 2001; Platten et al. 2002). These fishers typically target larger, reproductive males that have undergone sex reversal from medium-sized reproductive females, thus potentially causing significant localised depletion in the density of reproductive males. Disruptions to labrid assemblages may result in flow-on effects to other components of rocky reef systems including prey, predators and competitors.

On temperate rocky reefs of eastern Australia the functional ecology, life history and demographics of most labrid species are yet to be investigated with available knowledge restricted mostly to photographic identification guides offering general notes on distribution, habitat preferences and basic identification. Such a limited scope of scientific research is surprising as, being predators of benthic invertebrates, the role of labrids in structuring benthic assemblages may be significant. With an increase in coastal fishing pressure occurring in temperate eastern Australia (Henry and Lyle 2003; Kennelly and McVea 2003) a greater understanding of the functional significance of labrids in rocky reef systems is needed. Therefore, the aim of this study is to provide information to fill some of the significant gaps in the current understanding of labrid assemblages associated with temperate rocky reefs of eastern Australia. This will be accomplished by focusing on three abundant and co-occurring species (i.e. Ophthalmolepis lineolatus, Notolabrus gymnogenis and Pictilabrus laticlavius) in shallow waters of the central coast region of New South Wales (NSW). Information obtained in achieving this aim will be useful for making informed decisions about the ecological significance of labrids on temperate rocky reefs of eastern Australia, for predicting any foreseeable consequences of labrid overexploitation and for making informed management decisions for the protection of these fishes.
1.2 Thesis structure and overview

The following structure has been used to achieve the aim of this thesis. Chapter 1 outlines the general characteristics of labrids, their fisheries in south-eastern Australia and a description of each of the species focussed on in this thesis (i.e. *Ophthalmolepis lineolatus*, *Notolabrus gymnogenis* and *Pictilabrus laticlavius*). Chapter 2 introduces the study region and describes the general methods and locations that were selected for achieving the thesis aim. As a component of the general methods, a brief overview of a pilot study is provided which was performed to determine the optimal sampling strategy for behavioural observations. In Chapter 3, SCUBA surveying techniques are used to quantify spatial and temporal patterns of labrid distribution and abundance, at two locations, for the purpose of determining the relative importance of labrids in fish assemblages within the study region. Special emphasis is given to the role of habitats in determining patterns of labrid distribution.

Having established that labrids are consistently abundant and diverse within the study region, the following three chapters investigate aspects of the functional ecology, life history and demographics of the three focal labrids. Chapter 4 explores the diurnal behavioural repertoires of each of these species using SCUBA and handheld, underwater, video techniques. Among other behaviours, special consideration is given to area usage, social spacing, interactions, shelter use and colour change. Chapter 5 explores the dietary compositions and foraging behaviour of the focal species using a combination of SCUBA observations and gut content examination. Chapter 6 outlines the reproductive strategies, growth and demographics of the focal species using SCUBA observations, gonad examination, age estimates derived from otoliths, and length and weight measures. Finally, Chapter 7 provides a summary of the contribution this research has made to better understanding the ecology of labrids on temperate rocky reefs of eastern Australia and for assisting in making informed management decisions to prevent the ecological consequences of their over-harvesting. Suggestions for future research are also provided in the concluding chapter.
1.3 Introduction to labrids

Australian marine and estuarine waters provide habitat for over 4200 fish species (Hoese et al. 2007), with temperate regions of Australia characteristically having high levels of fish endemicity (approx. 80% of all fishes) (Pogonoski et al. 2002). Of all fishes inhabiting coastal Australia, fishes of the family Labridae (hereafter labrids) represent the second most speciose family after the family Gobiidae. Labrids are distributed worldwide within tropical, subtropical and temperate seas where they are represented by over 60 genera and in excess of 450 species (Parenti and Randall 2000). Of the 162 species in 41 genera currently reported in Australian waters (Pogonoski et al. 2002) more than 90 species have been recorded in temperate Australia (Jones 1999). On rocky reefs of temperate Australia, these fishes represent one of the most conspicuous, abundant and diverse groups, both morphologically and behaviourally. Worldwide, four labrid species are listed as ‘endangered’ or ‘vulnerable’ on the 2006 IUCN Red List of Threatened Species (IUCN 2006) with one, *Cheilinus undulatus*, occurring in waters of tropical Australia (Pogonoski et al. 2002). For several labrid species of south-eastern Australia (e.g. *Anampses elegans* and *Achoerodus viridis*), protection is offered in only part of their range (Pogonoski et al. 2002).

