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MISCELLANEOUS REPORT NO. 126

INVESTIGATION OF THE FISH AND FISHERIES OF THE LAKE WAIRARAPA WETLANDS

by

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CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF APPENDICES

Page

EXECUTIVE SUMMARY

INTRODUCTION

Management of water levels of Lake Wairarapa, in the lower Ruamahanga River basin, has been the subject of negotiations between the Wellington Regional Council, the Department of Conservation, the Wellington Fish and Game Council, Maori, and local interest groups such as farmers and recreationalists. The object of these negotiations has been to establish a regime of water level manipulation that best meets the seasonal requirements of flood control, fisheries, wildlife, and recreational users. Water level is controlled by a set of six barrage gates at the downstream end of the lake (Figure 1), the centre two of which are remotely controlled. A rectangular orifice (1.52 x 0.61 m) in the concrete base of the barrage structure, built to allow fish passage, is permanently open. When the gates are shut, even small differences in water height between the upstream and downstream sides of the gates (>85 mm) can create high water velocities (>1.0 m/s). While fish near the orifice would be swept through in the direction of the flow, most species would not be able to swim against the flow, and the water velocity would therefore present a barrier to fish migration.

Also within the lower Ruamahanga River Basin are Lakes Onoke and Pounui. Flapgates divide Lake Onoke from Pounui Lagoon and potentially impede fish access to Lake Pounui. The flapgates open on an outgoing tide when the water level at the Lake Onoke side of the gates falls below that of the Pounui Lagoon. The gates shut on an incoming tide as water begins to flow from Lake Onoke into Pounui Lagoon. Determining the influence of these two potential barriers on upstream migrations of fish is a major objective of this investigation.

The lower Ruamahanga River and its lakes are important to recreational fishers, yet little is known about this use. The important historical Maori fishery for eels, based on fishing downstream migrants in April and May when the barrier bar to Lake Onoke was closed, no longer exists because the bar is maintained in an open state. Commercial eel fishing is also an important activity in the area, and therefore the second major objective of this investigation is to provide information on the recreational and commercial fisheries of the Lake Wairarapa wetlands. From information about fish passage and fisheries use, the effects of water level manipulation through barrage operation can be examined.

THE BARRAGE GATES ON THE OUTLET OF LAKE WAIRARAPA

Both black and yellowbelly flounder occur in the Lake Wairarapa system. Both have a marine phase, and black flounder frequent freshwater or brackish water. Yellowbelly flounder are usually restricted to salt or brackish water. Thus black flounder are believed to have dominated the catch in Lake Wairarapa, though species were not usually specified by fishers. A dramatic decline in the catch of flounder in Lake Wairarapa has occurred, and the largest and most sudden drop happened at the completion of the diversion scheme. In 1974 the Ruamahanga River was diverted past Lake Wairarapa, and barrage gates on the lake outlet came into operation. Catch rates fell after diversion from a lake-wide value of 40-60 flounder per net per night to a maximum of 15-25 flounder per net per night at the north end of Lake Wairarapa, and 4-5 flounder per net per night elsewhere in the lake. The best catches appear to have been associated with freshwater inflows to the lake.

Catch rates of flounder have been stable following the diversion of the

Ruamahanga River in 1974 until about 1988. After 1988, catches in northern Lake Wairarapa again fell to their present level of about 2-3 flounder per net per night. This second fall in catch rates appears from fishers comments to have occurred in Lakes Onoke and Wairarapa and the Ruamahanga River simultaneously. This catch rate drop probably involves both black and yellowbelly flounders, though species were not differentiated. A majority of fishers using all locations have reported a decline in catches in the five years preceding the summer of 1991/1992. It is unlikely that yellowbelly flounders have been affected by the changes to the Ruamahanga River and Lake Wairarapa, but black flounders appear to have been severely affected.

Access of some obligately diadromous fish appears to be reduced by the barrage gates at the outlet of Lake Wairarapa. Evidence is somewhat circumstantial, however, and the effect on the migration of black and yellowbelly flounder and grey mullet could not be determined by relative abundance measured in this study. Koaro and redfinned bullies are probably excluded, and the abundance of torrentfish, yelloweyed mullet, and inanga are thought to be reduced by at least two-thirds compared to downstream. The abundance of *Paratya* shrimps in Lake Wairarapa may also be reduced by the barrage gates.

Opening the barrage gates in spring when juvenile eels and galaxiids migrate upstream, and in summer, the main time for migrations of fish such as black flounder, mullet, and kahawai into freshwater, would allow more fish into Lake Wairarapa. Increase of fish populations to prediversion numbers is unlikely because water from the Ruamahanga River, which used to provide an attraction for fish migrating into Lake Wairarapa, now flows around Lake Wairarapa. Restoration of the original flow patterns is the only measure likely to achieve the former abundance of species such as black flounder. However, opening the barrage gates for as long as possible in September and October, and from January to April, would allow the maximum number of eels, galaxiids, mullet, flounder, and torrentfish access to Lake Wairarapa without rerouting the flow of the Ruamahanga River through Lake Wairarapa.

Automation of the 4 unautomated barrage gates would be a valuable change to operation of the barrage gates. All six gates could then be opened remotely. Juvenile fish generally migrate at the surface and at the shallow margins, and opening the only two automated central gates forces fish away from the banks into deep water where they are vulnerable to predation. If only two more of the six gates were to be automated, then it should be the two gates nearest each bank.

FLAPGATES ON POUNUI LAGOON

The flapgates at the entrance to Pounui Lagoon restricts upstream fish migration. Yelloweyed mullet, triplefins, stargazers, *Helice crassa* (mudflat crab), and *Palaemon affinis* (shrimp) were present downstream of the flapgates but absent upstream. Catch rates of glass eels, inanga whitebait, and common smelt were much reduced upstream compared to downstream. *Paratya curvirostris* shrimps, however, were only found upstream of the flapgates. Fyke net catches showed that the abundance of shortfinned eels was lower upstream than downstream of the flapgates. The cause of reduced fish abundance upstream is probably due in part to the physical barrier of the flapgates and the high water velocities when the gates are open, and in part to low salinities in Pounui Lagoon, which would be unfavourable to some species. The flapgates restrict the entry of saline water as well as fish.

The complete removal of the flapgates is the only obvious solution to the barrier they currently present to upstream fish migration, apart from automating their action, which is probably too costly. The result of removal of the flapgates will be 1) improved access for eels and giant kokopu whitebait to Lake Pounui, a habitat of known value for both species, 2) access for inanga whitebait to valuable habitat for them, 3) improved access for redfinned bullies and *Paratya* shrimps to Pounui Stream, and 4) reintroduction of estuarine species to the lagoon.

MANAGEMENT OF WATER LEVEL IN LAKE WAIRARAPA

Brown mudfish occupy wetlands at lake margins (e.g., Donalds Block), and their habitat has been severely reduced in the lower Wairarapa. Therefore maintenance of their remaining habitat is imperative. These fish need water in autumn and winter for breeding and survival, but tolerate dry conditions in summer. Mudfish may actually require dry habitat in summer to reduce competition and predation. Populations of fish such as eels and mosquitofish that cannot aestivate will be eliminated from areas with standing water in winter, but in which the water dries in summer. Therefore the seasonal water level changes required by brown mudfish are probably the exact opposite of the current operating regime, in which lake levels are maintained artificially high in summer, and lowered in winter for flood protection.

LAKE ONOKE BAR OPENING

Lakes Onoke and Wairarapa and the Ruamahanga River support regionally important fisheries for whitebait, flounder, trout, perch, eels, yelloweyed mullet, kahawai, and red cod. All except perch and brown trout must migrate to and from the sea, and for these migrations to take place, the bar at the entrance to Lake Onoke must be open for some period of the year, especially spring and summer. During this investigation the bar at the entrance to Lake Onoke was never closed. From the responses of recreational fishers, and the catches of diadromous fish in this survey, the Lake Onoke bar appears not to be a significant barrier to the entry of fish to the Ruamahanga River system and its lakes. The present regime of mechanical bar opening does not seem to affect the existing fisheries values of the Lake Wairarapa wetlands. However, there was an important Maori fishery for eels migrating downstream, which could be readily caught when trapped by the closed bar. Mechanical opening of the bar probably also allows more migratory fish in and out of Lake Onoke, but is a direct trade-off with the values of the historic Maori eel fishery.

RECOMMENDATIONS

1) To protect and enhance the present fishery values of Lake Wairarapa:

A) Keep the barrage gates open as often and long as possible between August and April to maximise the number of migratory fish entering and leaving Lake Wairarapa.

Comment:

Juvenile galaxiids and eels migrate into freshwater in spring, and adult black flounder migrate upstream from mid-summer to autumn. Torrentfish migrate into freshwater in spring and autumn, and bullies migrate in late spring and in summer. Adult eels migrate downstream to the sea to spawn from February to June. Upstream migration of juveniles of redfinned bullies, torrentfish, koaro, and banded kokopu may be impeded by the barrage gates. Black flounder abundance in Lake Wairarapa has also been reduced by the barrage and diversion. The barrage gates should be open for the maximum time possible between August and April.

B) Automate, at a minimum, two additional barrage gates (those closest to the banks of the outlet channel), and preferably all four gates that cannot now be operated remotely. Open all gates simultaneously.

Comment:
The two gates that are automated at present are in the centre of the barrage. Migrant juveniles generally follow shallow margins, and thus are at present forced into deep water to find the open gates, where they are vulnerable to predation. Opening the two outside gates would allow migrant juveniles to travel the shortest distance necessary through deep water. In addition, water velocities will be lower if all six gates are raised simultaneously than if only two are raised at once. Automating all the gates would allow this, resulting in the lowest possible velocities, and thus facilitate upstream migration of juveniles.

C) At times when gates are open, ensure they are open to the surface or above to allow the passage of surface-swimming juveniles with the least disturbance.

Comment:
This will facilitate upstream migration of juveniles galaxiids and eels, which swim at the surface at the peak of their migration when close to the sea.

D) Restore some flow to Lake Wairarapa via the Ruamahanga Cutoff.

Comment:
The Ruamahanga Cutoff, through which the Ruamahanga River once flowed into Lake Wairarapa, is now a remnant channel of still water. Restoring flow to Lake Wairarapa through the Ruamahanga Cutoff would improve value of the channel as fish habitat, and would add to the attraction water flowing out of Lake Wairarapa through the barrage gates. This attraction water is necessary to maximise fish migrations into Lake Wairarapa. Provided some gated structure that could be opened during low flow was installed at the Ruamahanga River end of the Cutoff, it could be closed to prevent flooding at high flow.

2) To protect and restore the present fishery values of Pounui Lagoon and Lake Pounui, remove the flapgates completely from the culverts that drain Pounui Lagoon, allowing access of fish whose migrations from Lake Onoke are now prevented or restricted.

Comment:
Fish such as yelloweyed mullet and flounder are denied access to potentially valuable habitat by flapgates that now control flow into Pounui Lagoon. Upstream migrations of juvenile eels and giant kokopu into Lake Pounui may also be affected. Removal of the flapgates would recreate the original intertidal wetland, and would greatly improve fish access.

3) To protect the present fishery values of Lake Onoke, maintain the present bar opening regime, recognising that while it maintains the present-day fisheries for flounder, kahawai, red cod, mullet, and hoki, it has also eliminated the historic Maori eel fishery.

Comment:
A traditional fishery for adult eels migrating downstream to the sea spawn between February and June was once used by the local Maori, and was an important food source. Closure of the bar by storms prevented the migration of eels, making their capture simple, and the historic fishery is not possible while the bar is open.

CHAPTER 1. INTRODUCTION

1.1 PHYSICAL CHARACTERISTICS

The Lake Wairarapa wetlands, comprising Lakes Wairarapa and Onoke, and their associated wetlands, form the largest wetland complex in the lower North Island. Lake Wairarapa is shallow (mostly less than 2.5 m deep), about 18 km long, and about 6 km wide. Lake Wairarapa has a surface area of 80.7 km^2, and Lake Onoke has an area of 7.1 km^2 (Lowe and Green 1987). Lake Wairarapa is connected to the sea by Lake Onoke (Figure 1), the seaward bar of which is generally kept open to protect farmland in the lower Ruamahanga River from flooding. Also part of the wetlands are Lake Pounui and Pounui Lagoon. Lake Pounui drains into Pounui Lagoon, and Pounui Lagoon drains into Lake Onoke. Pounui Lagoon and Lake Onoke are separated by a stopbank, and water flows between them through two round concrete culvert pipes 11 m long and about 1 m in diameter. Flapgates at the downstream end of the culverts prevent tidal and flood water from flowing back upstream from Lake Onoke to Pounui Lagoon.

1.2 WATER LEVEL MANAGEMENT

Flood control in the lower Ruamahanga catchment has been a long-standing problem for farmers, water managers, and other land and water users. Part of the problem is caused by southerly swells that build a bar across the mouth of Lake Onoke (Figure 1), sometimes closing it completely. Historically, the Ruamahanga River flowed though both Lake Wairarapa and Lake Onoke. Lakes Wairarapa and Onoke covered an area of about 100 km^2 at low water levels, but during floods coinciding with bar closure, over 210 km^2 of the land surrounding the lakes and the lower Ruamahanga was flooded (McIlraith 1957). Some areas were flooded up to 8 times a year. Severe flooding in 1947 covered 200 km^2 additional to the lake area, and persisted in some areas for up to 8 days (Lake Wairarapa Co-ordinating Committee 1991).

To reduce flooding, the lower Ruamahanga River was widened and diverted around Lake Wairarapa as part of a project completed in 1974. Six radial-arm barrage gates at the Lake Wairarapa outlet were installed to control the level of the lake, primarily preventing flood and tidal water from flowing upstream into Lake Wairarapa from Lake Onoke and the lower Ruamahanga River. Several low-lying areas were protected from flooding by a combination of stopbanks and pump drainage. There is an orifice in the concrete base of the barrage that remains permanently open and submerged, allowing some fish passage at all times. The barrage gates generally remain closed, but are opened periodically to control water level.

Management of the Lake Onoke bar has also contributed to reducing the effect of floods. Rather than leaving the bar closed after southerly wave action has closed it, the water managers now frequently bulldoze the bar open. As a result of the combined effect of the river diversion, stopbank construction, drainage, and bar opening, floods now cover an area of only about 7.0 km^2 additional to the lake areas (Lake Wairarapa Co-ordinating Committee 1991). Lake level management has also reduced the duration of floods, which now generally last less than 10 days per year.

River development and flood control have reduced the fisheries values of the Wairarapa wetland by drainage of large areas that were fish habitat. However, Lakes Wairarapa and Onoke and their surrounding wetlands are still recognised as nationally important. In 1987 the Wairarapa wetland was identified as a wetland of national importance to fisheries, as it met 7 out of 8 of the 1973 IUCN criteria (Davis 1987).

