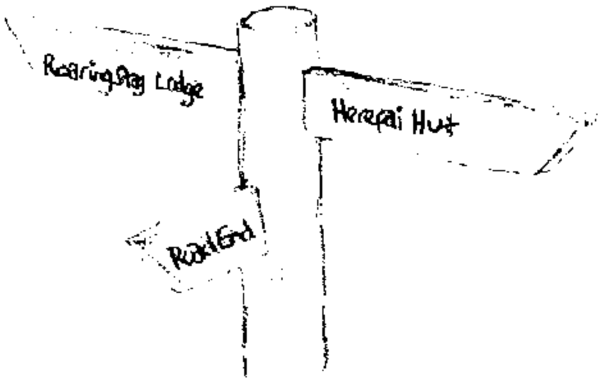
Shortjaw kokopu (*Galaxias postvectis* Clarke) distribution, habitat selection and seasonal activity in the northeastern Tararua Ranges



A thesis presented in partial fulfillment of the requirements
for the degree of a
Masters of Science in Ecology

At
Massey University, Palmerston North
New Zealand.

Scott Bowie
2002

Z

Errata

Page 3 (and other occurrences): replace "Boubee" with "Boubée".

Page 4, line 5: replace "particular" with "particularly"

Page 4: footnote [2] is on page 5

Page 5, line 6: remove hyphen

Page 5, para 3, line 6: replace "predating" with "preying on"

Page 14, para 2, line 3: replace "fluorscine" with "fluorescein"

Page 16, para 3, line 8: replace "preformed" with "performed"

Page 18, Figure 2: add to caption "Pie segments are proportional to total number of fish of each species."

Page 19: Replace P values = 0.001 with < 0.001.

Page 20, para 2: replace "pfankuch" with "Pfankuch".

Page 40, Table 3. add to caption "Sample size, n = 67".

Page 48, abstract last line: replace "sit" with "site"

Page 57, line 4: replace "concordence" with "concordance"

Page 63, para 2: add "Reach length surveyed was 200 metres".

Page 68, para 2: replace "principle" with "principal"

Page 69, para 3: replace "elctrofished" with "electrofished"

Abstract

Freshwater fish communities were surveyed at 59 sites in the Mangatainoka, Makakahi and Ruamahanga catchments of the northeastern Tararua Ranges during 2000/01. At each site, habitat characteristics were recorded and fish identified by spotlighting over a 100 m reach. Benthic invertebrate samples were also collected from 50 of these sites. Shortjaw kokopu (*Galaxias postvectis* Clarke) occurred at 16 sites, located in the Mangatainoka and Makakahi catchments only. Ninty-five shortjaw kokopu were caught in total, ranging from juveniles (≤90 mm) to adults (>120 mm), with adults comprising approximately 75% of the population. Six other fish species were also recorded. Koaro (*G. brevipinnis* Günther), longfin eel (*Anguilla dieffenbachii* Gray), Cran's bully (*Gobiomorphus basalis* Gray), torrentfish (*Cheimarrichthys fosteri* Haast) and brown trout (*Salmo trutta* Linnaeus) all co-occurred with shortjaw kokopu; and a single banded kokopu (*G. fasciatus* Gray) was found in the Ruamahanga catchment.

Discriminant analysis found six habitat factors defined shortjaw kokopu presence. These were low percentages of debris jams, pasture and backwaters; high percentages of shrubs and riffles; and high conductivity. The invertebrate community also proved effective at predicting shortjaw kokopu presence. However, it appears that shortjaw kokopu are limited in distribution by recruitment rather than habitat. Different age classes of shortjaw kokopu were also found to use distinct microhabitats. Sand substrate, pool length, width at the top of the pool, velocity, gradient below the pool, and cobble in the habitat above the pool were found to discriminate between the age class microhabitats.

At three sites in the Mangatainoka River, surveys were undertaken monthly, for 16 months. Number of shortjaw kokopu observed was greatly reduced at all three sites during winter and at a maximum in autumn. This showed that shortjaw kokopu exhibited reduced activity rather than seasonal movements within the catchment.