Labrids possess a pointed snout; terminal mouth usually with thick lips and protruding caniform teeth; pharyngeal teeth and jaws used for crushing hard prey items; elongate bodies varying greatly in size, shape and colour; cycloid scales; a long dorsal fin extending the length of the back; and a square, or slightly rounded, caudal fin (Kuiter 1996; Moyle and Cech 2000). The majority of labrids do not exceed 400 mm in length but some may grow to sizes in excess of 1 m (e.g. *Achoerodus gouldii, Achoerodus viridis* and *Cheilinus undulatus*). Most labrids are diurnally active, benthic carnivores feeding on various soft-bodied and hard-shelled prey items on hard reef substratum; however, some such as *Labroides dimidiatus* feed exclusively by engaging in cleaning behaviour. The reproductive life history of labrids typically involves sex reversal in the form of protogynous hermaphroditism, whereby most individuals reproduce as egg-producing, initial phase (IP) females prior to changing sex to become sperm-producing, terminal phase (TP) males. Sex reversal is often associated with distinct colour changes. Variations on this reproductive strategy are outlined in Chapter 6.
1.4 Fisheries

Several species of labrid are keenly sought for consumption by both recreational and commercial fishers in south-eastern Australia. Commercial fishers involved in the use of trap and line fishing methods regularly catch labrids and provide these to fish markets as discrete species or as ‘mixed fish’. Commercial species include *Notolabrus fucicola*, *Notolabrus tetricus*, *Bodianus unimaculatus*, *Ophthalmolepis lineolatus* and, to a lesser extent, *Notolabrus gymnogenis* (Sydney Fish Market 2005). It is not possible to acquire accurate catch data for each species from commercial records but catches of 22180, 2914, 2156 and 165 kg for 2003 are reported for *N. tetricus*, *B. unimaculatus*, *O. lineolatus* and *N. gymnogenis*, respectively (Sydney Fish Market 2005). However, these catch statistics are likely to be vastly under-representative of the true landings of each species as the majority of labrids captured by NSW commercial fishers are reported as nondescript ‘mixed wrasses’ (NSW Fisheries Commercial Catch Database) or are provided to markets as ‘mixed fishes’.

Being colourful fishes, labrids have proven attractive for consumption in some cultures, particularly the growing Asian culture in Australia. This led to the expansion of the live fish trade in 1993 for *N. fucicola* and *N. tetricus* in coastal waters of Tasmania and Victoria (Murphy and Lyle 1999; Lyle and Hodgson 2001). These fishes are caught and sold live after being transported by refrigeration trucks in cooled seawater (Seafood Industry of Victoria 2005). Sydney restaurants and seafood outlets provide the major market for live fishes with a retail value up to $30 per kilogram (Department of Primary Industries 2004). The rapid expansion of this fishery led to the introduction of management controls whereby minimum and maximum size limits were applied and limitations placed on the number of holders of live fish access licences (Murphy and Lyle 1999). Future expansion of the live fish trade to include *O. lineolatus* and *N. gymnogenis* is possible which prompts an immediate need for acquiring ecological and biological information on these species for their effective management.

Labrids are also commonly caught by recreational fishers using line and/or spear for use as bait, for consumption or, in the case of line fishers, as by-catch. Labrids taken by recreational fishers in temperate Australia include *Achoerodus viridis*, *O. lineolatus*, *N. gymnogenis*, *N. tetricus* and *Pictilabrus laticlavius* (Kingsford et al. 1991; Steffe et al.
1996; Henry and Lyle 2003; Kennelly and McVea 2003). Estimates of recreational captures of *O. lineolatus* and *N. gymnogenis* in NSW during 1993/94 are reported to be as high as 23970 and 6199 kg, respectively (Steffe *et al.* 1996), representing substantially higher harvest rates than the corresponding commercial harvesting rates of approximately 2500 and 150 kg in the same period (Sydney Fish Market 2005). More recent data on recreational landings of labrids in NSW is not available but personal observation and communication with recreational fishers suggests that, over the past decade, labrids are increasingly being retained for consumption. With approximately 17% of the NSW population (c.a. 100,000 fishers) participating in an estimated 30.4 million hours of fishing from mid-2000 to the end of 2001 (NSW Fisheries 2002), the impact of the recreational fishing sector on labrid populations is likely to be significant. Indeed, increases in labrid densities and the mean size of individuals are found in areas where recreational fishing is excluded (Edgar and Barrett 1997, 1999; Jones 1999; Gladstone 2001).