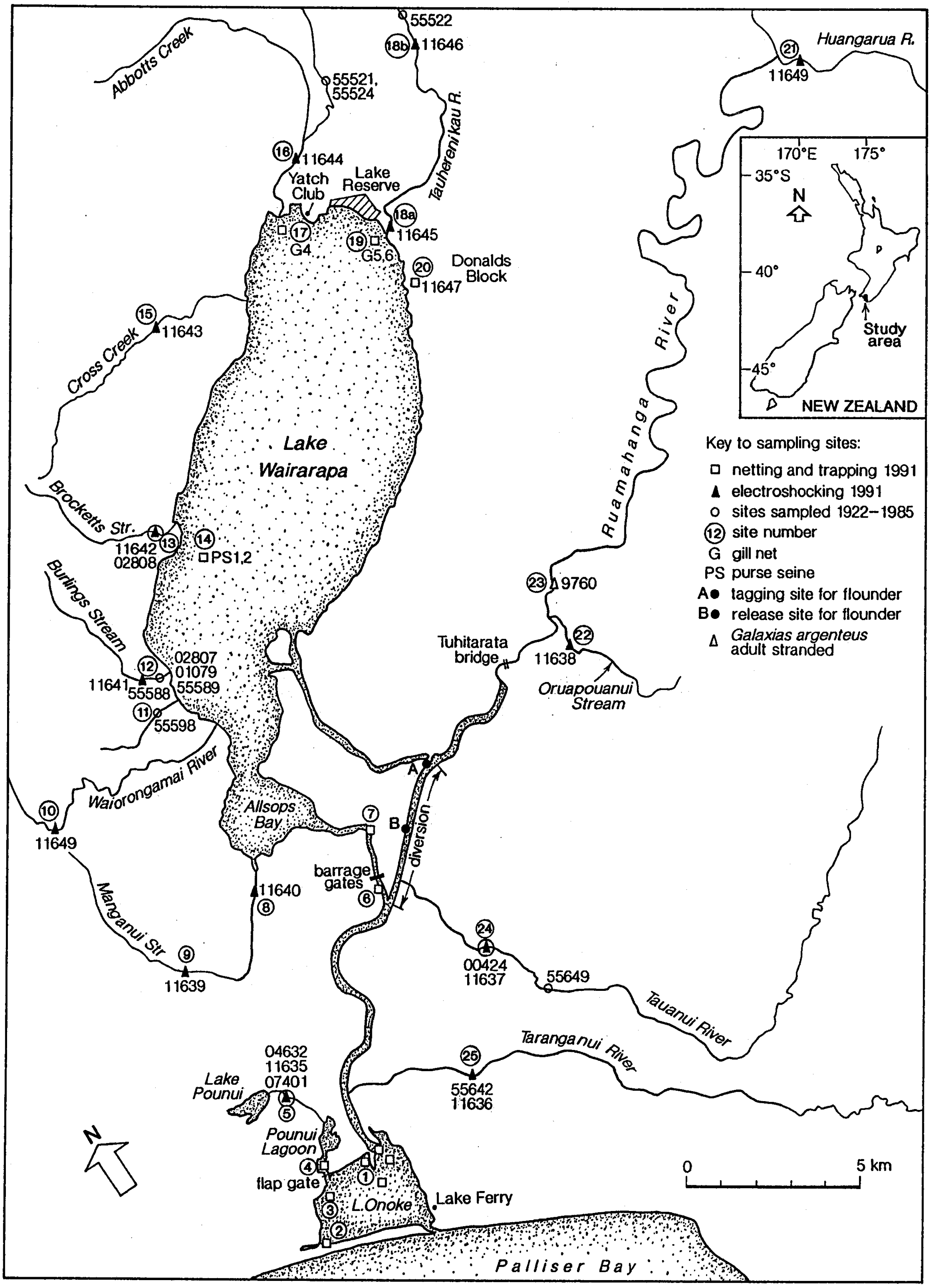


Figure 1. Location of sampling sites on Lake Wairarapa, Lake Onoke, the Ruamahanga River, and their tributaries. Five-digit numbers adjacent to site numbers refer to record numbers in the Freshwater Fisheries Database (NIWA, Hamilton).

Water level management should be considered in the context of the entire lake and wetland complex, because 70% of New Zealand's freshwater fish are diadromous (i.e., migrate to and from the sea).

1.3 OBJECTIVES

Conflict between the users of Lake Wairarapa and users of its surrounding wetlands, farmland, and tributaries resulted in the formation of guidelines for the management of lake levels (Lake Wairarapa Coordinating Committee 1991). These guidelines were, however, based on very little fisheries information, largely because little fisheries survey work had been carried out on the lakes and their wetlands. The guidelines were established to cover a three-year period, and are to be reviewed in 1994. The Department of Conservation (DOC) requires more information than previously existed on the fisheries for the review, and this report attempts to provide some of that information.

Specifically, information is needed on 1) the operation of the barrage gates at the lower end of Lake Wairarapa, 2) fish access to the Lake Wairarapa wetland complex, and 3) the frequency of manual opening of the gravel bar at the seaward end of Lake Onoke. Bar management is particularly important because it potentially controls access of migratory fish to the entire Lake Wairarapa wetlands and Ruamahanga River, and because the Maori eel fishery formerly relied on closure of the bar to trap downstream migrant eels. An application for taiapure has been discussed, and the recreational whitebait fishery is also reported to be heavily used.

To answer these questions, the following objectives were formulated:

1) To summarise prior fish distribution in Lakes Onoke, Wairarapa, and Pounui, and the lower Ruamahanga River from records in the Freshwater Fisheries Database;
2) To establish present fish distribution by resurveying sites fished previously, and surveying additional sites as required;
3) To establish the influence of the Lake Wairarapa barrage gates and Pounui Lagoon flapgates on upstream fish migration by investigating recent recruitment of native species to Lake Wairarapa, Pounui Lagoon, and their tributaries;
4) To investigate current fisheries use and users' perceptions of recent changes to fisheries in the lakes, their tributaries, and the lower Ruamahanga River;
5) To produce guidelines for lake level manipulation and fish passage requirements.

CHAPTER 2. THE FISH OF THE LAKE WAIRARAPA WETLANDS

2.1 INTRODUCTION

To establish present fish distribution, and to evaluate the potential of the Lake Wairarapa barrage gates and the Pounui Lagoon flapgates as barriers to upstream migrations of fish and invertebrates such as shrimps, an extensive trapping, netting, and electroshocking survey was carried out. These investigations were intended to augment existing knowledge of fish distribution contained in the Freshwater Fish Database maintained by MAF Fisheries (now NIWA Ecosystems), and previous published information (e.g., Ots and Eldon 1975, Jellyman 1979a, Jellyman 1979b).

Fish in the Lake Wairarapa wetlands, the adjacent Ruamahanga River, and their tributaries, have been recorded in records collected between May 1922 and March 1985. On 21 July 1991 there were 125 records for the catchment, identifying 22 fish species, of which 17 were native, and 5 were exotic (Table 1, Appendix 1). One of the native species (the grayling), last recorded in the river system in the Tauherenikau River near Featherston in 1922, is now presumed to be extinct (McDowall 1990). Though both black and yellowbelly flounders occur in coastal lakes such as Onoke, Wairarapa, and Ellesmere, black flounders penetrate upstream into freshwater, whereas yellowbelly flounders are usually restricted to salt or brackish water (McDowall 1990). Yellowbelly flounders are rare in Lake Wairarapa itself (Stevens pers. comm.).

Important fish migrations mainly occur in spring and early summer (late October to early December). Smelt, elvers, galaxiids, and glass eels migrate at this time, and the peak of migrations of galaxiids and juvenile eels are generally around the new moon phase (Burnet 1965, Jellyman 1979a, Jellyman 1983, McCleave and Wipplehauser 1987, McDowall 1988, McDowall 1990). Black and yellowbelly flounders, kahawai, yelloweyed mullet, grey mullet, longfinned and shortfinned eels, and banded and shortjawed kokopu also migrate varying distances into freshwater, and their comparative densities immediately upstream and downstream of barriers can provide evidence of effectiveness of migration. Kahawai have peak migrations into river mouths around the new and full moon phases (Rowe 1983).

The freshwater shrimp *Paratya curvirostris* also migrates between saltwater and freshwater. The first larval stage cannot survive long in freshwater, but does survive in seawater (Chapman and Lewis 1976). This fact, and documented upstream migrations (Shaw 1981) and population dynamics (Carpenter 1983), indicate that *Paratya* can reliably be considered a migratory species requiring access to salt water.

Comparative densities of diadromous fish in tributaries can also be used to evaluate the effects of barriers on migration. Lake Wairarapa has a number of tributary streams, as does the lower Ruamahanga River. Short-lived species that live a maximum of 8-10 years are likely to be good indicators of the extent of present-day migrations. Such fish include banded kokopu, torrentfish, shortjawed kokopu, giant kokopu, redfinned bullies, and lampreys. As the barrage gates were completed in 1974 (Lake Wairarapa Co-ordinating Committee 1991), the presence of fish of these species upstream of the gates will indicate that juveniles have migrated past them. Inanga, smelt, yelloweyed mullet, grey mullet, and black flounder have poor climbing ability compared to juvenile eels and some galaxiids, so these species are especially sensitive to barriers to upstream migration.

Of the fish species in New Zealand that may be diadromous, not all are compelled to migrate to and from the sea to complete their life cycles (McDowall 1990). Common bullies, koaro, banded kokopu, giant kokopu, and common smelt, for instance, may form

Table 1. Freshwater fish species found in the Ruamahanga River Catchment. 1=found; 0=not found.

Common name	Scientific name	Species code	Survey date	
			May 1922 -March 1985	29 Oct -5 Dec 1991
Native species				
lamprey	*Geotria australis*	geoaus	1	0
grayling	*Prototroctes oxyrhynchus*	prooxy	1	0
longfinned eel	*Anguilla dieffenbachii*	angdie	1	1
shortfinned eel	*Anguilla australis*	angaus	1	1
common smelt	*Retropinna retropinna*	retret	1	1
inanga	*Galaxias maculatus*	galmac	1	1
koaro	*Galaxias brevipinnis*	galbre	1	1
giant kokopu	*Galaxias argenteus*	galarg	1	1
banded kokopu	*Galaxias fasciatus*	galfas	1	1
shortjawed kokopu	*Galaxias postvectis*	galpos	1	0
dwarf galaxias	*Galaxias divergens*	galdiv	1	0
brown mudfish	*Neochanna apoda*	neoapo	1	1
kahawai	*Arripis trutta*	arrtru	0	1
yelloweyed mullet	*Aldrichetta forsteri*	aldfor	0	1
grey mullet	*Mugil cephalus*	mugcep	0	1
stargazer	*Leptoscopus macropygus*	lepmac	0	1
torrentfish	*Cheimarrichthys fosteri*	chefos	1	1
triplefin	*Tripterygion nigripenne*	trinig	0	1
redfinned bully	*Gobiomorphus huttoni*	gobhut	1	1
common bully	*Gobiomorphus cotidianus*	gobcot	1	1
bluegilled bully	*Gobiomorphus hubbsi*	gobhub	0	1
upland bully	*Gobiomorphus breviceps*	gobbre	1	1
Cran's bully	*Gobiomorphus basalis*	gobbas	1	1
black flounder	*Rhombosolea retiaria*	rhoret	1	1
yellowbelly flounder	*Rhombosolea leporina*	rholep	0	1
Exotic species				
brown trout	*Salmo trutta*	saltru	1	1
rainbow trout	*Oncorhynchus mykiss*	oncmyk	1	0
quinnat salmon	*Oncorhynchus tshawytscha*	onctsh	1	0
goldfish	*Carassius auratus*	caraur	1	0
perch	*Perca fluviatilis*	perflu	1	1

lake-locked populations without an obligatory marine phase. Thus caution is required in using the presence or absence of these species as indications of fish passage. Diadromous common bullies, which have head pores, can be distinguished from lake-locked common bullies, which do not have head pores (McDowall 1990). In common smelt, vertebral counts distinguish diadromous and lake-locked forms. The latter have fewer vertebrae than diadromous smelt (Ward et al. 1989).

2.2 METHODS

2.2.1 Netting and trapping

Fish were sampled by netting and trapping between 29 October and 1 November 1991, as close as possible to the new moon phase of 4-8 November. A combination of fyke, trap, beach and purse seine, and gill netting was used. Sites used were 1-7, 14, 17, and 19 (Figure 1). More detailed location of different types of nets is shown in Figure 2. Gee minnow traps and fyke nets were used in wetlands at the north eastern margin of Lake Wairarapa (Donalds Block, Site 20, Figure 1) specifically to catch brown mudfish (*Neochanna apoda*).

Gee minnow traps had square steel mesh 6 mm on a side, with funnel orifices of 25-30 mm diameter. This orifice size excluded large eels. Fyke nets were of standard construction for commercial eeling, with 6- and 12-mm stretched mesh, a single wing, and two internal funnels of 100-mm diameter (e.g., Hubert 1983, p103). Fyke nets were set on the bottom. The two gill nets were of multifilament polyester 40 m long and 1.5 m deep, with one mesh size each (90-mm and 115-mm stretched mesh), and were set at the surface. Panel nets were gill nets of monofilament nylon 32 m long and 2 m deep, and had three 10-m sections of 55-mm, 80-mm, 110-mm stretched mesh, and one 2-m long section of 30-mm stretched mesh. Panel nets were also set at the surface. The purse seine net was 20 m long and 3 m deep, with 2-mm stretched mesh. Beach seines were 10 m long with 4-mm stretched mesh, mounted on poles for dragging. Trap nets were a box construction consisting of two cubes of 1-m sides of 1-mm mesh polyester netting, with a leaders and two wings of 2-mm mesh grey fibreglass netting (Hayes 1989). The central leader was 15 m long by 1 m deep, and the two angled wings were 5 m long and 1 m deep. The entrance to each cube was a funnel with a 10-cm^2 orifice. A double-pot design was used to separate piscivorous fish from their potential prey. The funnel entrance to the second pot had 1-cm square plastic mesh to exclude large eels that might prey on the smaller fish in the trap. The first funnel had no excluding mesh. Traps nets were set on the bottom. At Site 20, Gee minnow traps were baited with beef stewing steak, and the fyke nets were baited with ox liver. Other traps and nets were not baited. All nets were set at 1500-2000 h and retrieved the next morning at 0800-1100 h, except for beach seines, which were swept out from the beach and back in about 5-10 minutes, and purse seines which were set and retrieved from a boat in about 10 minutes. Nets set overnight were assumed to have been fishing for 18 h.

2.2.2 Electroshocking

Electroshocking was carried out with a 90-W battery-powered backpack shocker using an earth return circuit (Burnet 1967). Sampling was carried out between 3 and 5 December 1991 to coincide with the next new moon phase following the time of the netting survey (2-6 December). Fishing was carried out once in an upstream direction, and stop nets were not used. In water with velocities greater than about 0.3 m/s, a 5-mm mesh net about 1.5 m wide and 1 m deep stretched between two vertical poles was used.

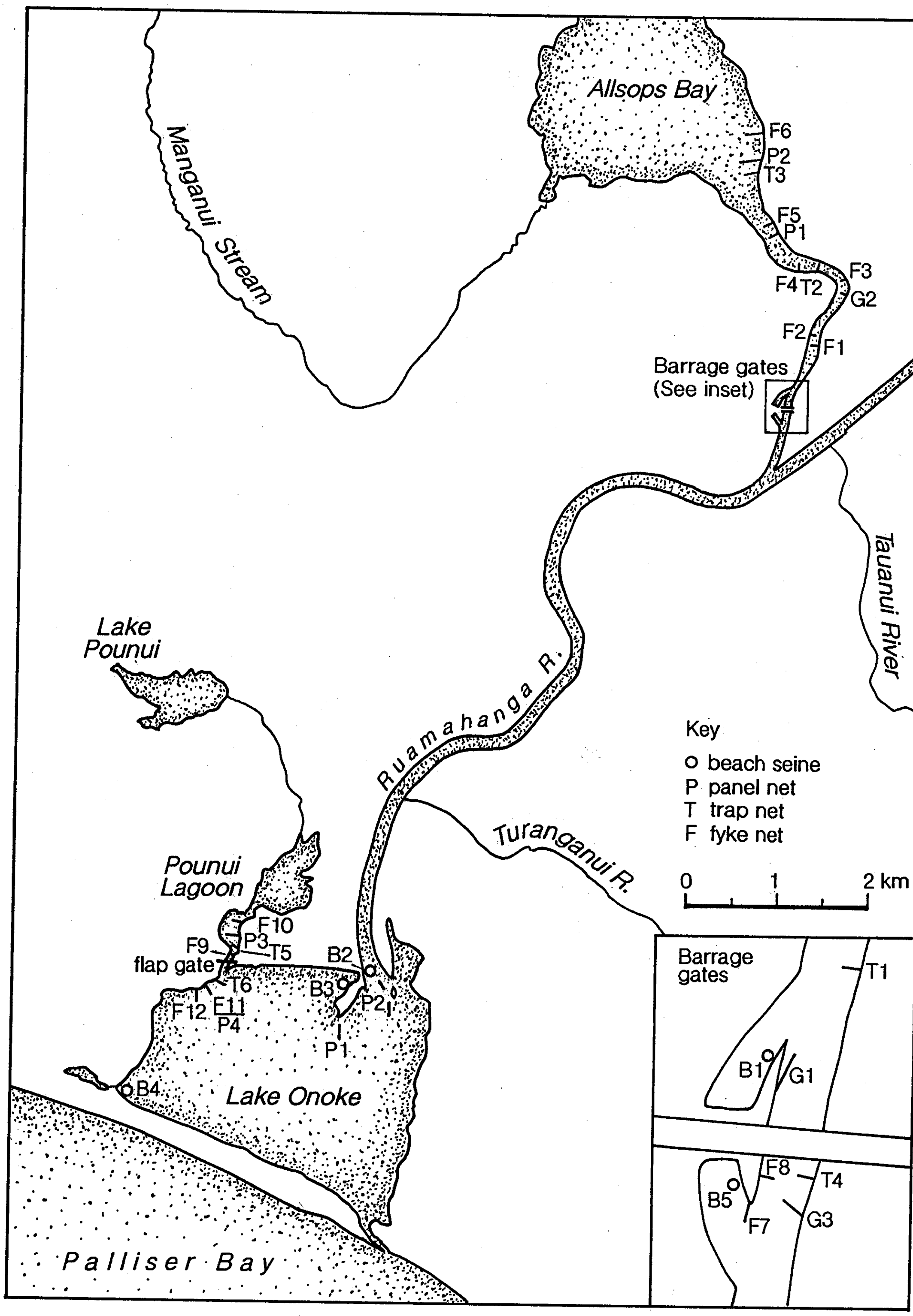


Figure 2. Location of netting sites at the Lake Wairarapa outlet and Lake Onoke.