Three methods for surveying fish communities were tested on shortjaw kokopu. Gee-minnow traps failed to catch any shortjaw kokopu, but electrofishing and spotlighting both proved effective. While spotlighting caught more shortjaw kokopu at more sites, no significant difference in performance was found between the two methods.

Acknowledgements

I am grateful to everybody who has influenced this project, especially to my supervisor, Dr Ian Henderson, who helped set the project up. While 3rd year limnology developed my interest in New Zealand's freshwater fish, it was Ian's inspiration for this project which made it happen. I am also incredibly grateful for his thorough editing skills and statistical know-how.

To Sjaan Charteris who was incredible support when things went to custard. Her thorough editing, her driving ambition for me to finish and her ability to keep me on the straight and narrow, ensured that I gave my best, managed my time efficiently, but maintained my sanity in the process. For that, I am sincerely thankful.

I would like to acknowledge the funding from the Department of Conservation and horizons.mw. The river-line run by horizons.mw proved incredibly beneficial, allowing trips to be planned efficiently.

I am incredibly grateful to my parents, Robbie and Robyn, and sister Cookie, who ventured into the field when volunteers were in short supply. They endured much hardship to see me fulfil my aspirations, tolerating some rough sleeping conditions, some long-nights in semi-freezing water, some sever bruising, and some long days hiking into remote, but incredibly picturesque locations.

To the Ecology Group, Massey University. Thankyou to all who ventured into the field, especially Kirsty Francis, Matt Wong, Cindy Jenkins, Debbie Kyngdon and Mark Hamer; and also to other volunteers, Callum Kay and Sarah Clarke, who were not always happy to be there, but were prepared to give up their time. Mike Joy and Russell Death had a lot of valuable advise; and Jens Jorgensen created some fine field equipment. Paul Barrett, Cathy Lake, Tracy Harris and Hayden Hewitt provided some excellent technical support; and Erica Reid, Barbara Just, Jodi Matenga and Diana Crow, all provided great administrative support.

I am particularly grateful to the landowners in the Putara Valley, particularly Paul and Chrissy Ferry, Jenny and John Davidson and Jim and Bev Bryant for access to sampling sites.

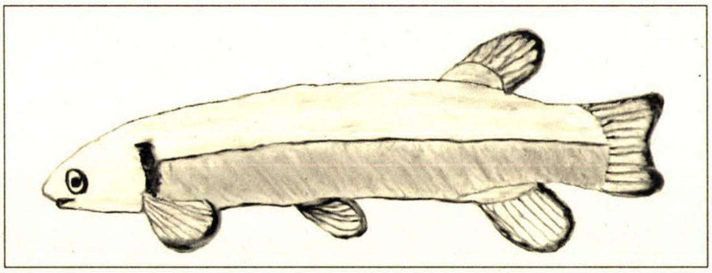
Thank you also to the Manawatu Department of Conservation, and to Russell Death (Massey University), for the use of both gee-minnow traps and an electrofishing machine.

Russell proved quite motivational, with his biting, yet thought-provoking talks. To Erica, Barb and Tracy for their willingness to play the scape-goat when I needed some light relief. To Sjaan for keeping me motivated, especially when the situation didn't always go my way. And to Matt for always indulging my need for a coffee break.

Finally, a special thank you to Jim and Bev Bryant, and my father Robbie, for their help rescuing my car when it broke down, middle of the night, middle of nowhere.

Table of Contents

1 General Introduction



F.E. Clarke (1899) on shortjaw kokopu:

"The third westland species I enlarge upon, more frequently inhabits the sluggish and muddy-bottomed creeks, but is also found in company with Galaxias kokopu in the gravel-bottomed and some of the rocky creeks. In its proportions it somewhat approximates to the description of fasciatus, though it grows much larger, but seldom beyond 10 in. in length. It is not as hardy in the aquarium as G. kokopu, and has generally the same feeding habits, except that it does not take a surface-bait as well. Strange to say, it is seldom, if ever, troubled with the flesh-worms before mentioned. I have distinguished this one with the specific name of postvectis, on account of its perculiar and constant markings."