Whilst management initiatives have been employed for some labrids of NSW, such as *A. viridis* (bag limit of 2 fishes per day using hand line; no size limit), all other labrids (excluding the protected *Anampses elegans*) have a generous bag limit of 20 fish per day with no size restrictions (NSW Department of Primary Industries 2005b). As the population ecology and biology of most NSW temperate labrids is yet to be investigated (Table 1.1), it is not known whether these current management regulations are effective for sustaining labrid populations.

### 1.5 Labrids of temperate south-eastern Australia

The 83 labrid species found in NSW coastal waters (Hoese *et al.* 2007) are a mixture of both temperate and tropical species. In addition to resident temperate labrids, juvenile tropical labrids including *Thalassoma lunare, Halichoeres nebulosus* and *Stethojulis interrupta* may be found in temperate waters during late summer and autumn carried from tropical spawning sites by the East Australian Current (Holbrook *et al.* 1994; Parker 1999). Whilst tropical labrids have broad ranges extending throughout the Indo-Pacific, most temperate labrids of south-eastern Australia have distributions that are globally isolated and restricted (e.g. *Achoerodus viridis* and *Notolabrus gymnogenis*). Some labrids in this region do have extended distributions across southern Australia.
(e.g. *Pictilabrus laticlavius* and *Ophthalmolepis lineolatus*) and to New Zealand (e.g. *Pseudolabrus luculentus* and *Notolabrus fucicola*) or as far east as Easter Island (e.g. *Notolabrus inscriptus*) (Jones 1999). On the NSW central coast, labrid assemblages consist predominantly of *N. gymnogenis*, *O. lineolatus*, *A. viridis* and *P. laticlavius*, in addition to lower densities of *Pseudolabrus guentheri, Coris picta, Austrolabrus maculatus* and *Eupictrichthys angustipes* (Curley *et al.* 2002; Kuiter 1993).

Despite labrids being conspicuous and well represented on rocky reefs of south-eastern Australia, there is a lack of information outlining their patterns of distribution and abundance, behaviour, feeding ecology, life history, demographics and ecological significance. Most research on temperate labrids has focused on species outside NSW or has focused on *A. viridis* (Table 1.1). This lack of information represents a significant gap in understanding the ecological role of temperate labrids, limits the capacity to predict the system-wide impact of human activities on rocky reef systems and places constraints on the effective management of fishing practices in the region. In response, three resident labrids of the central coast region of NSW have been selected for investigation as these species are locally abundant yet, to date, very little is known of their functional ecology, life history and demographics. The species *O. lineolatus* and *N. gymnogenis* represent fishes regularly caught by commercial and recreational fishers with the potential for an expanded market into the live fish trade. The labrid *P. laticlavius* has an ecological niche which preliminary investigations suggest is distinct from *O. lineolatus* and *N. gymnogenis*. 
Table 1.1: Examples of research conducted on selected labrid species known to be part of rocky reef fish assemblages of temperate south-eastern Australia. Asterisks denote species investigated in the present study.