Electroshocking was carried out from 2-10 m upstream down to the net, so immobilised fish drifted into it. In water velocities slower than about 0.3 m/s, fish immobilised by the electric field were scooped from the water with fine-meshed metal nets mounted on wooden poles.

2.2.3 Smelt populations

To determine whether common smelt were of anadromous of lake-locked origin, smelt preserved in 10% formalin were X-rayed, and their vertebrae counted from these X-rays.

2.3 RESULTS

2.3.1 Fish abundance in Lake Wairarapa and its tributaries

No quantitative data exist from before the construction of the stopbank and flapgate on the outlet of Pounui Lagoon in the early 1970s, and the Lake Wairarapa barrage gates in 1974, to directly compare fish access with and without these structures. A qualitative comparison of obligately diadromous species occurring at sites upstream and downstream of the barriers shows that neither are a complete barrier to passage of fish and shrimps (Table 2).

2.3.1.1 Tributary streams. Electroshocking of tributaries sites revealed no differences in total densities of obligately diadromous fish species that could be attributed to the effect of barriers. Fish species present were shortfinned and longfinned eels (including glass eels), torrentfish, koaro, banded kokopu, inanga, and redfinned and bluegilled bullies. The geometric mean of total density of all fish species combined was 7.1 fish/100 m^2 in tributaries upstream of the barrage, and 13.7 fish/100 m^2 for tributaries not under the influence of the barrage (Table 3A). Median densities were 5.0 and 22.9 fish/100 m^2 respectively. Despite the large differences between medians, densities of obligately diadromous fish in the two groups of tributaries were not different (Table 3A, Mann-Whitney *U* test, p=0.497).

An analysis by species also showed some differences between densities of obligately diadromous species in tributaries upstream and downstream of the barrage gates (Figure 3, Appendix 2). For those known obligately diadromous species for which valid tests could be done (shortfinned eels and longfinned eels), densities were not significantly different in tributaries upstream of the barrage gates compared to tributaries that could not have been affected by the gates (Mann-Whitney *U* test, $p \geq 0.571$). For redfinned bullies, torrentfish, koaro, and banded kokopu densities were lower upstream of the barrage gates than below, though statistical comparisons could not be made because of insufficient samples. Koaro and banded kokopu were also found at one site each (sites 22 and 25 respectively), and both these sites were not under the influence of the barrage gates. Bluegilled bullies were found at only one site (Burlings Stream, Site 12), and this was upstream of the barrage gates. A single giant kokopu adult was found stranded and dead on the bank of the Ruamahanga River at Site 23.

Common bullies, however, which may be diadromous or lake-locked, were found at significantly higher densities in tributaries upstream of the barrage gates (median 36.5 fish/100 m^2) than in tributaries that could not be affected by the gates (median 8.4 fish/100 m^2, Figure 3). Common bullies were found at all 8 tributaries fished upstream of the barrage gates, and fish examined had a range of head pore states, a character diagnostic of lake-locked and diadromous populations. Common bullies without head pores (i.e., lake-

Table 2. Frequencies of obligately diadromous species of fish and shrimp downstream and upstream of barriers in the Lake Wairarapa wetlands. All methods combined. See Figure 1 for locations of numbered sampling sites.

Species	Number of fish				
	Lake Onoke flapgate		Lake Wairarapa barrage gates		Total
	downstream (Site 3)	upstream (Site 4)	downstream (Site 6)	upstream (Site 7)	
yelloweyed mullet	32	0	9	28	69
longfinned eel	9	4	13	40	66
shortfinned eel	4	4	17	34	59
kahawai	8	0	0	0	8
torrentfish	0	0	5	5	10
giant kokopu	0	0	1	0	1
koaro	0	0	1	0	1
banded kokopu	1	0	1	0	2
inanga	34	53	8	6	101
common bully	4	14	103	136	257
bluegilled bully	0	0	0	1	1
redfinned bully	0	4	19	0	23
stargazer	1	0	0	1	2
grey mullet	0	0	0	1	1
anadromous common smelt	3	0	1	6	10
yellowbelly flounder	1	0	0	0	1
black flounder	2	0	0	0	2
Paratya shrimps	1	4	4	9	18
triplefin	10	0	0	0	10
TOTAL	138	116	277	350	881

Table 3. A) Total densities of obligatory diadromous fish caught by electroshocking in tributaries of Lake Wairarapa and the Ruamahanga River upstream of the barrage gates, and not under the influence of the barrage gates. B) Mean lengths of common bullies with different states of head pore development.

A) Total densities of obligatory diadromous fish

Site number	Density (fish/100 m^2)
Upstream of barrage gates	
18B	2.50
9	3.25
10	3.25
15	3.33
12	6.57
16	10.63
13	21.67
8	46.94
Not under influence of barrage gates	
25	2.22
24	21.50
21	24.29
22	30.00
Upstream of Pounui Lagoon flapgates	
5	18.57

B) Mean lengths of common bullies

Head pore development	Sample size	Total length (mm)						
		Mean	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
No head pores (1)	10	49.1	49	3.8	30	70	41	57
Poorly developed (2)	3	50.7	50	2.3	47	55	47	55
Well developed (3)	25	62.9	63	2.6	39	90	52	68

Probabilities calculated by Tukey HSD (honestly significant difference) means test

	(1)	(2)	(3)
(1)	1.000		
(2)	0.980	1.000	
(3)	0.013	0.247	1.000

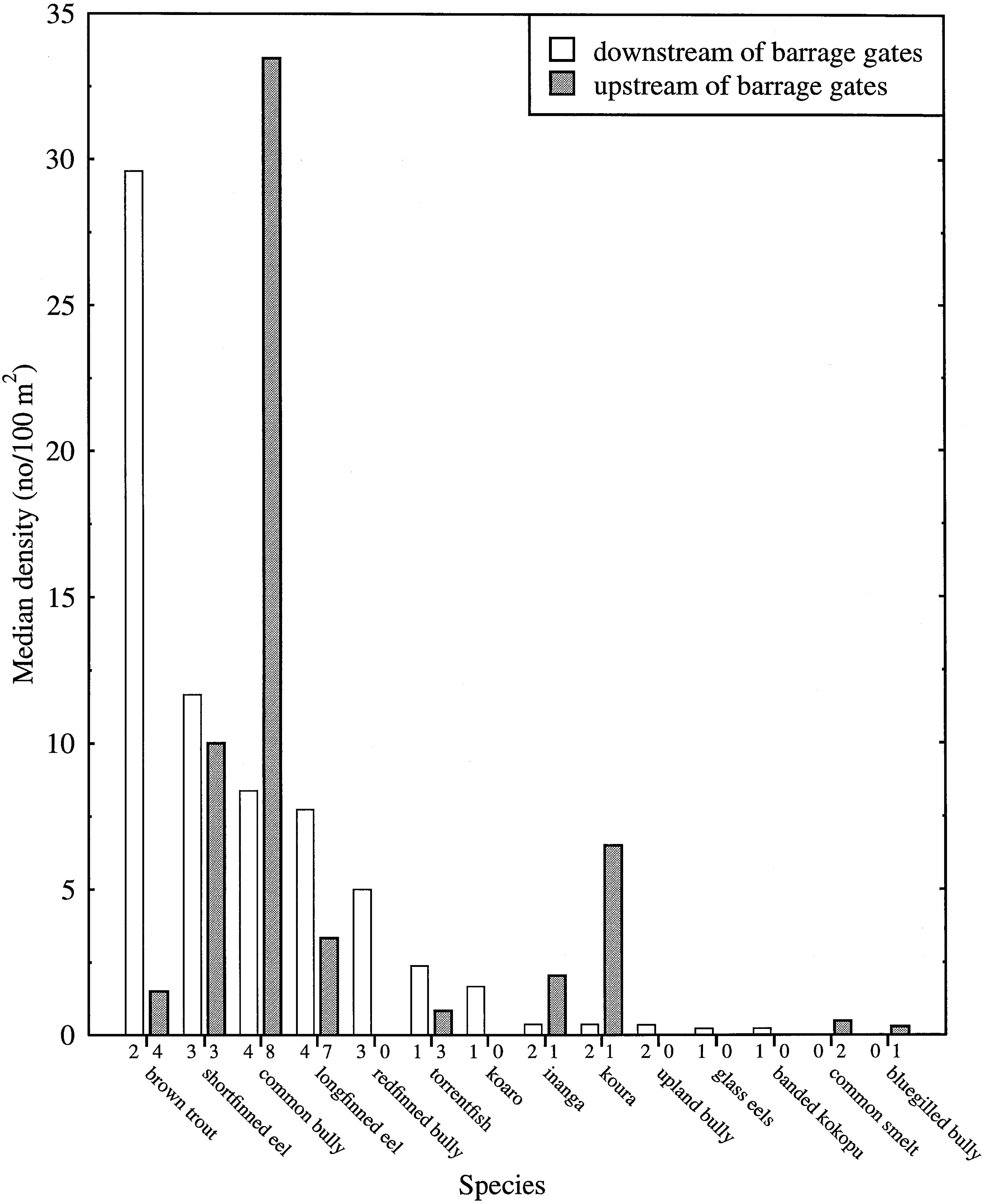


Figure 3. Median densities of fish and koura caught by electroshocking in tributaries of Lake Wairarapa and the Ruamahanga River upstream (8 sites) and downstream (4 sites) of the barrage gates on the outlet of Lake Wairarapa. Species codes as in Table 1. Numbers below bars are numbers of sites with that species.

locked) were found at Sites 10, 16, 18A, and 21, and ranged from 28 to 70 mm TL (total length) (N=20). Their modal length was 50-60 mm TL (Figure 4A). Bullies at Site 21 (Huangarua River) could not be affected by any artificial barrier. Common bullies with well-developed head pores (i.e., diadromous) were found at Sites 10, 16, 18A, 21, and 25, and ranged from 39 to 90 mm TL (N=34), and had a modal length of 60-70 mm TL (Figure 4C). At Site 16 (Abbots Creek), common bullies with poorly developed head pores were found. These bullies ranged from 47 to 55 mm TL (N=3, Figure 4B). Mean lengths of bullies with well-developed head pores and without head pores were different (Tukey HSD test, p=0.013, Table 3B), but the bullies with poorly developed head pores were not different from either of the other groups. Length frequencies of all bullies measured, primarily captured by electroshocking in tributaries, reflected the modal length of lake-locked bullies rather than diadromous (Figure 4D).

Common smelt can also be diadromous or lake-locked. Common smelt were found by electroshocking at only two sites out of eight upstream of the barrage gates, and at of the four sites that could not have been affected by the barrage gates.

Brown trout can be anadromous, lake-locked, or resident. Densities were not different between the tributary types (Mann-Whitney *U* test, p=0.165), though the median upstream of the barrage gates appeared much lower than downstream.

Shrimps (*Paratya curvirostris*) were found in two out of eight tributaries upstream of the barrage gates, but were not found by electroshocking in the four tributaries that could not have been affected by the barrage gates (Appendix 2).

2.3.1.2 Netting in the lake outlet. The barrage gates appear to be a partial barrier to yelloweyed mullet (Table 4A). There is no quantitative evidence for reduced abundance in other species upstream of the barrier. Some species had higher densities upstream of the barrage gates than downstream (small shortfinned eels, caught in trap nets, common bullies, mysid shrimps, and common smelt).

2.3.1.3 Northern and central lake. Gill netting in the northern part of the lake (Sites 17 and 19) caught only perch and brown trout (Table 5A). Purse seines in the central part (Site 14) caught several small common bullies, some mysid shrimps, *Potamopyrgus antipodarum* snails, and a few larval smelt. Panel nets set in Lake Onoke (Site 1) caught a relatively diverse range of fish, including yelloweyed mullet, kahawai, brown trout, black flounder, perch, and common smelt (Table 5A).

2.3.2 Fish abundance in Lake Onoke and its tributaries.

2.3.2.1 Flapgates at Pounui Lagoon. From catches of fish in trap nets, fyke nets, and panel gill nets the flapgate between Lake Onoke and Pounui Lagoon appears to be a barrier to fish migration. For some fish species the barrier to upstream migration appears to be complete. Yelloweyed mullet and the triplefin *Tripterygion nigripenne*, though present in catches downstream of the flapgate, were absent from catches above the flapgate (Table 4B). For other fish species, the flapgate appears to be a partial but significant barrier to upstream migration. Catches of shortfinned and longfinned eels, inanga whitebait, and common smelt were much reduced upstream of the flapgate compared to downstream. In the gravel-bedded outlet stream of Lake Pounui (Site 5), a relatively wide diversity of obligately diadromous fish were found in December 1991. Total density of obligately diadromous species was 18.6 fish/100 m^2; species were inanga post-whitebait (50-70 mm TL), glass eels, redfinned bullies, and longfinned and

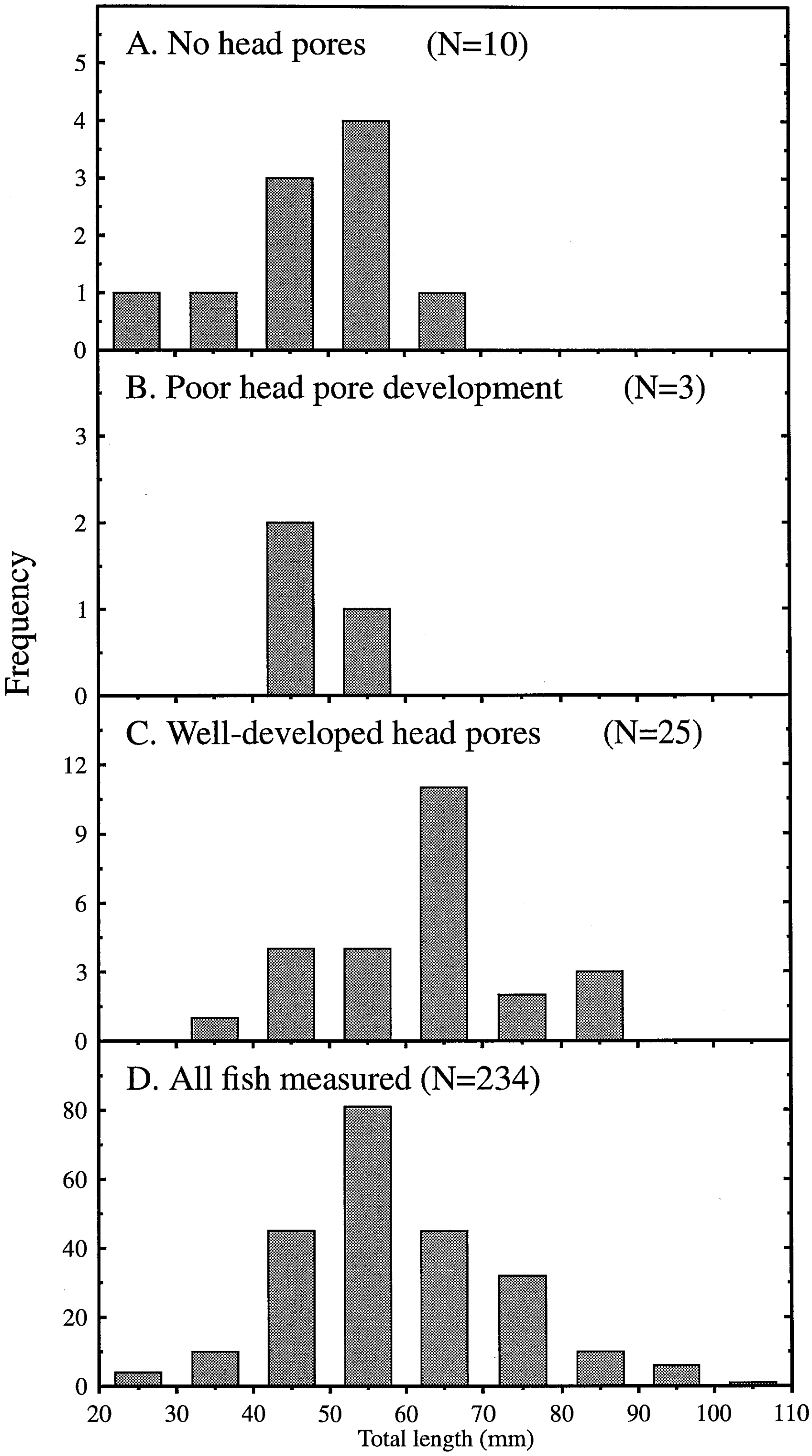


Figure 4. Frequencies of common bullies A) without head pores, B) with poor head pore development, C) with well-developed head pores, and D) all fish measured in Lake Wairarapa and its tributaries in 1991.