New Zealand has 36 recognized species of native freshwater fish, with two more recently discovered, but yet to be formally classified (R.M. Allibone (DoC[1]: Wellington) *pers. comm.* November 2001). Seven other species of marine wanderers also frequent freshwater from time to time (McDowall 2000). Of these 36 species, seven are members of the bully family (*Gobiomorphus* spp., Eleotridae), three of the eel family (*Anguilla* spp., Anguillidae), two of the smelt family (Retropinnidae) and 20 of the family Galaxiidae. The remaining four species are lamprey (*Geotria australis* Gray), torrentfish (*Cheimarrichthys fosteri*), black flounder (*Rhombosolea retiaria* Hutton) and the now extinct grayling (*Prototroctes oxyrhynchus* Günther).

Many of New Zealand's freshwater fish require access to both marine and freshwater, commonly known as diadromy. There are three forms of diadromy: catadromy, living in freshwater but migrating to sea to spawn (e.g. eels); anadromy, living at sea but migrating into freshwater to spawn (e.g. lamprey); and amphidromy, migration between marine and freshwater but not related to spawning (e.g. torrentfish) (McDowall 1990). The galaxiidae family comprises five diadromous and 15 non-diadromous species. The diadromous species (whitebait) exhibit either catadromy, i.e. inanga (*Galaxias maculatus* (Jenyns)) or amphidromy, i.e. giant kokopu (*G. argenteus* (Gmelin)), banded kokopu (*G. fasciatus*), shortjaw kokopu (*G. postvectis*) and koaro (*G. brevipinnis*).

Of the diadromous galaxiids, shortjaw kokopu are thought to be the rarest, listed as category A in the endangered species rankings (Molloy & Davis 1994). Sharing this endangered species rating are several New Zealand icons such as kiwi (*Apteryx* spp.), takahe (*Porphyrio mantelli hochstetteri*), black robin (*Petroica traversi*) and kakapo (*Strigops habroptilus*). Shortjaw kokopu are widely distributed throughout New Zealand, from Puysegur Point on the South Island's south coast, to Kaitaia in the north and Bay of Plenty in the east, but at any given location, they are generally found in very low numbers (approximately 1-3 fish per 100 m; McDowall 1990, McDowall *et al.* 1996). Several factors have been suggested that may explain the rarity of shortjaw kokopu. They may be confined to specific microhabitats that are rare (i.e. particular stream and substrate size), their activity patterns may not complement most survey methods (i.e. they are hard to find), they may be rare through over-harvesting of

[1] Department of Conservation.

juvenile whitebait, manmade barriers to migration may affect access to adult habitat, or competition/predation by introduced trout may decrease populations.

A diadromous lifecycle, like that of shortjaw kokopu, is beneficial for many species as it allows them to distribute around New Zealand's coastline, colonizing many rivers. This can be impeded however, if the rivers contain barriers to whitebait migration. These barriers can be natural, i.e. waterfalls and dry reaches, or manmade, i.e. dams and weirs (McDowall 1984, 1990). A diadromous lifecycle may therefore place constraints on habitat selection.

