Spawning, egg development and recruitment of diadromous galaxiids in Taranaki, New Zealand.

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ABSTRACT

Spawning biology of *Galaxias postvectis* Clarke (shortjaw kokopu) was investigated in streams in northwest Taranaki, New Zealand. Most *G. postvectis* were found to spawn near their adult habitat on the river bank during spate flows between May 9 and 17, 2001. Other galaxiids captured appeared to begin spawning earlier in late April. Sixteen galaxiid nests were discovered amongst flooded areas, lying on or amongst the substrate, vegetation and debris on the banks of the Katikara Stream. Mitochondrial (mt) DNA sequences were used to identify these morphologically similar eggs, with 12 being identified as *G. postvectis* and four as *G. fasciatus* Gray (banded kokopu). *Galaxias fasciatus* nest sites had more vegetation and debris than *G. postvectis* nests. The presence of a backwater or pool, cover and gravel were found to be important characteristics associated with both species nests.

Egg development took around three to four weeks on the Katikara Stream margins. Under experimental conditions, most *G. postvectis* and *G. fasciatus* eggs were found to hatch within the first hour of re-immersion in water, and more hatching occurred in moving than still water at warmer temperatures. In the Katikara Stream, eggs hatched and moved downstream only at times of increased water levels. MtDNA sequences were used to identify *G. fasciatus, G. postvectis* and *G. brevipinnis* Günther (koaro) larvae caught drifting downstream in May and June, 2001. From reproductive assessment of adults captured, developmental stage of eggs in nests found, and timing of emigrating larvae, *G. fasciatus* appeared to spawn earlier than *G. brevipinnis,* and both species spawned earlier than *G. postvectis.*

Whitebait migrations were examined within the tidal influence and c. 40 km inland in two rivers in south Taranaki, one with a dam and one without. Whitebait catches were dominated by *G. maculatus* (Jenyns) (inanga) and catches appeared to be similar in both rivers. Large schools of whitebait were however seen below the Patea Dam from October onwards in the Patea River. No whitebait were found to surmount the dam using the elver pass. So the presence of a dam does not appear to affect whitebait recruitment within the tidal influence, however it does block whitebait migrating further upstream to adult habitat.

EXPLANATION OF TEXT

This thesis is a combination of five individual papers. This has resulted in some repetition in introductions, methods and site descriptions between chapters. Chapter 3 was co-written with P.A. Ritchie (Institute of Molecular BioSciences – Massey University) and has been submitted to the New Zealand Journal of Marine and Freshwater Research.

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General Introduction

The New Zealand freshwater fish fauna is dominated by diadromous species that require access to and from the sea to complete their lifecycles (McDowall 1990). Five of these diadromous species belong to the genus *Galaxias* and are *Galaxias maculatus* (inanga), G. *brevipinnis* (koaro), *G. fasciatus* (banded kokopu), *G. argenteus* (Gmelin) (giant kokopu), and *G. postvectis* (shortjaw kokopu) (McDowall 1965).

Diadromous galaxiids spawn in freshwater and the newly hatched larvae migrate to the sea. Subsequently, after four to six months at sea these species, at this stage known commonly as whitebait, return to freshwater in mixed species shoals to find habitat to mature in. However, during peak migration into freshwater in late winter and spring, many whitebait are caught by both recreational and commercial fisherman (McDowall 1990).

Galaxias maculatus dominates the whitebait catch of most rivers with the remaining galaxiid species forming a small but variable part of the fishery (McDowall & Eldon 1980). If they escape capture by whitebaiters or predators, they continue to migrate upstream into adult habitats (McDowall 1990). Some adult whitebait habitats are long distances upstream in small headwater tributaries (McDowall 1990), and it is vital that fish passage is not prevented if headwater populations are to persist. Dams are one barrier to migration that has been found to have a negative effect on fish communities (Joy & Death 2000). The mechanism or cues underlying the movement of whitebait from the sea back into river mouths is unknown. However, it is thought that the presence of whitebait adults in the headwaters may cue whitebait's river selection (Rowe et al. 1992; Baker & Montgomery 2000). Furthermore, it is unknown whether the presence of a dam and a lack of whitebait adults upstream of such a barrier affects whitebait recruitment into a river.