Table 4. Numbers of fish and invertebrates caught per net per night in each net type (A) set upstream (Site 7) and downstream (Site 6) of the barrage gates at Lake Wairarapa, and (B) set upstream (Site 4) and downstream (Site 3) of the flapgate at Pounui Lagoon, Lake Onoke, in November 1991. Species as in Table 1, except for: *Helice crassa* (mudflat crab); *Palaemon affinis* (shrimp); *Paratya curvirostris* (shrimp). a, anadromous; l, lake-locked. Site numbers as Figure 1.

A. Barrage gates at Lake Wairarapa

Species	Catch per trap net		Catch per fyke net		Catch per panel net		Catch per gill net		Catch per beach seine	
	ds	us	ds	us	ds	us	ds	us	ds	us
yelloweyed mullet	8	1.0	0	0.0	-	12	1	0.5	0	0
shortfinned eel	2	684.3	7.5	2.5	-	0	0	0	0	0
longfinned eel	1	1.7	2	2.2	-	0	0	0	0	0
glass eels	4	7.0	0	0.0	-	0	0	0	0	0
banded kokopu whitebait	0	0.0	0	0.0	-	0	0	0	0	0
inanga	0	0.0	1	0.2	-	0	0	0	1	1
inanga whitebait	3	0.0	0	0.0	-	0	0	0	5	12
common bullies	42	105.7	6	18.8	-	0	0	0	43	93
stargazer	0	0.0	0	0.0	-	0.5	0	0	0	0
mysid shrimps	0	666.7	0	0.0	-	0	0	0	200	0
grey mullet	0	0.0	0	0.0	-	0.5	0	0	0	0
Palaemon affinis	0	0.0	0	0.0	-	0	0	0	0	0
Paratya shrimp	6	0.0	0	8.3	-	0	0	0	6	0
perch	0	1.3	2.5	0.5	-	12	1	0	0	5
common smelt	119	170.0	0	0.0	-	0	0	0	9	18
common smelt (a)	0	0.3	0.5	0.5	-	13.5	0	0	0	9
common smelt (l)	0	0.0	0	0.3	-	0	0	0	0	6
brown trout	0	0.3	0	0.0	-	0.5	0	0.5	0	0
triplefin	0	0.0	0	0.0	-	0	0	0	0	0
No. of nets	1	3	2	6	0	2	1	2	1	1

B. Pounui Lagoon flapgates

Species	Catch per trap net		Catch per fyke net		Catch per panel net	
	ds	us	ds	us	ds	us
yelloweyed mullet	138	0	4	0	1	0
shortfinned eel	65	0	8.5	3	0	0
longfinned eel	32	0	0.5	2	0	0
glass eels	100	25	0	0	0	0
banded kokopu whitebait	1	0	0	0	0	0
inanga	3	24	0	0	0	0
inanga whitebait	234	27	0	0	0	0
common bully	2	7	1	1	0	0
mudflat crab	1	0	0	0	0	0
stargazer	1	0	0	0	0	0
Palaemon affinis	1	0	0	0	0	0
Paratya shrimp	0	450	0	0	0	0
perch	1	2	0.5	0.5	0	2
common smelt	352	24	2	0	117	0
yellowbelly flounder	0	0	0	0	1	0
triplefin	7	0	0.5	0	1	0
No. of nets	1	1	2	2	1	1

Table 5. Numbers of fish and invertebrates caught by (A) netting in the northern and eastern parts of Lakes Wairarapa and Onoke in November 1991, and B) electroshocking catch in the Lake Pounui outlet stream (Site 5, 20-m reach 7-m wide fished) and C) fyke nets and Gee minnow traps set overnight at Donalds Block in December 1991. Species as in Table 1; a, anadromous; l, lake-locked.

A. Northern and eastern parts of Lakes Wairarapa and Onoke

Fish species	Catch per net (number of fish)				
	Site 1	Site 1	Site 2	Site 17	Site 19
yelloweyed mullet	4.5	27	67	0	0
kahawai	4.0	0	0	0	0
inanga	0.0	1	0	0	0
inanga whitebait	0.0	9	30	0	0
perch	0.5	0	0	6	3
common smelt	0.5	4	5	0	0
common smelt (a)	0.0	10	0	0	0
common smelt (l)	0.0	0.5	0	0	0
black flounder	1.0	0	0	0	0
brown trout	1.5	0	0	4	0
triplefin	0.0	4.5	0	0	0
Number of nets	2	2	1	1	2
Net types	Panel	Beach seine	Beach seine	Gill	Gill

B. Catch in the Lake Pounui outlet stream (Site 5, 20-m reach 7-m wide fished)

Species	Number	Fish density (no./100 m^2)
inanga post-whitebait	14	10.0
common bully	5	3.6
glass eel	5	3.6
redfinned bully	4	2.9
koura	3	2.1
longfinned eel	2	1.4
shortfinned eel	1	0.7
brown trout	1	0.7
Paratya shrimps	occasional	-

C. Catch at Donalds Block

Trap or net type	Number	Habitat	Depth (m)	Number of animals per trap or net					
				neoapo	angaus	gobcot	galmac	tadpol	frog
fyke	13	drain	0.32	0	4	2	1	0	0
fyke	14	lagoon	0.20	0	0	0	0	200	0
fyke	15	lagoon	0.20	0	0	0	0	2500	0
fyke	16	drain	0.80	0	36	0	0	0	0
fyke	17	drain	0.80	0	19	0	0	0	0
Gee minnow	1	drain	0.28	0	0	8	2	0	0
Gee minnow	2	drain	0.28	0	1	0	0	0	0
Gee minnow	3	drain	0.12	0	0	1	0	1	0
Gee minnow	4	drain	0.26	0	0	1	0	1	1
Gee minnow	5	lagoon	0.20	1	0	0	0	16	0
Gee minnow	6	lagoon	0.20	0	0	0	0	10	0
Gee minnow	7	drain	1.00	0	2	1	0	0	0
Gee minnow	8	drain	1.00	0	3	0	0	0	0
Gee minnow	9	drain	0.14	0	0	0	0	0	0
Gee minnow	10	drain	0.16	0	0	0	0	0	0

shortfinned eels (Table 5B). The obligately diadromous *Paratya* shrimps were also found. Species that are not obligately diadromous (common bullies, brown trout, koura) were also found.

Water velocity was measured at the orifice of the flapgates (i.e., the downstream ends of the two 11-m long culverts under the stop bank) at 0900 h on 1 November 1991 as 0.42 m/s. At the time of measurement, the tide was falling, and at about mid-tide. There was about a 4-h delay in the time of full tide at the flapgates compared to the advertised time of full tide.

2.3.2.2 North and eastern lake. Panel nets set at Site 1, near the entrance of the Ruamahanga River to Lake Onoke, caught a relatively high diversity of estuarine fish (Table 5A). Yelloweyed mullet, kahawai, perch, brown trout, common smelt and black flounder were all present.

2.3.3 Eels

Between late October and early December 1991 16 fyke nets and 6 trap nets were set overnight in Lakes Wairarapa and Onoke, and in Donalds Block at the margin of Lake Wairarapa. Thirteen tributary sites were electroshocked. A total of 2,319 shortfinned eels, 180 longfinned eels, and 156 glass eels and elvers (species not determined) were caught, and while these are very limited data from which to draw reliable conclusions about the state of the eel fishery, some interpretations can be made. Fyke net catches appeared low (range 1-36 eels per fyke net per night). Shortfinned eels were caught in 13 out of 17 fyke nets, but longfinned eels were caught in only 6. Mean number of shortfinned eels was 6.6 per fyke ($\pm$5.0 confidence interval), whereas catch rate for longfinned eels was 1.3 ($\pm$1.2 confidence interval). Catch rates were different between species (Mann-Whitney *U* test, p=0.016).

Shortfinned eels dominated catches in the lakes and lake margins, comprising 83.6% of the eel catch in fykes nets, and 98.2% of the eel catch in trap nets (Table 6A). Smaller eels were retained by the trap nets than by fyke nets. In tributaries, electroshocking revealed that longfinned eels dominated the catch (59.4%). The eels caught were generally small individuals (Table 6A). Few eels were longer than 550 mm TL. Longfinned eels were generally larger than shortfinned eels, though the difference was much less pronounced in tributaries. Most eels had a wide range of food in their stomachs, including whitebait and shrimps. This may, however, have been influenced by trapping methods, in which eels were confined with their prey in nets, at least for a short time.

Catch per unit effort (CPUE) has also been expressed in terms of g/net/h. On this basis, trap nets set in the outlet of Lake Wairarapa, upstream and downstream of the barrage gates, ranged from 2.9 to 185.6 g/net/h for both eel species, with a mean of 75.0, and median of 55.7 (Table 6B).

2.3.4 Common smelt

Common smelt occurred throughout the system. Counts of vertebrae showed that smelt in the main body of Lake Wairarapa had a modal count of 55 (mean$\pm$95% confidence interval 55.3$\pm$0.33), compared to 61 (mean 59.4$\pm$1.26) in smelt in the Ruamahanga River (Figure 5A and 5C). Smelt in the outlet of Lake Wairarapa, downstream of the barrage gates, had a modal count of 55 (mean 58.2$\pm$1.33), but a large proportion of counts were between 59 and 64 vertebrae (Figure 5B). Nonparametric

Table 6. A) length frequencies of eels in Lakes Wairarapa and Onoke, and their tributaries, B) catch rates in g/net/h, and C) fyke net catch rates per 18 h set of eels in Lakes Wairarapa and Onoke.

A. Length frequencies of eels

Method	Species	Number of eels in each size class (total length in mm)							Total	Percent by species
		55-60	60-119	120-249	250-349	350-449	450-549	550-950		
trap net	shortfinned	0	2000	35	58	16	7	1	2117	98.2
N=6	longfinned	0	0	0	8	26	3	1	38	1.8
	total	150	2000	35	66	42	10	2	2305	
electroshock	shortfinned	0	42	25	9	3	2	1	82	39.4
N=13	longfinned	0	48	53	9	4	5	1	120	59.4
	total	6	90	78	18	7	7	2	208	
fyke net	shortfinned	0	0	16	15	36	34	11	112	83.6
N=13	longfinned	0	0	0	4	8	6	4	22	16.4
	total	0	0	16	19	44	40	15	134	

B. Catch rates of eels (g/net/h)

Species	Mean	Median	Minimum	Maximum	Standard error
Trap nets in outlet of Lake Wairarapa (N=4)					
shortfinned	49.9	7.0	0.0	185.6	45.4
longfinned	24.9	14.7	0.0	70.4	16.3
glass eels	0.15	0.15	0.0	0.35	0.08
all species	75.0	55.7	2.9	185.6	40.7
Trap net in Lake Onoke (N=1)					
shortfinned	401.0				
longfinned	249.2				
glass eels	0.88				
all species	651.1				
Trap net in Pounui Lagoon (N=1)					
shortfinned	0.0				
longfinned	0.0				
glass eels	0.35				
all species	0.35				
Fyke nets in all locations (N=17)					
shortfinned	83.6	47.1	0.0	298.0	24.8
longfinned	31.8	0.0	0.0	138.8	12.7
glass eels	0.00	0.00	0.00	0.00	
all species	115.4	64.8	0.0	402.5	64.8

C. Fyke net catch rates (kg/net/18 h set)

Species	Mean	Median	Minimum	Maximum	Standard error
Fyke nets in all locations (N=17)					
shortfinned	1505	848	0.0	5363	446
longfinned	572	0.0	0.0	2732	228
glass eels	0.0	0.0	0.0	0.0	
all species	2077	1167	0.0	7245	519

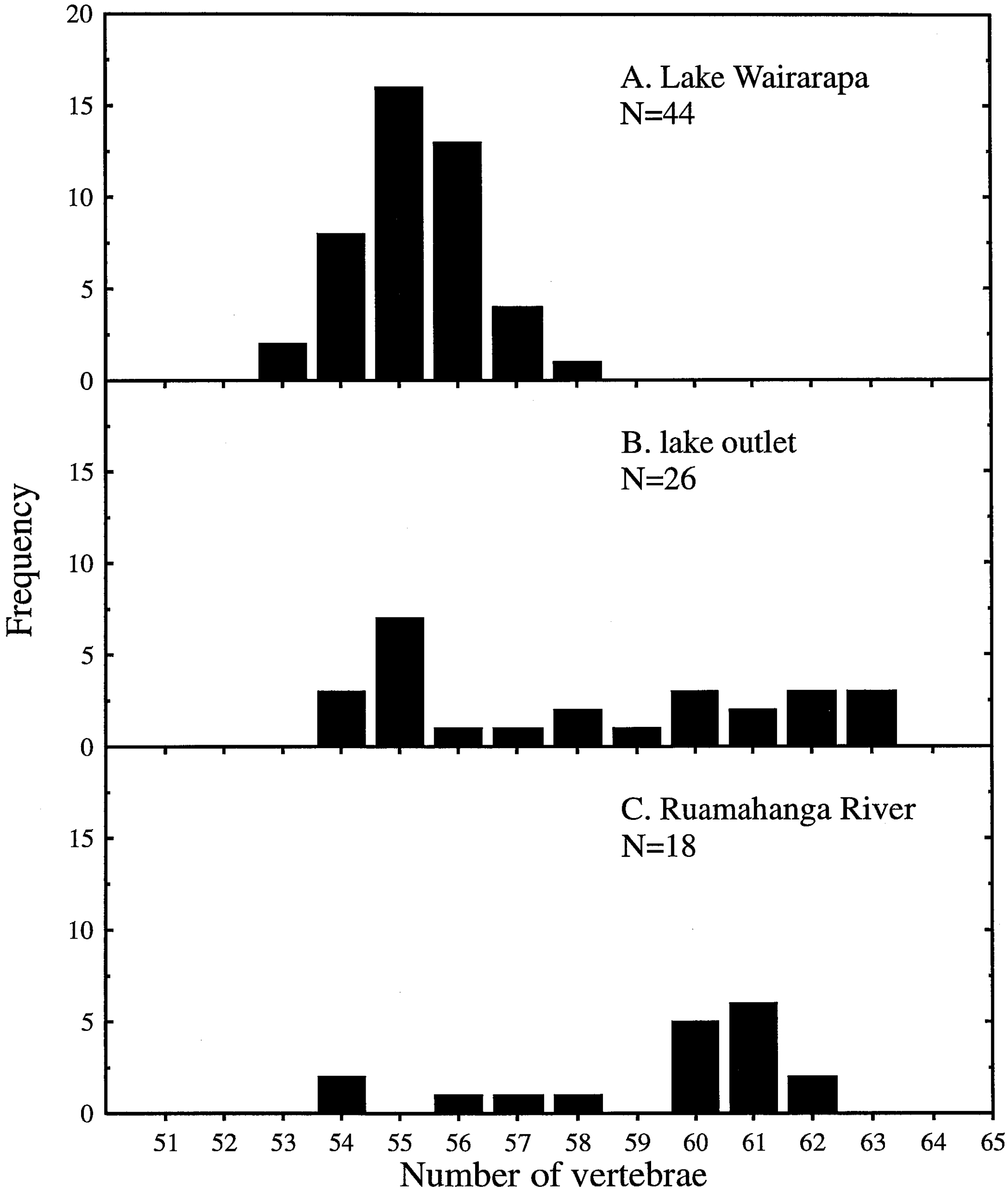


Figure 5. Frequency of vertebral counts in common smelt (*Retropinna retropinna*) from A) Lake Wairarapa, B) the Lake Wairarapa outlet to the Ruamahanga, and C) the Ruamahanga River in the Lake Wairarapa wetlands.