Habitat quality is an important determinant of shortjaw kokopu presence (Williams & Given 1981, McDowall 1984, Swales 1991, McDowall *et al.* 1996). Many studies suggest forest cover of the stream is an important component of shortjaw kokopu habitat (McDowall *et al.* 1977, Eldon 1983, Eldon 1984, Nicoll 1984, Main 1987, McDowall 1990, 1996, 1997, McDowall *et al.* 1996). However, other studies on West Coast populations of shortjaw kokopu have shown that shortjaw kokopu avoid forests dominated by beech (*Nothofagus* spp; McDowall *et al.* 1977, McDowall *et al.* 1996, McDowall 1997, 2000). Removing this forest cover is thought to be a major cause of declining native fish populations (McDowall 1984, 1990, Rowe *et al.* 1999), however the effects of exotic forest are less clear. Recent studies have found populations of banded kokopu in mature exotic forests (Hicks 1998, Rowe *et al.* 1999, Rowe 2000), although unmodified native forest is still thought to be preferred (Rowe *et al.* 1999). In the short term, these exotic forests act like native forests, providing the overhead cover, humidity, and potential food supply required by banded kokopu. However, at a larger scale, exotic forests have several drawbacks. They have a limited lifespan (c. 25 years) before harvesting removes them, which in turn causes turbidity problems in the water (Rowe 2000). They also regulate the flow different to native forests, having higher flood peaks than native forest, but reducing water levels during dry periods (Hicks 1998). Banded kokopu, and galaxiids in general, are sensitive to turbidity (Boubee *et al.* 1997, Richardson *et al.* 1998, Rowe & Dean 1998, Richardson *et al.* 2001). Suspended sediments in the water restrict the migration of juvenile banded kokopu into these rivers (Boubee *et al.* 1997, Richardson *et al.* 1998, Richardson *et al.* 2001) and also restricting banded kokopu feeding (Richardson *et al.* 1998, Rowe & Dean 1998). Koaro were also found to avoid turbid habitats (Boubee *et al.* 1997, Richardson *et al.* 1998), but were better able to feed in these habitats (Richardson *et al.* 1998, Rowe & Dean 1998), which was attributed to their dispersal into glacial silt clouded rivers. Studies on the other diadromous galaxiids habitat, including shortjaw kokopu, are limited, but are suggested to be similar to the requirements of banded kokopu (Hicks 1998). Substrate type has also been identified as important for shortjaw kokopu, particular the presence of boulders and cobbles (McDowall 1990, 2000, McDowall *et al.* 1996). Fine sediments in the substrate may also be a problem for galaxiids through its impact on preferred prey (Main 1987, McDowall 1996, McDowall *et al.* 1996). However, more work is required on the habitat needs of shortjaw kokopu.

Migratory access is a problem that faces all diadromous fish, including shortjaw kokopu (McDowall 1984, 1990, 1998). Based on analysis of NZFFD[2] records from the South Islands, West Coast, McDowall (1998) suggested that most of New Zealand's diadromous fish are found at low altitudes and short distances inland. In contrast, non-diadromous species tend to be further inland and at higher altitudes. While some diadromous fish, including shortjaw kokopu, are capable of significant inland migrations, McDowall (1998) found that most individuals colonised suitable habitat at downstream sites. He reasoned that, particularly for shortjaw kokopu, this was because of abundance of suitable habitat near the coast. Joy *et al.* (2000) found a similar altitude relationship in Taranaki; however, shortjaw kokopu were found more commonly further inland. Jowett & Richardson (1995), Jowett *et al.* (1996) and Jowett *et al.* (1998) also found similar trends for shortjaw kokopu.

There are many methods used to survey fish communities, including those with shortjaw kokopu present. Electrofishing machines are an effective non-lethal means of surveying and identifying fish in an entire stretch of river, catching many of the species in the community. However, R.F.G. Barrier ((DoC: Wellington) *pers. comm.* October 2001) has suggested that electrofishing is not a good estimator of some galaxiid communities because many species are either not caught or only in small proportions relative to their true abundance. In the case of galaxiids, including shortjaw kokopu, daytime refuge may mean hiding under rocks, so electrofishing will still stun them, but may not extracted them from between rocks. For some diadromous galaxiids, especially shortjaw kokopu, spotlight surveying is a suggested better method (R.F.G. Barrier (DoC: Wellington) *pers. comm.* October 2001). This method allows nocturnal fish communities to be surveyed during their active period. Other methods of fish community surveying are the use of traps and nets. However, these require fish to move around to encounter the traps. Highly territorial or site attached species may be under-estimated by trapping. Shortjaw-kokopu are often found in the same or neighboring microhabitat between survey trips (e.g. Caskey 1999), so setting traps in one microhabitat may not catch the shortjaw kokopu from nearby microhabitats. However, more information is needed to determine the best method for shortjaw kokopu surveying.