The spawning biology and ecology of *G. maculatus* is relatively well known (McDowall 1968), however little is known about the other species. *Galaxias maculatus* spawn amongst terrestrial vegetation on full or new moons in estuarine areas when spring tides cover marginal vegetation (McDowall 1968). Spawning of *G. fasciatus* has been observed in autumn over a relatively brief period from April to mid June, among flooded terrestrial vegetation and nests have been found on stream margins among vegetation (Hopkins 1979; Mitchell 1991; Mitchell & Penlington 1982). Downstream movement of emigrating larvae have also been found in June during a flood (Ots & Eldon 1975). *Galaxias brevipinnis* nests have been discovered in autumn around adult habitat in New Zealand (Allibone & Caskey 2000) and southeastern Australia (O'Conner & Koehn 1998). McDowall & Suren (1995) have also recorded *G. brevipinnis* larvae emigrating downstream in March in a South Island stream. However no observations of spawning, emigrating larvae or egg deposition of *G. argenteus* or *G. postvectis* have been documented. McDowall & Kelly (1999) have suggested spawning occurs for *G. argenteus* between early June and early August, and downstream migrations of ripe male *G. argenteus* have also been seen during late autumn to winter (McDowall 1990). Ripe *G. postvectis* have been found in March and spent fish in May around their adult habitat, suggesting spawning occurs, like *G. fasciatus* and *G. brevipinnis*, during autumn and early winter (Caskey 1999; McDowall 1990; McDowall et al. 1996). However, much of the reproductive biology of *G. postvectis* and *G. argenteus* is currently unknown.

Terrestrial deposition of eggs at spawning is found in *G. maculatus, G. brevipinnis* and *G. fasciatus* (Benzie 1968a; Mitchell & Penlington 1982; O'Conner & Koehn 1998 respectively), but is rare in fish worldwide (Balon 1981). Closely related non-diadromous galaxiids however, have been found to spawn in the water (Benzie 1968b; Cadwallader 1976; Allibone & McDowall 1997; Allibone & Townsend 1997); therefore bankside spawning may be a diadromous galaxiid trait.

Little is known about hatching of galaxiid eggs, however re-immersion in water has been found to cue hatching of some galaxiid eggs laid in terrestrial environments (Mitchell 1989; O'Conner & Koehn 1998). Temperature affects hatching of *G. maculatus,* with hatching slow and poor below 10°C (Mitchell 1989). R.M. Allibone (pers. comm.) has found hatching of *G. maculatus* improves dramatically in the dark verses daylight. Australian *G. brevipinnis* eggs have been found to only hatch when shaken in water (O'Conner & Koehn 1998). Little is known about the hatching of *G. postvectis* and *G. fasciatus* eggs, and the effect water temperature, light, water movement and time since immersion have on egg hatching.

Early life stages of diadromous galaxiids, including egg, larval and whitebait stages, lack the diagnostic features of their adults, and consequently identification is difficult.

Galaxias maculatus whitebait can be identified when migrating into freshwater without difficulty (McDowall 1964), however the remaining whitebait species are very similar and thus harder to distinguish (McDowall & Eldon 1980). Morphological characteristics have been used to separate whitebait species in the past, except *G. postvectis* and *G. brevipinnis* whitebait that have no known morphological differences (McDowall 1990; McDowall et al. 1996). Identification of larval galaxiids (<35 mm) caught in the sea after emigrating from freshwater have been found to be incorrect using these taxonomic features (McDowall & Robertson 1975). A key to understanding the species lifecycles is going to be the ability to distinguish these species. One method used previously on other fish species is the use of molecular markers, like mitochondrial DNA sequences (Lindstrom 1999; Tringali et al. 1999). Problems have been found with hatching and sequencing whole galaxiid eggs (R.M. Allibone pers. comm.), but a method of identification for whitebait species is needed for all life stages.

This study focuses on the reproductive biology of *G. postvectis, G. fasciatus, G. brevipinnis, G. argenteus,* especially *G. postvectis*, and examines whitebait migration in a dammed and undammed river.

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