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<th>Scientific name</th>
<th>Theme</th>
<th>Study Region</th>
<th>Author/s</th>
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<td>Eastern blue groper, Eastern blue wrasse</td>
<td><em>Achoerodus viridis</em></td>
<td>Distribution/size structure</td>
<td>NSW</td>
<td>Gillanders 1997b; Gillanders and Kingsford 1998; Curley <em>et al.</em> 2002</td>
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<td>Reproductive biology</td>
<td>NSW</td>
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<td>Age/growth</td>
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<td>Feeding ecology</td>
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1.6. Focal species

1.6.1 Maori wrasse (Ophthalmolepis lineolatus) – [Valenciennes 1838]

*Ophthalmolepis lineolatus*, or Maori wrasse, derive their common name from the presence of numerous bright blue facial markings around the eyes (similar to facial tattoos in Maori culture). This species has recently received the common name of violet-line Maori wrasse (Sydney Fish Market 2005) to distinguish it from the tropical labrid *Cheilinus undulatus*, which is known commonly as Maori or humphead Maori wrasse. Individuals of *O. lineolatus* have a distinct body coloumration with an orange-brown upper, white middle and yellow-orange lower bands extending horizontally along the length of the body (Figure 1.1a). Sexual dichromism exists between stages with TP males possessing a black band through the midsection (Figure 1.1b). Maximum attainable length is generally less than 450 mm TL (Kuiter 1996).

![Figure 1.1: Morphology and distribution of *Ophthalmolepis lineolatus*. Shown are a 200 mm initial phase female (a) and a 330 mm terminal phase male (b). The distribution of *O. lineolatus* is highlighted in red (c). Cross-hatching around the coast of Tasmania indicates the distribution of this species is typically restricted to deeper waters. Photograph (a) provided by David Powter.](image-url)
O. lineolatus are widespread throughout temperate Australia with a distribution extending from southern Queensland, throughout southern Australia (excluding shallow waters of Tasmania), to the Houtman Abrolhos (Western Australia) (Kuiter 1996) (Figure 1.1c). O. lineolatus are found in loose aggregations from depths of 3 m to at least 60 m, with highest densities on relatively deep coastal reefs at reef-sand interfaces (Kuiter 1993; Curley et al. 2002).

1.6.2 Crimson-banded wrasse (Notolabrus gymnogenis) – [Günther 1862]

Notolabrus gymnogenis are sexually dichromatic with TP males exhibiting a crimson transverse band through the midsection (not visible in Figure 1.2b); crimson dorsal and anal fins; white caudal peduncle; yellow caudal fin; and a head exhibiting a dark upper and light lower half (Figure 1.2b). Juvenile and IP individuals are light brown with numerous rows of white dots of various sizes covering the body (Figure 1.2a). TP males attain a maximum length of 400 mm TL (Kuiter 1993).

Figure 1.2: Morphology and distribution of Notolabrus gymnogenis. Shown are a 230 mm initial phase female (a) and a 320 mm terminal phase male (b). The distribution of N. gymnogenis is highlighted in red (c).
*N. gymnogenis* are found in high abundances from southern Queensland to Mallacoota (Victoria) (Figure 1.2c) on coastal rocky reefs in depths of 2 m to at least 40 m (Kuiter 1996). Juveniles are cryptic favouring reefs with high algal coverage, whilst IP and TP individuals are highly visual. Individual males and loose aggregations of females are distributed over most available hard substrate (Kuiter 1996; Curley *et al.* 2002).

### 1.6.3 Senator wrasse (*Pictilabrus laticlavius*) – [Richardson 1839]

Juvenile and IP *Pictilabrus laticlavius* are dull green to brown providing excellent cryptic colouration in their preferred algal habitat (Figure 1.3a). Juveniles also possess numerous small dots on the dorsal surface and a distinct black dot at the base of the dorsal fin (Kuiter 1996). *P. laticlavius* are sexually dichromatic with TP individuals lime green with 2 lateral, purple stripes extending from the opercula and merging into a single stripe through the caudal peduncle. An additional broad, perpendicular stripe extends from the lower stripe to the anal fin (Figure 1.3b).

![Figure 1.3](image-url)

**Figure 1.3:** Morphology and distribution of *Pictilabrus laticlavius*. Shown are a 100 mm initial phase female (a) and a 190 mm terminal phase male (b). The distribution of *P. laticlavius* is highlighted in red (c).
P. laticlavius are widespread throughout temperate Australia with a distribution ranging from Byron Bay (NSW), throughout southern Australia, to the Houtman Abrolhos (Western Australia) in algal habitat from depths of 2 to 30 m (Kuiter 1996) (Figure 1.3c). Individuals typically do not exceed 250 mm TL (Kuiter 1996).