Most native fish, including shortjaw kokopu, become harder to find during winter (Cadwallader 1975, R.F.G. Barrier (DoC: Wellington) *pers. comm.* October 2001). This is a problem in all survey methods, but especially in spotlight surveys, which require fish to be active within their habitat. Some salmonids are known to become nocturnal in low water temperatures (≤5°C), regardless of the length of daylight. However, diadromous galaxiids in New Zealand are already nocturnal (McDowall 1990). A non-diadromous galaxiid, *Galaxias vulgaris* Stokell, has been found to have peaks in activity relating to time since darkness fell. For the diadromous galaxiids, this may partially explain the perception that they are hard to find, surveys have been undertaken at the wrong times. Other observed patterns are of reduced activity during winter. However, for shortjaw kokopu, only seasonal growth rates have been studied (Caskey 1999), with annual activity pattern requiring investigation.

Introduced trout have often been described as a limiting factor on native fish distribution, including shortjaw kokopu (McDowall 1984, McDowall *et al.* 1996). While not excluding adult shortjaw kokopu from specific habitat, McDowall *et al.* (1996) argues that trout hold the competitive advantage and do prey on juveniles. Brown trout are known to feed on migrating whitebait shoals (McDowall *et al.* 1996); and while there is no direct evidence of trout predating shortjaw kokopu whitebait in particular, Eldon (1983) surmised that in rivers which support large numbers of shortjaw kokopu whitebait (e.g. Buller River), trout predation on shortjaw kokopu is

---

[2] New Zealand Freshwater Fish Database, maintained by the National Institute of Water and Atmosphere (NIWA; McDowall & Richardson 1983).

highly probable. Unfortunately, this problem is difficult to control, especially for diadromous species with a need for sea access (McDowall 1984), so further work is needed into the effects trout have on different size classes of shortjaw kokopu.

1.1. Study Area

All study sites are located within a 100 km^2 region of the northeastern Tararua Ranges, North Island, New Zealand at approximately 40° 40′ S, 175° 30′ E. Three main catchments drain the study area, the northern flowing Mangatainoka and Makakahi Rivers, and the southern flowing Ruamahanga River. The Mangatainoka and Makakahi Rivers are tributaries of the Manawatu River, which flows to the west coast of the North Island, while the Ruamahanga feeds into Cook Strait. The lower Manawatu River has a series of barrage dams at several sites upstream of the Manawatu Gorge (Anonymous 2001) while the Ruamahanga has a barrage control gate at Lake Wairarapa.

All three rivers originate in the largely unmodified Tararua Forest Park. At lower altitudes, the canopy is dominated by red beech (*Nothofagus fusca*), intermixed with podocarp forest. At higher altitudes, red beech/podocarp forest is replaced by kamahi (*Weinmannia racemosa*) and leatherwood (*Olearia colensoi*) shrubs, in the Mangatainoka and Makakahi catchments, and by silver beech (*N. menziesii*) in the Ruamahanga (New Zealand Forest Service 1976). In the Tararua Ranges north of the main Mangatainoka catchment, all beech species are absent (Rogers & McGlone 1994). The Makakahi River also flows through an exotic tree plantation (*Pinus radiata*) at the park boundary.

The documented fish community of the three study rivers in the northeastern Tararua Ranges has been relatively unknown until early 1999 when a large population of shortjaw kokopu was discovered in the headwaters of the Mangatainoka River (Anonymous 1999) (Table 1). However, the Mangahao River, one of the neighboring catchments of the Manawatu River, has been heavily surveyed (Table 1). This is because of the desiltation process required for the power generation dam on the river (Boubée *et al.* 1995).

Table 1. Fish species recorded from NZFFD records of the northern Tararua Ranges up to and including the discovery of a large population of shortjaw kokopu (Anonymous 1999).