Mann-Whitney *U* tests showed that vertebral counts of smelt from Lake Wairarapa and the Ruamahanga River were different ($p<0.001$), as were counts from Lake Wairarapa and its outlet ($p=0.001$). However, there was no difference between counts from the lake outlet and the Ruamahanga River ($p=0.294$).

2.3.5 Perch

Mean size of perch caught at all sites was 203 mm FL ($\pm$16.2 mm, 95% confidence interval, N=48). Length frequency distribution suggested 3 size classes were caught; 80-130 mm FL (N=7), 150-250 mm FL (N=31), and 260-340 mm FL (N=10). Biases of fishing methods, mesh sizes, and locations probably account for the low numbers of small fish caught.

2.3.6 Yelloweyed mullet

Three size classes of yelloweyed mullet were apparent from data from netting and trapping from all sites combined (Figure 6). The largest fish recorded was 330 mm FL, and there appears to be an increase in size as fish move upstream from Lake Onoke. Schools of small yelloweyed mullet 30-50 mm FL were caught by beach seining the shallow margins at Sites 1 and 2 (Table 5A). At Sites 6 and 7, however, these smaller fish were absent in beach seine catches, and fish $\geq$150 mm FL were most abundant. At Site 2, beach seining was the only technique used. This method would not be expected to catch fish greater than about 60 mm FL, so the absence of larger fish may be an artifact.

2.3.7 Brown mudfish

In the wetland area known as Donalds Block, shortfinned eels, common bullies, inanga, tadpoles, a frog, and a single brown mudfish were caught (Table 5C). This catch was the result of 5 fyke nets and 10 Gee minnow traps set overnight. The mesh of fykes nets (15-mm stretched mesh) was generally too large to retain mudfish, but caught eels. Fyke nets 14 and 15 were set in the same shallow lagoon as Gee minnow traps 5 and 6. The brown mudfish was caught in one of these Gee minnow traps, but no other fish species were caught in this lagoon, which is known to dry completely in summer. Large numbers of tadpoles were caught here, however. Shortfinned eels were caught in fyke nets at all drain sites, but no mudfish were caught in drains, even in shallow ones (Table 5C).

Boggy Pond wetland was inspected for its value as habitat for brown mudfish, but no trapping was carried out there. Deep ditches around the wetland contained water all year round, and consequently would probably have little value as mudfish habitat. Seasonally dry lagoons in the area might provide habitat suitable for brown mudfish.

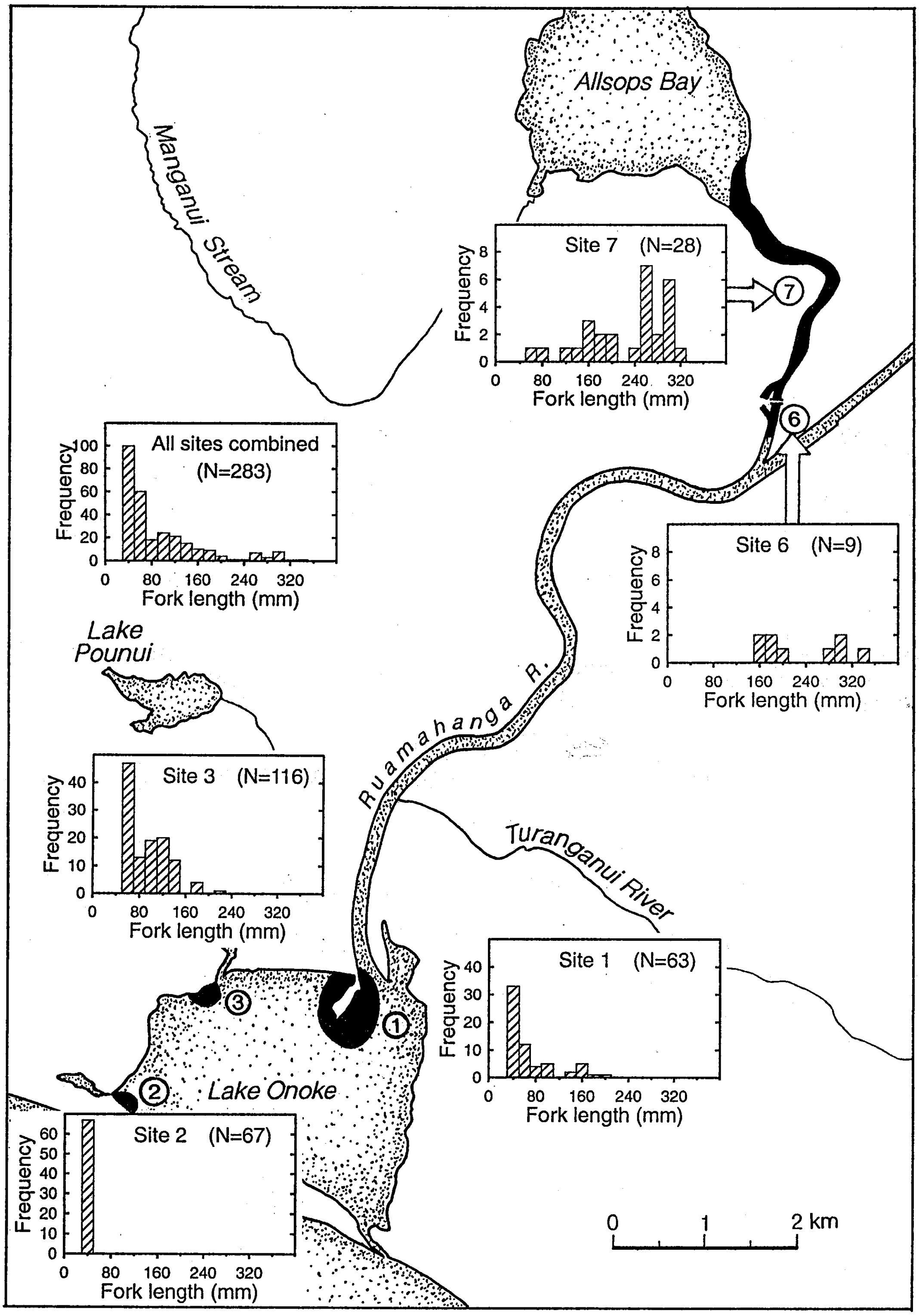


Figure 6. Length frequencies of yelloweyed mullet in Lakes Onoke and Wairarapa between 29 October and 1 November 1991.

2.4 DISCUSSION

2.4.1 Evaluation of potential fish barriers

2.4.1.1 Lake Wairarapa barrage gates. Diadromous species (i.e., migratory between the sea and freshwater) that can be conclusively demonstrated as present downstream of a potential barrier, but absent upstream, can usually be accepted as straightforward evidence of a block to migration. However, in the case of fish in the Lake Wairarapa wetlands, determining the effect of barriers to migration is not necessarily a simple matter. Some fish, such as black flounder and yelloweyed and grey mullet, may not be present in freshwater for 12 months of the year, so seasonal patterns of abundance are important. Resources available for this study prevented investigation of seasonal abundance. For fish resident in freshwater for a great proportion of their adult lives, such as eels, torrentfish, bullies, and galaxiids, a barrier to migration may be only partial, allowing a proportion of the potential recruits access to upstream habitats. Thus in place of a protracted study of migratory patterns, three lines of evidence for fish migration were inferred from data from only two sampling periods. These lines of evidence are: 1) presence or absence of migratory fish at sites upstream of a potential barrier before and after its construction; 2) comparison of current presence or absence of a species upstream and downstream of the barrier, and 3) for species present both upstream and downstream, comparison of relative densities in optimal habitats both sides of the barrier.

The effect of the barrage gates can be examined "before and after" using fish distribution in historical records. Comparison of present distributions of diadromous fish with historical distributions are only circumstantial, largely because most historical records were not quantitative. Numbers of fish were rarely recorded, and where they were, the length or area of fishing was not. The record of grayling in the Tauherenikau River in 1922 (Appendix 1) is interesting, but not relevant to this study because they are now extinct nationwide. The only reliable changes are that 5 koaro were recorded in Burlings Stream in August 1972, before barrage gate construction, and in July 1979 they were recorded as "rare". In December 1991, I found none in Burlings Stream, even in apparently suitable habitat. Koaro were not found at any site above the barrage gates, and only a single fish in the Orouapouanui Stream (Site 22) was found in the entire survey.

Banded kokopu were recorded in a small tributary of Burlings Stream before construction of the barrage gates, and this population is probably diadromous, as fry were reared successfully in salt water, but did not survive in freshwater (Ots and Eldon 1975). One adult lamprey was recorded from Burlings Stream in August 1961, and in Otauira Stream (a tributary of Abbots Creek) in 1940. None were found in December 1991.

Examining present-day distribution of fish above and below the barrage gates, several obligatory diadromous species were present in tributaries below the gates, but absent above. Redfinned bullies were absent from the 8 sites sampled above the gates, but present at 3 out of 4 sites below the gates (Figure 3). Banded kokopu were also absent from the 8 sites sampled above the gates, but present at 1 out of only 4 sites below the gates. A single fish was found in the Turanganui River (Site 25), downstream of the barrage gates. However, banded kokopu usually inhabit heavily shaded forest streams (Hanchet 1990, Gumbley 1993), and such sites were not fished in the 1991 survey. However, bluegilled bullies, another obligatory diadromous species, were found only above the barrage gates.

Examining abundance of species present in tributaries above and below the barrage gates, low densities (<10 fish/100 m^2) of all obligately diadromous species combined occurred at 5 out of 8 sites above the gates, but at only 1 out of 4 sites below the gates

(Table 3A). Because of the combination of small number of sites, and high density of fish at Site 8, the densities above and below the barrage gates were not statistically different, however. Examining abundance of each species, densities of shortfinned and longfinned eels were not different in tributaries above and below the barrage gates. Large numbers of diadromous common bullies also negotiate the barrage gates.

Median densities of longfinned eels, redfinned bullies, torrentfish, koaro, and banded kokopu were lower in tributaries upstream of the barrage gates than downstream (Figure 3). The only obligately diadromous species found at higher densities above the gates than below were shortfinned eels, inanga, and bluegilled bullies. Common bullies, common smelt, and brown trout were found at higher densities above the gates than below, but these species have lake-locked populations as well as diadromous populations in Lake Wairarapa (Figure 4, Table 3B, McDowall 1990).

Trapping and netting upstream and downstream of the barrage gates shows evidence of reduced migration. Upstream of the gates, catch rates of yelloweyed mullet, inanga whitebait, and *Paratya curvirostris* shrimps in trap nets were much reduced compared to downstream of the gates (Table 4A). On the other hand, catch rates of common bullies, mysid shrimps, and shortfinned eel elvers in trap net were much higher upstream of the gates. Yelloweyed mullet, stargazers, grey mullet, and anadromous smelt do negotiate the barrage gates, as panel net catches show. Mysids have the ability to breed entirely in freshwater (Chapman and Lewis 1976), so do not provide evidence of migration.

Both diadromous and anadromous common bullies and common smelt were caught in Lake Wairarapa. Adult common bullies from lake-locked populations are smaller than their sea-going counterparts. Lake-locked fish commonly reach 70-80 mm, whereas sea-going adults usually reach 110 mm (McDowall 1990). From the size of bullies with and without head pores in this study, there appear to be both lake-locked and sea-going populations in the tributaries of Lake Wairarapa. Lake-locked common bullies in the Huangarua River may result from rearing in Lake Onoke.

In common smelt, lake-locked or diadromous populations may be distinguished by diagnostic vertebral counts. Lake-locked common smelt in the Waikato River system have mean counts of 51-52 vertebrae, whereas diadromous stocks have about 60 (Ward et al. 1989). In the Lake Wairarapa system, mean vertebral counts show that anadromous common smelt migrate into the lake, and that lake-locked smelt migrate or are washed out of the lake (Figure 5).

Black and yellowbelly flounder, kahawai, grey mullet, and adult eels migrate in late summer and autumn (e.g., Rowe 1983, MAFFish North 1989). Because this sampling was in November and December to coincide with peak migrations of juvenile galaxiids and eels, flounder, mullet, and adult eels may be under-represented in the samples. Only two black flounder (caught at Site 1), one yellowbelly flounder (Site 3), and one grey mullet (Site 7) were caught in the 1991 survey, though these species are likely to be more common in summer.

The migration of black and yellowbelly flounder was studied incidentally as part of a recent growth study (Stevens 1993). Both species were caught in the Ruamahanga River diversion about 4 km upstream of the confluence with the outlet of Lake Wairarapa (at the original lake entrance), tagged, and released back into the river at the local powerboat club 2 km downstream of the point of capture (Figure 1). Of 71 tagged fish (37 black flounder and 34 yellowbelly flounder), 23 were recaptured and returned to Stevens (14 black flounder and 9 yellowbelly flounder). Most recapture sites (13 out of 17) were within 5 km of the original capture site. However, two black flounders that had migrated through the barrage gates were recaptured in Lake Wairarapa (Stevens 1993). One was within 250 m of the gates, and the other was at the north end of the lake. Stevens encountered a strong perception among fishers that Lake Wairarapa is no longer worth fishing for flounder because of a large decline in catch rates, and thus lack of fishing effort may be partly responsible for the low catch of tagged flounder upstream of the barrage gates. The only recorded movement outside of the waterway was a black flounder that travelled 454 km north in 500 days to the Awakino River, on the west coast of the North Island in northern Taranaki (Stevens 1993).

The qualitative impact of the barrage on the fish fauna appears to be small. Only koaro and redfinned bullies appear to be excluded, and other species present on the downstream side are also present on the upstream side. The present periods of opening of the barrage gates allow fish passage of most migratory fish species.

Quantitatively, the combination of the barrage and the reduced outflow of freshwater from the lake appear to have caused significant changes to fish populations, but results must be interpreted with caution. Trap nets of the design used in this study give the most accurate representation of lake fish communities of any gear type (Hayes 1989), but the sampling effort was relatively small compared to the large area of Lake Wairarapa and its tributaries. Sampling in late summer for black flounder, grey mullet, and eels would be a useful extension of these data. The abundance of torrentfish, yelloweyed mullet, and inanga seems to be reduced by at least two-thirds compared to downstream (Table 4A, trap net results). The abundance of *Paratya* shrimps in Lake Wairarapa may also be reduced by the barrage gates. Yellowbelly flounder were not found upstream of the barrage, but have apparently always been rare in Lake Wairarapa (Stevens pers. comm.).