Common name Scientific name	Mangatainoka River	Makakahi River	Ruamahanga River	Mangahao River
Lamprey *Geotria australis* Gray		✓		
Longfin eel *Anguilla dieffenbachia* Gray	✓		✓	✓
Shortfin eel *A. australis* Richardson	✓		✓	✓
Common smelt *Retropinna retropinna* (Richardson)	✓			
Shortjaw kokopu *G. postvectis* Clarke	✓			✓
Banded kokopu *G. fasciatus* Gray				✓
Koaro *G. brevipinnis* Günther	✓			
Dwarf galaxies *G. divergens* Stokell				✓
Brown mudfish *Neochanna apoda* Günther			✓	✓
Common bully *G. cotidianus* McDowall			✓	✓
Redfin bully *Gobiomorphus huttoni* (Ogilby)			✓	
Upland bully *G. breviceps* Stokell	✓	✓	✓	✓
Cran's bully *G. basalis* Gray				✓
Torrentfish *Cheimarrichthys fosteri* Haast	✓		✓	✓
Brown Trout *Salmo trutta* Linnaeus	✓	✓	✓	✓

In this study, habitat features and invertebrate communities that characterise the presence of shortjaw kokopu in the northeastern Tararua Ranges are investigated. Habitat characteristics are examined in relation to the presence of three age classes, particularly juvenile shortjaw kokopu. The seasonal activity of shortjaw kokopu, the associated fish community and the best method for surveying shortjaw kokopu is also examined.

This thesis is presented as four individual papers. This has resulted in some repetition in introductions and methods between chapters. Part of this work has also been partially presented in a report for the Department of Conservation (Bowie & Henderson 2002).

1.2 References

Anonymous 1999. Fish find gives scientists hope for rare species. *Dominion,* Wellington, New Zealand. 20-02-1999: 1.

Anonymous 2001. Going with the flow on Mangatainoka flood control. *New Zealand Fish and Game Magazine: Taranaki/Wellington Supplement,* August: 6-7.

Boubee, J., Forsyth, D., Richardson, J., Barrier, R. & James, M. 1995: 1995 Mangahao Dams desilting fish & invertebrate survey. NIWA, Hamilton, New Zealand. Survey ELE312-01/1.

Boubee, J. A. T., Dean, T. L., West, D. W. & Barrier, R. F. G. 1997: Avoidance of suspended sediment by the juvenile migratory stage of six New Zealand native fish species. *New Zealand Journal of Marine and Freshwater Research 31*: 61-69.

Bowie, S. & Henderson, I. 2002: Shortjaw kokopu (*Galaxias postvectis*) in the northern Tararua Ranges: Distribution and habitat selection. Department of Conservation, Wellington, New Zealand. DOC Science Internal Series 30

Cadwallader, P. L. 1975: Spontaneous locomotory activity of *Galaxias vulgaris* Stokell (Pisces: Salmoniformes). *New Zealand Journal of Marine and Freshwater Research 9*: 27-34.

Caskey, D. 1999: Shortjawed kokopu (*Galaxias postvectis*) research and surveys June 1998- June 1999. Department of Conservation, Stratford, New Zealand.

Clarke, F. E. 1899: Notes on New Zealand Galaxidae, more especially those of the Western Slopes: with descriptions of new species, &c. *Transactions and Proceedings of the New Zealand Institute 31*: 78-91.

Eldon, G. A. 1983: Enigma of the third kokopu. *Freshwater Catch (NZ) 23*: 17-18.

Eldon, G. A. 1984: Carnivorous kokopu in captivity. *Freshwater Catch (NZ) 25*: 9.

Hicks, B. 1998: Effects of forestry on fish. *Fish and Game New Zealand 7*: 38-41.

Jowett, I. G., Hayes, J. W., Deans, N. & Eldon, G. A. 1998: Comparison of fish communities and abundance in unmodified streams of Kahurangi National Park with other areas of New Zealand. *New Zealand Journal of Marine and Freshwater Research 32*: 307-322.

Jowett, I. G. & Richardson, J. 1995: Habitat preferences of common, riverine New Zealand native fishes and implications for flow management. *New Zealand Journal of Marine and Freshwater Research 29*: 13-23.

Jowett, I. G., Richardson, J. & McDowall, R. M. 1996: Relative effects of in-stream habitat and land use on fish distribution and abundance in tributaries of the Grey River, New Zealand. *New Zealand Journal of Marine and Freshwater Research 30*: 463-475.

Joy, M. K., Henderson, I. M. & Death, R. G. 2000: Diadromy and longitudinal patterns of upstream penetration of freshwater fish in Taranaki, New Zealand. *New Zealand Journal of Marine and Freshwater Research 34*: 531-534.