The question of whether habitat is optimal or even comparable in the lake or tributaries either side of the barrage gate is important in comparisons of catch rates and densities. Visually, at least, conditions in the outlet channel upstream and downstream of the barrage gates appears very similar. Tributaries sampled were quite variable, but encompassed a similar range of conditions upstream and downstream of the barrage gates. I believe comparisons of densities and catch rates are valid, though sample sizes are marginal.

The small rectangular orifice (1.52 x 0.61 m) in centre of the concrete base of the barrage, intended for fish passage, is permanently open. This orifice remains open at all times. Whenever the gates are shut, and there is a head difference between the upstream and downstream sides of the barrage, water flows under the influence of this head difference at velocities that vary according to a rating curve derived from field measurements as follows:

$$\text{Velocity} = 3.44\ (\text{head difference in m})^{0.5}.$$

Because of "entry losses", presumably leakage around the gates, engineers assume that in fact a 20-mm head difference is required to produce a velocity of about 0.3 m/s (Wairarapa Catchment Board and Regional Water Board correspondence, 13 March 1986). For head differences above 20 mm, the rating curve is assumed to be correct. Even small differences in water height between the upstream and downstream sides of the gates (>85 mm) can create high water velocities (>1.0 m/s) when the barrage gates are shut. Sustained swimming speeds of shortfinned eels, inanga, banded kokopu, common bullies, common smelt, and grey mullet are 0.29-0.31 m/s for distances 10-15 m (Mitchell 1989). Direction of flow will reverse with variations in tidal height, and with flood discharges, and may actively assist fish passage by entraining fish in the direction of the flow. However, while fish near the orifice would be swept through in the direction of the flow, most species would not be able to swim against the flow, and the water velocity would present a barrier to fish migration when the barrage gates are closed.

2.4.1.2 Pounui Lagoon flapgates. Though the influence of the barrage gates on fish migration may be somewhat equivocal, the effect of the Pounui Lagoon flapgates is much less so. In trap nets, yelloweyed mullet, and shortfinned and longfinned eels, and triplefins were present downstream of the flapgates, but absent upstream (Table 4B). Present in the downstream trap net, but absent in the trap net catch upstream of the flapgate were triplefins, stargazer, *Helice crassa* (mudflat crab), and *Palaemon affinis* (shrimp). Catch rates of glass eels, inanga whitebait, and common smelt were much reduced upstream compared to downstream. *Paratya curvirostris* shrimps, however, were only found upstream of the flapgates. Fyke and panel nets catches corroborate trap net evidence for yelloweyed mullet and common smelt. Fyke nets show reduced catch rates of shortfinned eels upstream compared to downstream. Perch were more abundant upstream of the flapgates than downstream.

Presence of obligately diadromous fish and shrimp species in the outlet stream from Lake Pounui show that successful recruitment of inanga, eels, redfinned bullies occurs. To what extent densities may be affected by the flapgates is not known, though densities of all obligately diadromous fish species combined (18.6 fish/100 m^2) is similar to the median of densities in the four tributaries not under the influence of the barrage gates (22.9 fish/100 m^2, Table 3A). Giant kokopu have been recorded from Lake Pounui upstream of Site 5 (Jellyman 1979b). Whether juveniles of giant kokopu continue to maintain this population is unknown.

The gates themselves present a complete barrier to fish from Lake Onoke during the incoming tide, when they are completely shut. On an outgoing tide, when the gates are open, a velocity barrier almost certainly prevents most fish from migrating upstream for most of the outgoing tide. Velocities measured at the downstream end of the culvert affected by the flapgates (0.42 m/s) exceed the sustained swimming velocities (0.29-0.31 m/s) of shortfinned eels, inanga, banded kokopu, common bullies, common smelt, and grey mullet for distances 10-15 m (Mitchell 1989). Apart from a brief period at the start of the outgoing tide when velocities might be low enough to allow fish passage, velocities through the culverts when the flapgates are open appear to be too swift to permit upstream migration of fish into Pounui Lagoon. These findings are consistent with the reduced catch rates upstream of the flapgated culverts.

Closure of the flapgates during incoming tides not only restricts fish migration. It also modifies the salinity of Pounui Lagoon by preventing tidal water, usually saline, from entering the lagoon from Lake Onoke. This change in salinity may itself restrict the entry of some species to Pounui Lagoon. The absence from upstream of the Pounui Lagoon flapgate of species such as yelloweyed mullet, yellowbelly flounder, kahawai, stargazers, and triplefins that occur downstream of the gates may reflect lower salinities upstream compared to downstream, in addition to a partial barrier to upstream migration (Tables 2 and 4B).

2.4.2 Eels

Compared to previous data for eel size in the Wairarapa, eels in this survey were smaller. Mean size of shortfinned eels in Lake Pounui in the 1970s (at the time unexploited), was 525±107 mm TL (mean±one standard deviation, range 201-1042 mm TL, N=1070). Longfinned eels were 500±167 mm TL (range 291-1310 mm TL, N=521, Jellyman, pers. comm.). Modal size caught by fyke netting was 350-449 mm TL for shortfinned and longfinned eels caught in Lakes Wairarapa and Onoke in 1991 (Table 6A).

Catch rates of shortfinned and longfinned eels combined in trap nets were lower in Pounui Lagoon (0.35 g/net/h) and Lake Wairarapa (2.9 to 186 g/net/h), but similar in Lake Pounui (651 g/net/h, Table 6B), to catch rates in the same nets in two Waikato lakes (267-857 g/net/h, Hayes et al. 1992; shortfinned eels were the only species present). Catch rates in trap nets and fyke nets were similar upstream and downstream of the barrage gates, but sample sizes were too small and variability too great to allow statistical comparison.

Fyke net catch rates in all locations combined in the Lake Wairarapa system (2.08±2.47 kg/net/night, mean±95% confidence interval, Table 6C) were about one third of the national average from 1983-1989 (6.3 kg/net/night, Annala 1993). Size of eels has also declined, according to local eel fishers, and both relatively low fyke net catch rates of eels and declines in eel size are probably attributable to eel fishing.

2.4.3 Brown mudfish

Brown mudfish are of special significance because they have a requirement for wetland-like habitats. They have also been found in small swampy streams, ditches, and drains, but are very vulnerable to habitat disturbance. Brown mudfish were recorded in the Wairarapa in tributaries of the Waiohine River, itself a tributary of the lower Ruamahanga River (Eldon 1978). During the course of his study, Eldon found that brown mudfish populations in two ditch sites were drastically reduced by drain cleaning activities designed to improve drainage. Many wetland areas in the Wairarapa have been drained to increase the area available for pastoral farming (1237 ha between 1966 and 1981). The "Polder Scheme" of the 1980s planned to claim about half of the area of Lake Wairarapa, including the wetland fringe, and turn the drained land into dairy farms (Lake Wairarapa Co-ordinating Committee 1991). Though this scheme has been abandoned, pressure to convert more wetlands to farms is constant. Brown mudfish are certain to be widespread in wetland areas of the Wairarapa, but as the low catch in Donalds Block indicates, may be at very low densities. This makes preservation of the remaining wetland habitat, and its natural seasonal water level fluctuations, crucial for the survival of brown mudfish in the Wairarapa.

CHAPTER 3. THE FISHERIES OF THE LAKE WAIRARAPA WETLANDS

3.1 INTRODUCTION

In New Zealand, estuaries and the lower reaches of rivers are popular sites of fishing for pleasure, food, and sometimes commerce. Species frequently fished for are flounder (*Rhombosolea* spp.), trout (*Salmo trutta* and *Oncorhynchus mykiss*), kahawai (*Arripis trutta*), red cod (*Pseudophycis bacchus*, e.g., Pierce 1987), whitebait, and grey mullet (*Mugil cephalus*) (Taranaki Catchment Commission 1981, Unwin and Davis 1983, Hardy 1986, Pierce 1987, Saxton et al. 1987, Stancliff et al. 1988a).

The whitebait season extends from 1 August to 30 November. The principal target of fishing are the upstream migrant juveniles of five species of the Family Galaxiidae (Salmoniformes). These are: inanga (*Galaxias maculatus*), koaro (*G. brevipinnis*), banded kokopu (*G. fasciatus*), giant kokopu (*G. argenteus*), and shortjawed kokopu (*G. postvectis*). Inanga are generally the most common of these (McDowall and Eldon 1980, McDowall 1990). Frequently, also among the whitebaiter's catch are juveniles and adults of diadromous bullies (*Gobiomorphus* spp.), eels (*Anguilla* spp.), and smelt (*Retropinna* spp., McDowall 1984).

The purpose of this study was to form a profile of the recreational fisheries use of Lakes Wairarapa and Onoke, and the lower Ruamahanga River, and to estimate the number of whitebaiters and their catch.

3.2 METHODS

3.2.1 Whitebait fishery

3.2.1.1 Numbers of whitebaiters and nets. Numbers of whitebaiters using the Ruamahanga River or Lake Onoke on a sample of 8 randomly selected weekend days and 6 randomly selected week days were counted from a boat using a standardised form (Appendix 3). Counts were also made on Sunday and Monday of Labour Day weekend because the weekend has traditionally been highly used by whitebaiters.

Lake Onoke and the Ruamahanga River were arbitrarily divided into three survey reaches for the convenience of the surveyor (Figure 1). The three reaches were

1) Lake Onoke shore (from mouth of Lake Onoke at the sea to the downstream end of the Ruamahanga River channel - a distance of about 3km),
2) the lower river (the Ruamahanga River from Lake Onoke to the confluence of the Lake Wairarapa outlet - a point about 8 km upstream from the sea), and
3) the upper river (from the confluence of the Lake Wairarapa outlet to Robinsons Bridge near Tuhitarata - a distance of about 21 km upstream from the sea).

3.2.1.2 Creel survey of whitebaiters. Catches made by individual whitebaiters (a creel survey), and their personal details such as age, sex, and length of fishing experience, were determined using a consistent series of questions (Appendix 4). As an introduction to questioning for the creel survey, whitebaiters were assured that personal information would remain confidential, and that they would remain anonymous. They were also assured that any information gathered would be used only for analysis of the fishery, and would not lead to prosecution in cases of illegal fishing. They were also asked if they had been surveyed before, and if they kept a diary of their fishing.

The methods used to survey numbers of whitebaiters (Appendix 3) and the (Appendix 4) were similar to those used by the Taranaki Catchment Commission (1981), Saxton et al. (1987), and Rowe et al. (1992). Where whitebaiters estimated their catch in number or fractions of cups (a common practice), a cup was taken to mean 250 g of whitebait. In converting weight of catch to number of whitebait, a weight of 0.4 g per individual was assumed, based on weight-length relationships (Stancliff et al. 1988a, p28).

3.2.2 Other recreational fisheries

The questions asked of users of recreational fisheries other than whitebait during the telephone survey are shown in Appendix 5. Recreational fishers were initially identified from the survey of individual whitebaiters (Appendix 4). Participants were assured that they would remain anonymous, and were told of the importance of the survey to DOC to help manage the Lake Wairarapa wetland area.

3.3 RESULTS

3.3.1 Whitebait fishery

3.3.1.1 Catch composition. Eight samples of whitebait were collected from whitebaiters using set nets, and from unattended set nets, during the 1991 season. Dates on which samples were collected were 24 August (N=1), 25 September (N=2), 2 October (N=2), and 27 October (N=3). Only smelt and juvenile kahawai were caught in the three samples from August and September. Whitebaiters' catch when interviewed was often not large, and few were prepared to surrender any for the catch sampling.

A total of 940 fish and 326 *Paratya* shrimps were used for the catch composition analysis (Table 7A). The predominant species in the catch (excluding shrimps) was inanga whitebait (75%). Common bullies (10%) and koaro whitebait (5%) were the next most abundant species. Common smelt formed 4% of the catch, and giant kokopu 3%. All other fish species were $\leq$1% of the total numbers. Considering *Galaxias* species alone, inanga formed 89.6% of the catch, koaro 6.4%, giant kokopu 3.6%, and banded kokopu 0.5%.

3.3.1.2 Numbers of whitebaiters and nets. During the survey, a total of 448 whitebaiters were counted (Appendix 6). Both scoop netters and set netters with nets actually fishing in Lake Onoke choose incoming tides over outgoing tides (Table 7B). Set netters in the lower river and upper river also favoured incoming tides over outgoing. In Lake Onoke and in the lower river, whitebaiters choose river conditions of falling flood rather than low flow. In the upper river, however, set netters choose low flow conditions over falling flood. Set netters were biased towards fishing in fine rather than overcast weather; scoop netters showed less bias. Sensibly, netters of both types avoided rain. Set netters were also biased to calm wind conditions, but scoop netters were biased towards fresh wind conditions. Netters of both types avoided strong winds, though over all reaches, scoop netters were more strongly biased against strong wind than set netters.

Of the 448 whitebaiters counted, 79.5% had set nets, and 20.5% had scoop nets. The total number of nets actually being used for fishing at the time of the surveys was 462, of which 90 were scoop nets and 372 were set nets. Mean proportions of nets in the water in Lake Onoke were 37.3% scoop nets, and 62.7% set nets. In the lower and upper river, set nets were used almost exclusively (Table 8).

There were significantly more whitebaiters per kilometre fishing in Lake Onoke than in either the lower or the upper Ruamahanga River (Table 9, two-way ANOVA, p=0.001). However, there was no difference in the number of whitebaiters fishing on weekend days compared to week days (p=0.816). The interaction between day type and

Table 7. A) Species composition of the catch in whitebait nets and B) tide, river, and weather conditions selected by whitebaiters in the Ruamahanga River and Lake Wairarapa in the 1991 whitebait season.

A. Species composition of the catch

Sample number	Number per set net: Whitebait: inanga	koaro	giant kokopu	banded kokopu	inanga juveniles	glass eels	common bullies	redfinned bullies	common smelt	kahawai juveniles	*Paratya* shrimps
1	226	0	0	0	0	0	0	0	0	0	0
2	55	0	0	0	0	0	0	0	0	0	0
3	70	0	0	0	0	2	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	1	0
5	0	0	0	0	0	0	0	0	4	0	0
6	0	0	0	0	0	0	0	0	33	0	0
7	110	4	0	0	6	0	49	0	2	0	26
8	243	46	28	4	3	0	49	4	1	0	300
Total	704	50	28	4	9	2	98	4	40	1	326
% of total catch	55.6	3.9	2.2	0.3	0.7	0.2	7.7	0.3	3.2	0.1	25.8
% excluding shrimps	74.9	5.3	3.0	0.4	1.0	0.2	10.4	0.4	4.3	0.1	
% of whitebait only	89.6	6.4	3.6	0.5							

B) tide, river, and weather conditions selected by whitebaiters

Location	Condition	Number of scoop nets	Number of set nets	Total number of nets	Number of counts	Scoop nets (%)	Set nets (%)	Total nets (%)	Proportion of counts (%)
Conditions of tide									
Lake Onoke	incoming	76	144	220	7	84.4	86.7	85.9	53.8
Lake Onoke	out	14	22	36	6	15.6	13.3	14.1	46.2
Lake Onoke	slack	0	0	0	0	0.0	0.0	0.0	0.0
lower river	incoming	0	14	14	9	0.0	51.9	51.9	64.3
lower river	out	0	9	9	4	0.0	33.3	33.3	28.6
lower river	slack	0	4	4	1	0.0	14.8	14.8	7.1
upper river	incoming	0	135	135	11	0.0	75.4	75.4	73.3
upper river	out	0	44	44	4	0.0	24.6	24.6	26.7
upper river	slack	0	0	0	0	0.0	0.0	0.0	0.0
all reaches	incoming	76	293	369	27	84.4	78.8	79.9	64.3
all reaches	out	14	75	89	14	15.6	20.2	19.3	33.3
all reaches	slack	0	4	4	1	0.0	1.1	0.9	2.4
Condition of river									
Lake Onoke	falling fresh	70	132	202	8	77.8	79.5	78.9	61.5
Lake Onoke	low water	20	34	54	5	22.2	20.5	21.1	38.5
lower river	falling fresh	0	21	21	9	0.0	77.8	77.8	64.3
lower river	low water	0	6	6	5	0.0	22.2	22.2	35.7
upper river	falling fresh	0	25	25	10	0.0	14.0	14.0	66.7
upper river	low water	0	154	154	5	0.0	86.0	86.0	33.3
all reaches	falling fresh	20	80	100	24	100.0	30.7	35.6	55.8
all reaches	low water	0	181	181	19	0.0	69.3	64.4	44.2
Condition of weather									
Lake Onoke	fine	44	97	141	6	48.9	58.4	55.1	46.2
Lake Onoke	overcast	46	66	112	6	51.1	39.8	43.8	46.2
Lake Onoke	rain	0	3	3	1	0.0	1.8	1.2	7.7
lower river	fine	0	12	12	6	0.0	44.4	44.4	42.9
lower river	overcast	0	15	15	7	0.0	55.6	55.6	50.0
lower river	rain	0	0	0	1	0.0	0.0	0.0	7.1
upper river	fine	0	130	130	5	0.0	72.6	72.6	33.3
upper river	overcast	0	49	49	9	0.0	27.4	27.4	60.0
upper river	rain	0	0	0	1	0.0	0.0	0.0	6.7
all reaches	fine	44	239	283	17	48.9	64.2	61.3	40.5
all reaches	overcast	46	130	176	22	51.1	34.9	38.1	52.4
all reaches	rain	0	3	3	3	0.0	0.8	0.6	7.1
Condition of wind									
Lake Onoke	calm	16	45	61	2	17.8	27.1	23.8	15.4
Lake Onoke	fresh	74	118	192	9	82.2	71.1	75.0	69.2
Lake Onoke	strong	0	3	3	2	0.0	1.8	1.2	15.4
lower river	calm	0	0	0	0	0.0	0.0	0.0	0.0
lower river	fresh	0	24	24	10	0.0	88.9	88.9	71.4
lower river	strong	0	3	3	4	0.0	11.1	11.1	28.6
upper river	calm	0	40	40	1	0.0	22.3	22.3	6.7
upper river	fresh	0	122	122	9	0.0	68.2	68.2	60.0
upper river	strong	0	17	17	5	0.0	9.5	9.5	33.3
all reaches	calm	16	85	101	3	17.8	22.8	21.9	7.1
all reaches	fresh	74	264	338	28	82.2	71.0	73.2	66.7
all reaches	strong	0	23	23	11	0.0	6.2	5.0	26.2

Table 8. Number of whitebaiters and nets per kilometre along the shore of Lake Onoke (0-3 km upstream from the sea), along the lower Ruamahanga River (3-8 km upstream from the sea), and along the upper Ruamahanga River (8-21 km upstream from the sea) between 11 August and 20 November 1991. Date - YYMMDD, where Y=year digits, M=month digits, and D=day digits, e.g., 910913 is 13 September 1991.

Date	Number of nets per km the water	Number of whitebaiters with nets per km	Proportion of net types with whitebaiters		Proportion of net types in the water	
			scoop	set	scoop	set
1) Weekend days						
A) Lake Onoke						
910913	1.0	1.0	1.00	0.00	1.00	0.00
911002	3.0	3.3	0.33	0.67	0.30	0.70
911120	3.7	3.7	0.18	0.82	0.18	0.82
910925	9.0	9.7	0.44	0.56	0.41	0.59
911019	21.0	22.0	0.37	0.63	0.35	0.65
B) Lower river						
911019	0.0	0.0				
911120	0.0	0.0				
911003	0.0	0.2			0.00	1.00
911002	0.4	0.4	0.00	1.00	0.00	1.00
910913	0.8	0.8	0.00	1.00	0.00	1.00
910925	1.0	1.2	0.00	1.00	0.00	1.00
C) Upper river						
911003	0.0	0.0				
911003	0.0	0.0				
911120	0.1	0.3	0.00	1.00	0.00	1.00
910925	0.2	0.2	0.00	1.00	0.00	1.00
911019	0.6	0.6	0.00	1.00	0.00	1.00
911002	0.7	0.7	0.00	1.00	0.00	1.00
910913	3.2	3.3	0.00	1.00	0.00	1.00
2) Week days						
A) Lake Onoke						
911027	0.0	0.0				
911028	0.0	0.0				
911005	1.0	1.0	0.00	1.00	0.00	1.00
910907	1.7	1.7	0.60	0.40	0.60	0.40
911109	2.3	2.3	0.43	0.57	0.43	0.57
910824	11.7	13.3	0.43	0.57	0.38	0.63
910811	20.0	13.1	0.06	0.94	0.05	0.95
910922	20.7	20.3	0.40	0.60	0.41	0.59
B) Lower river						
911027	0.0	0.0				
911028	0.0	0.0				
910811	0.0	0.0				
911005	0.0	0.0				
910824	0.4	0.4	0.00	1.00	0.00	1.00
911109	0.6	0.6	0.00	1.00	0.00	1.00
910922	0.6	0.6	0.00	1.00	0.00	1.00
910907	1.2	1.2	0.00	1.00	0.00	1.00
C) Upper river						
911109	0.0	0.0				
910811	0.0	0.0				
911005	0.0	0.0				
910922	0.0	0.0				
910824	0.3	0.1	0.50	0.50	0.00	1.00
910907	1.3	1.3	0.00	1.00	0.00	1.00
911028	4.1	4.2	0.00	1.00	0.00	1.00
911027	7.5	8.5	0.00	1.00	0.00	1.00

Table 9. A) Means and B) ANOVA table for number of whitebaiters with nets per kilometre along three zones of Lake Onoke and the Ruamahanga River (see Table 7 for explanation of zones). Total for reach calculated from mean number per km multiplied by reach length.

A) Number of whitebaiters with nets

	Mean no. per km	N	Standard error	Total for reach mean	Total for reach 95% CL
Means by day type					
1) Week days	2.60	18	1.27		
2) Week end days	2.66	24	1.08		
Means by location					
3) Lake Onoke	7.04	13	2.17	21.1	6.5
4) Lower river	0.39	14	0.12	2.0	0.6
5) Upper river	0.92	15	0.42	12.0	5.5
Means by day type and location					
1) x 3)	7.93	5	3.80		
1) x 4)	0.43	6	0.20		
1) x 5)	0.64	7	0.41		
2) x 3)	6.47	8	2.79		
2) x 4)	0.35	8	0.15		
2) x 5)	1.16	8	0.71		

B) ANOVA table

Source of variation	Sums of squares	Degrees of freedom	Mean square	F ratio	Significance level
1) Day type	1.168	1	1.168	0.055	0.816
2) Location	370.837	2	185.418	8.740	0.001
Interaction between 1) and 2)	6.838	2	3.419	0.161	0.852
Error	763.710	36	21.214		
Total (corrected)	1142.553	41			

location was also not significant (p=0.852).

The number of sampling occasions were too few to determine effects of time of day, time of the tide, of weather. The bar at Lake Onoke, which closes periodically during a southerly storm, had been open for 59 days at the start of the survey, and remained open for the duration. At the end of the survey, the bar had been open for a total of 160 days.

3.3.1.3 Creel survey of whitebaiters. Ninety-one interviews of whitebaiters at their fishing sites (creel surveys) were conducted in the three reaches combined. Of the 91 interviews conducted, three whitebaiters were interviewed twice, and one was interviewed three times. All others were interviewed only once. Details specific to that day's fishing were recorded for repeat interviews, but data that would not have changed between days (e.g., age, sex, and place of origin) was not recorded. Raw data are presented in Appendix 7. Not all reaches had whitebaiters present on any given day.

The most common place of origin of the whitebaiters was the Hutt Valley (21% of interviewees), with the Wairarapa towns of Greytown, Carterton, Masterton, and Martinborough almost equally common origins (11-15% of interviewees). Other places were the homes of 6% or fewer interviewees (Table 10A).

Details of age, lengths of years of fishing experience, number of travelling companions, length and frequencies of visits, were also sought. Whitebaiters were predominantly male (73%; N=89 for both sexes). Mean ages of men and women were the same (ANOVA, p=0.4433). Mean age for both sexes combined was 49 years, with a minimum of 14 and maximum of 81 (Table 10B). Mean ages of whitebaiters was not different among reaches (ANOVA, p=0.752). Distribution of ages was bimodal, with peaks in the 40-50 and 60-70 years age groups (Figure 7A). Most whitebaiters travelled with 1 other person (Table 10B, Figure 7C), and stayed for a single day (Table 10B, Figure 7E). Means for these attributes were not different among reaches (ANOVA, p>0.273, Table 10B). Mean frequency of visits during the season ranged from 18 to 30 for the three reaches, but were not different (ANOVA, p=0.637). The distribution of number of visits was trimodal, with peaks in the 0-9 visits per year group, the 40-50 visits group, and the 110-120 visits group (Figure 7D). Individual lengths of stay (Table 10B, Figure 7E) were multiplied by frequency of visits to give total days' fishing per season. Mean number of total days' fishing ranged between 13 and 27 for the three reaches, but were again not different among reaches (ANOVA, p=0.5436, Table 10B).

Length of experience of whitebaiters ranged from a minimum of 0 years for first-timers to a maximum of 67 years (Table 11A), and was related to age (regression analysis, r^2=0.334, p<0.001, N=81). Whitebaiters fishing Lake Onoke had on average less experience than those fishing the river (ANOVA, p=0.023, Table 11A). Mean length of experience of whitebaiters fishing the two river reaches was not different. Mean length of experience of whitebaiters interviewed on each day varied considerably, but was not different among days for each reach (ANOVA, $p \geq 0.137$) because of small sample sizes and large standard errors (Table 11B). Combining all river sections, length of experience was also not significantly different between days (ANOVA, p=0.240, Table 11C).

The wide range of total daily catch for all reaches combined (125 to 6,625 g, Table 12A, Figure 7F) was not significantly related to the number of whitebaiters interviewed in the reach (regression analysis, r^2=0.282, p=0.062, N=13). However, total catch per day for all reaches and whitebaiters combined was related to the median number of years' experience of whitebaiters (Table 11C) fishing on any one day (r^2=0.606, p=0.002, N=13).

Table 10. A) place of origin and B) demography of whitebaiters at Lake Onoke and in the lower Ruamahanga River in the 1991 season.

A) Place of origin

Home town	Number of respondents	Percentage of respondents
Hutt Valley	19	20.9
Greytown	14	15.4
Carterton	13	14.3
Masterton	11	12.1
Martinborough	10	11.0
Featherston	5	5.5
Pirinoa	4	4.4
Lake Ferry	3	3.3
Wellington	3	3.3
Paihiatua	2	2.2
Wainuiomata	1	1.1
Johnsonville	1	1.1
Whangamoana	1	1.1
Tauranga	1	1.1
Eketahuna	1	1.1
Levin	1	1.1
Porirua	1	1.1
Total	91	100.0

B) Demography of whitebaiters

Reach	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
Age of whitebaiters								
Both sexes, all reaches	84	49.3	49.5	1.75	14	81	37	62
By reach p=0.7524								
Lake Onoke	47	48.7	49.0	2.14	17	72	37	62
Lower river	6	54.0	60.5	8.70	23	76	71	
Upper river	31	49.4	48.0	3.12	14	81	37	67
Number of travelling companions p=0.5475								
Lake Onoke	48	1.6	1.0	0.17	0	6	1	2
Lower river	6	1.0	1.0	0.00	1	1	1	1
Upper river	32	1.5	1.0	0.33	0	10	1	2
All reaches	86	1.5	1.0	0.16	0	10	1	2
Length of stay p=0.2725								
Lake Onoke	49	1.3	1.0	0.18	0.5	7	1.0	1
Lower river	6	0.8	1.0	0.11	0.5	1	0.5	1
Upper river	32	1.0	1.0	0.09	0.5	3	1.0	1
All reaches	87	1.2	1.0	0.11	0.5	7	1.0	1
Frequency of visits p=0.6370								
Lake Onoke	48	30.5	9.0	5.24	1	120	4	50
Lower river	6	17.8	12.0	6.83	5	50	8	20
Upper river	32	26.8	26.0	4.95	1	120	4	32
All reaches	86	28.2	16.0	3.48	1	120	4	50
Total days' fishing p=0.5436								
Lake Onoke	53	26.1	12	4.20	0	120	4	32
Lower river	6	13.0	12	3.52	4	25	5	20
Upper river	32	26.9	26	4.96	1	120	4	32
All reaches	91	25.5	16	3.01	0	120	4	32
Catch by sex p=0.2817								
Female	24	192.9	125	30.96	1	500	125	250
Male	65	313.5	125	66.47	0	4000	125	250
Both sexes	90	289.0	125	49.56	0	4000	125	250

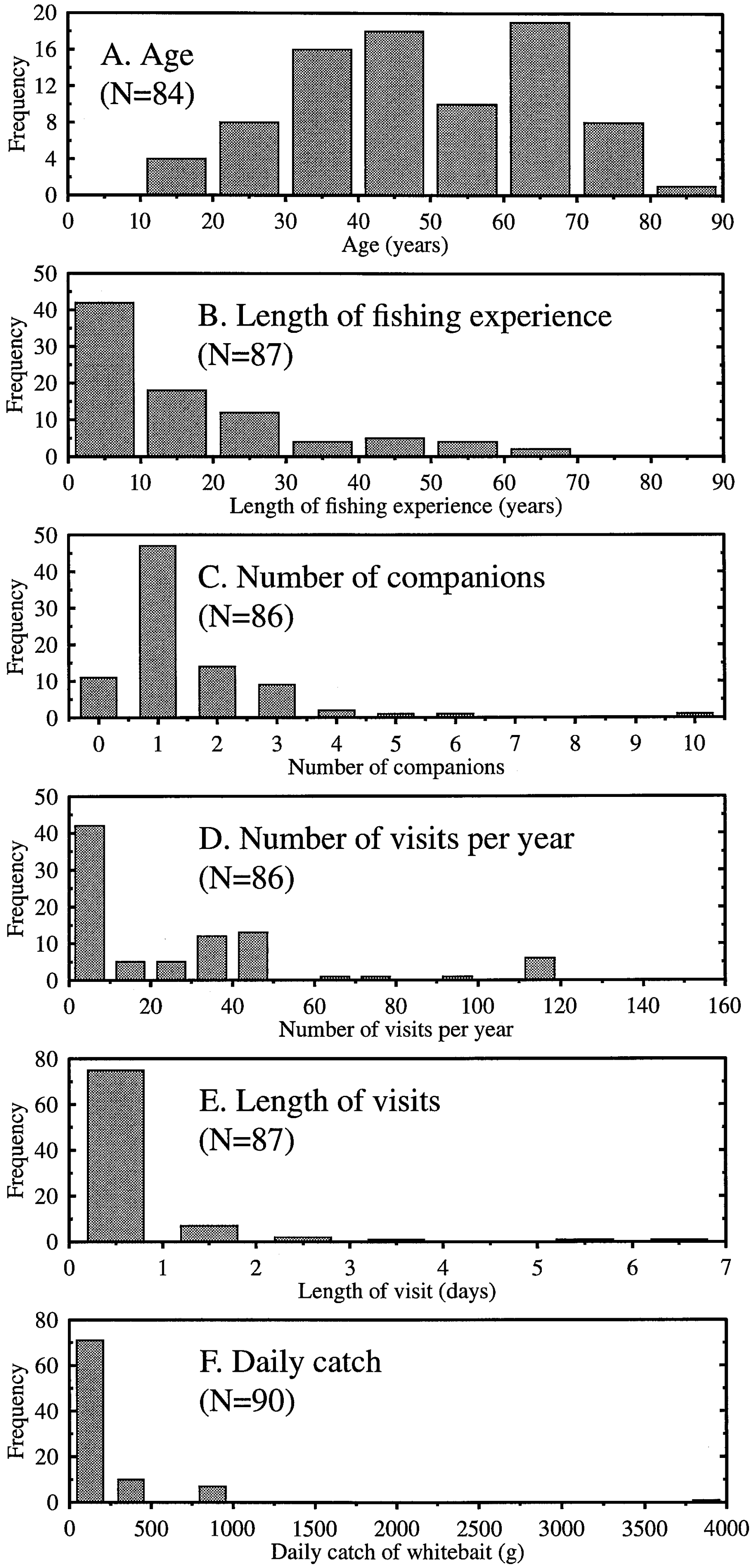


Figure 7. Frequency of A) ages, B) length of fishing experience, C) number of companions, D) number of visits per year, E) length of visits, and F) daily catch for whitebaiters in the Lake Wairarapa wetlands for the 1991 season.