Main, M. 1987: Feeding habits of the shortjawed kokopu. *Freshwater Catch (NZ) 31*: 13.

McDowall, R. M. 1984: Designing reserves for freshwater fish in New Zealand. *Journal of the Royal Society of New Zealand 14*: 17-27.

McDowall, R. M. 1990: New Zealand Freshwater Fishes: A natural history and guide, 2 Ed. Auckland, New Zealand. Heinemann Reed, 553 pp.

McDowall, R. M. 1996: Volcanism and freshwater fish biogeography in the northeastern North Island of New Zealand. *Journal of Biogeography 26*: 139-148.

McDowall, R. M. 1997: Indigenous vegetation type and the distribution of the shortjawed kokopu, *Galaxias postvectis* (Teleostei: Galaxiidae), in New Zealand. *New Zealand Journal of Zoology 24*: 243-255.

McDowall, R. M. 1998: Fighting the flow: dowstream-upstream linkages in the ecology of diadromous fish faunas in West Coast New Zealand Rivers. *Freshwater Biology 40*: 111-122.

McDowall, R. M. 2000: The Reed Field Guide to New Zealand Freshwater Fish. Auckland, New Zealand. Reed Publishing (NZ) Ltd, 224 pp.

McDowall, R. M., Eldon, G. A., Bonnett, M. L. & Sykes, J. R. E. 1996: Critical habitat for the conservation of shortjawed kokopu, *Galaxias postvectis* Clarke. Wellington, New Zealand. Department of Conservation, 80 pp.

McDowall, R. M., Graynoth, E. & Eldon, G. A. 1977: The occurrence and distribution of fishes in streams draining the beech forests of the West Coast and Southland, South Island, New Zealand. *Journal of the Royal Society of New Zealand 7*: 405-424.

McDowall, R. M. & Richardson, J. 1983: The New Zealand freshwater fish survey: a guide to input and output. New Zealand Ministry of Agriculture and Fisheries, 15 pp.

Molloy, J. & Davis, A. 1994: Setting priorities for the conservation of New Zealand's threatened plants and animals, 2 Ed. Wellington, New Zealand. Department of Conservation, 64 pp.

New Zealand Forest Service 1976: Tararua State Forest Park, Wellington, New Zealand. A.R. Shearer, Government Printer, 28 pp.

Nicoll, G. 1984: Freshwater life surveyed in South Westland. *Freshwater Catch (NZ) 24*: 4-6.

Richardson, J., Boubee, J., Dean, T., Hicks, M., Rowe, D. & West, D. 1998: Effects of suspended solids on migratory native fish. *Water and Atmosphere 6*: 22-23.

Richardson, J., Rowe, D. K. & Smith, J. P. 2001: Effects of turbidity on the migration of juvenile banded kokopu (*Galaxias fasciatus*) in a natural stream. *New Zealand Journal of Marine and Freshwater Research 35*: 191-196.

Rogers, G. M. & McGlone, M. S. 1994: A history of Kaiparoro clearing and the limits of *Nothofagus* in the northern Tararua Ranges, New Zealand. *New Zealand Journal of Botany 32*: 463-482.

Rowe, D. 2000: Can pine plantations restore whitebait fisheries? *New Zealand Tree Grower 21*: 34-35.

Rowe, D. K., Chisnall, B. L., Dean, T. L. & Richardson, J. 1999: Effects of land use on native fish communities in east coast streams of the North Island of New Zealand. *New Zealand Journal of Marine and Freshwater Research 33*: 141-151.

Rowe, D. K. & Dean, T. L. 1998: Effects of turbidity on the feeding ability of the juvenile migrant stage of six New Zealand freshwater fish species. *New Zealand Journal of Marine and Freshwater Research 32*: 21-29.

Swales, S. 1991: Threats and conservation of native fish. *Freshwater Catch (NZ) 45*: 19-21.

Williams, G. R. & Given, D. R. 1981: The red data book of New Zealand: rare and endangered species of endemic terrestrial vertebrates and vascular plants, Wellington, New Zealand. Nature Conservation Council, 175 pp.