Table 11. Length of experience whitebaiting for whitebaiters interviewed at Lake Onoke and in the lower Ruamahanga River in the 1991 season.

A. Length of experience whitebaiting for each of the three reaches p=0.0234 means different with LSD, but not with Tukey f=3.928, n=88

Reach	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
Lake Onoke	49	14.1	10.0	1.94	0.00000	56.0000	4.00000	20.0000
Lower river	6	30.5	22.5	9.05	8.00000	65.0000	15.0000	50.0000
Upper river	32	22.6	16.5	3.69	0.00000	67.0000	5.00000	30.0000

B. Length of experience whitebaiting for each of the three reaches for each date

Date	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
Lake Onoke p=0.1367								
910811	7	8.3	10.0	2.25	1.0	18.0	3.0	12.0
910824	8	13.1	9.0	5.74	0.0	50.0	2.5	16.0
910907	2	15.0	15.0	5.00	10.0	20.0	10.0	20.0
910913	1	56.0	56.0					
910922	9	17.3	10.0	5.02	2.0	40.0	5.0	30.0
910925	6	12.0	7.0	5.12	0.0	30.0	3.0	25.0
911002	2	4.5	4.5	0.50	4.0	5.0	4.0	5.0
911005	1	2.0	2.0					
911019	8	13.8	11.0	4.46	1.0	35.0	3.5	22.5
911109	3	22.3	20.0	5.04	15.0	32.0	15.0	32.0
911120	2	14.0	14.0	11.00	3.0	25.0	3.0	25.0
Lower river can't test								
910824	1	15.0	15.0					
910907	1	20.0	20.0					
910922	1	65.0	65.0					
910925	1	25.0	25.0					
911002	1	50.0	50.0					
911109	1	8.0	8.0					
Upper river p=0.2980								
910824	1	5.0	5.0	0.00	5.0	5.0	5.0	5.0
910907	4	32.5	31.5	15.63	0.0	67.0	6.5	58.5
910913	5	34.2	30.0	11.52	1.0	60.0	20.0	60.0
910925	2	50.0	50.0	0.00	50.0	50.0	50.0	50.0
911002	2	20.0	20.0	10.00	10.0	30.0	10.0	30.0
911019	1	30.0	30.0	0.00	30.0	30.0	30.0	30.0
911027	5	18.2	7.0	10.96	1.0	60.0	3.0	20.0
911028	9	12.6	12.0	3.14	0.0	30.0	5.0	20.0
911120	3	14.0	10.0	8.33	2.0	30.0	2.0	30.0

C. Length of experience whitebaiting for each of the three reaches combined for each date p=0.2402

Date	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
910811	7	8.3	10.0	2.25	1	18	3	12
910824	10	12.5	9.0	4.60	0	50	3	15
910907	7	25.7	20.0	9.04	0	67	10	50
910913	6	37.8	43.0	10.08	1	60	20	60
910922	10	22.1	17.5	6.55	2	65	5	35
910925	9	21.9	25.0	6.41	0	50	4	30
911002	5	19.8	10.0	8.89	4	50	5	30
911005	1	2.0	2.0	0.00	2	2	2	2
911019	9	15.6	12.0	4.32	1	35	5	30
911027	5	18.2	7.0	10.96	1	60	3	20
911028	9	12.6	12.0	3.14	0	30	5	20
911109	4	18.8	17.5	5.06	8	32	11.5	26
911120	5	14.0	10.0	5.74	2	30	3	25

Table 12. Total, mean, and median daily catches of whitebait by 91 interviewees fishing on 13 days in Lake Onoke and the Ruamahanga River, 1991. p, probabilites of differences among mean daily catches (ANOVA).

Date	Day of the week	N	Daily catch of whitebait (g)							
			Total catch	Mean	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
A) All reaches combined p=0.0885 no difference by date										
910811	Sun	7	1000	142.9	125	17.86	125	250	125	125
910824	Sat	10	1375	137.5	125	12.50	125	250	125	125
910907	Sat	7	1375	196.4	125	53.57	125	500	125	250
910913	Fri	7	6625	946.4	250	530.93	125	4000	125	1000
910922	Sun	10	4125	412.5	250	107.13	125	1000	125	500
910925	Wed	9	1751	194.6	125	47.04	1	500	125	250
911002	Wed	5	503	100.6	125	24.40	3	125	125	125
911005	Sat	1	125	125.0	125	0.00	125	125	125	125
911019	Sat	12	3750	312.5	125	97.92	125	1000	125	375
911027	Sun	5	750	150.0	125	25.00	125	250	125	125
911028	Mon	8	2501	312.6	188	120.41	0	1000	63	500
911109	Sat	4	1250	312.5	313	108.25	125	500	125	500
911120	Wed	5	877	175.3	125	93.40	0.5	500	1	250
Total		90	26006	289.0	125	49.5582	0	4000	125	250
B) Lake Onoke										
Both methods combined p=0.2201										
910811	Sun	7	1000	142.9	125	17.86	125	250	125	125
910824	Sat	8	1125	140.6	125	15.63	125	250	125	125
910907	Sat	2	250	125.0	125	0.00	125	125	125	125
910913	Fri	2	250	125.0	125	0.00	125	125	125	125
910922	Sun	9	4000	444.4	250	114.32	125	1000	250	500
910925	Wed	6	1500	250.0	250	55.90	125	500	125	250
911002	Wed	2	250	125.0	125	0.00	125	125	125	125
911005	Sat	1	125	125.0	125	0.00	125	125	125	125
911019	Sat	11	3500	318.2	125	107.08	125	1000	125	500
911109	Sat	3	750	250.0	125	125.00	125	500	125	500
911120	Wed	2	2	0.8	0.75	0.25	0.5	1	0.5	1
Scoop netting p=0.1498										
910824		3	375	125.0	125	0.00	125	125	125	125
910907		1	125	125.0	125	0.00	125	125	125	125
910913		2	250	125.0	125	0.00	125	125	125	125
910922		3	2250	750.0	1000	250.00	250	1000	250	1000
910925		3	625	208.3	250	41.67	125	250	125	250
911002		1	125	125.0	125	0.00	125	125	125	125
911019		4	2625	656.3	750	212.71	125	1000	312.5	1000
911109		1	125	125.0	125	0.00	125	125	125	125
Set netting p=0.0320 911120 lower than 910922, rest all the same										
910811		7	1000	142.9	125	17.86	125	250	125	125
910824		4	625	156.3	125	31.25	125	250	125	188
910907		1	125	125.0	125	0.00	125	125	125	125
910922		5	1625	325.0	250	75.00	125	500	250	500
910925		3	875	291.7	250	110.24	125	500	125	500
911002		1	125	125.0	125	0.00	125	125	125	125
911005		1	125	125.0	125	0.00	125	125	125	125
911019		7	875	125.0	125	0.00	125	125	125	125
911109		2	625	312.5	312.5	187.50	125	500	125	500
911120		2	2	0.8	0.75	0.25	0.5	1	0.5	1
C) Lower Ruamahanga River can't test										
910824	Sat	1	125	125.0	125	0.00	125	125	125	125
910907	Sat	1	500	500.0	500	0.00	500	500	500	500
910922	Sun	1	125	125.0	125	0.00	125	125	125	125
910925	Wed	1	125	125.0	125	0.00	125	125	125	125
911002	Wed	1	125	125.0	125	0.00	125	125	125	125
911109	Sat	1	500	500.0	500	0.00	500	500	500	500
D) Upper Ruamahanga River p=0.3095										
910824	Sat	1	125	125.0	125	0.00	125	125	125	125
910907	Sat	4	625	156.3	125	31.25	125	250	125	187.5
910913	Fri	5	6375	1275.0	1000	705.34	125	4000	250	1000
910925	Wed	2	126	63.0	63	62.00	1	125	1	125
911002	Wed	2	128	64.0	64	61.00	3	125	3	125
911019	Sat	1	250	250.0	250	0.00	250	250	250	250
911027	Sun	5	750	150.0	125	25.00	125	250	125	125
911028	Mon	8	2501	312.6	187.5	120.41	0	1000	63	500
911120	Wed	3	875	291.7	250	110.24	125	500	125	500

A multiple regression relating length of fishing experience (median time in years, X_1), and number of whitebaiters (X_2), to total daily catch of whitebait in grams (Y),

$$Y = -1310.51 + 121.29X_1 + 215.46X_2,$$

was highly significant (multiple r^2=0.718, p=0.002, N=13).

Mean daily catch of whitebait in the three reaches combined was also related to length of experience of whitebaiters fishing on each day (Figure 8A). Mean catch rate for each day was also related to length of experience of whitebaiters (Figure 8B). Mean catch rates for all reaches, methods, and days were not different between men (314 g/h) and women (193 g/h, ANOVA, p=0.2817, Table 10B). There was no difference between catch rates for men and women when means for Lake Onoke were considered alone, for either scoop netting (ANOVA, p=0.086) or for set netting (p=0.360). Catch rate was also not different on incoming or outgoing tides for either scoop netting (ANOVA, p=0.843) or for set netting (p=0.973).

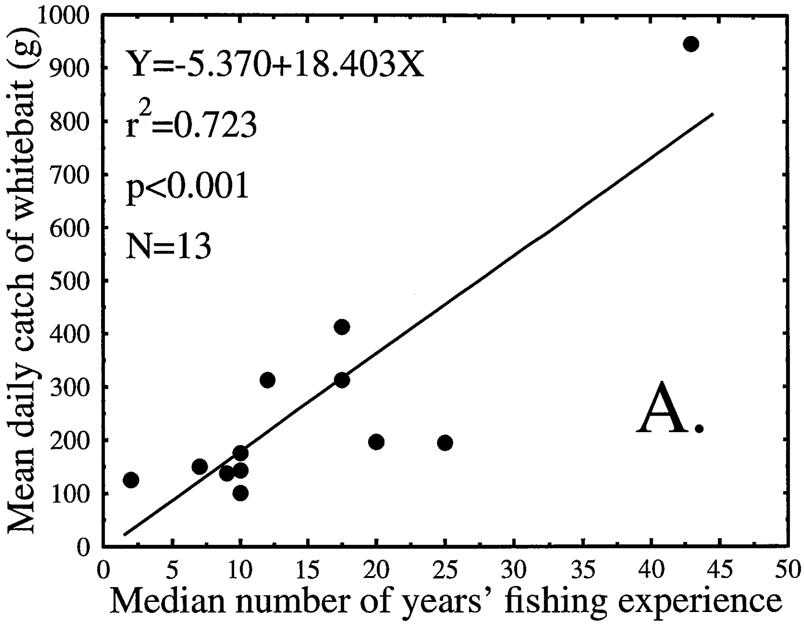
Whitebaiting in Lake Onoke showed a number of distinctions from the other two reaches. Unlike the two river reaches, total daily catch in Lake Onoke was related to the mean number of hours spent fishing on any given day (regression analysis, r^2=0.767, p=0.004, N=8), but was unrelated to time fishing in the other reaches (r^2=0.009, p=0.907, N=4, for the lower river; r^2=0.005, p=0.886, N=7, for the upper river). Total daily catch was also related to the mean number of whitebaiters fishing on each day in Lake Onoke (r^2=0.771, p<0.001, N=11), but was unrelated in the upper river (r^2=0.318, p=0.114, N=9). The test could not be carried out for the lower river because of insufficient sample size.

Of the two types of nets were used by whitebaiters interviewed in this survey, set nets were used throughout the three reaches, whereas scoop nets were used only along the shores of Lake Onoke (Table 13A). Scoop nets were predominantly used within 100 m of the mouth of Lake Onoke, where they were used by 18 out of 26 whitebaiters. The other whitebaiters used set nets. In Lake Onoke, however, catch rates were significantly higher for scoop netting (mean 130.7 g/h) than for set netting (mean 65.8 g/h, ANOVA, p=0.020). Catch rates for all reaches combined appeared higher for scoop netting (mean 130.7 g/h) than for set netting (mean 95.8 g/h), but the difference was not significant (ANOVA, p=0.393). There was no difference among catch rates for set netting among the three reaches (ANOVA, p=0.195).

Mean catch rates on each day varied widely between reaches and methods, from 0.6 g/h for set netting in Lake Onoke to 351.7 g/h for set netting in the upper river (Table 13B). Daily mean catch rates were not significantly different, however, because of low sample sizes and high standard errors.

Whitebaiters were canvassed for their expectations of daily and seasonal catch. Means of expected daily catches that were considered excellent, good, average, and poor were 3430, 1170, 510, and 200 g respectively (Table 14A). Means of expected seasonal catches that were considered good, average, and poor were 8220, 3600, 1080 g. There was no difference for each expected catch level among means for the three reaches for either daily catch (ANOVA, $p \geq 0.124$) or seasonal catch ($p \geq 0.735$).

Whitebaiters tended to come and go from the whitebaiting sites during the day, favouring incoming tides, and interviews were not made at the same time each day. For these reasons, mean time spent whitebaiting on any one day varied among the three reaches from 1.5 to 6.3 h (Table 15A). There was no relationship between hours spent fishing and time of day of the interviews in Lake Onoke (regression analysis, r^2= 0.036, p=0.268, N=36), or in the lower river reach (r^2=0.342, p=0.415, N=4). In the upper river reach, however, there was a significant relationship (r^2=0.340, p=0.004, N=22). Because



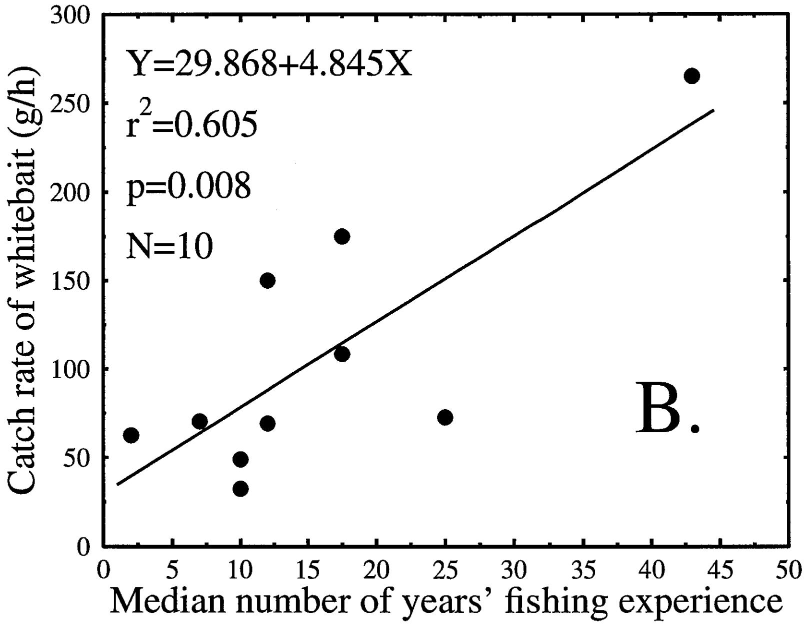


Figure 8. Relationship of A) mean daily catch and B) catch rate to length of experience whitebaiting for whitebaiters in Lake Onoke and the Ruamahanga River in the 1991 season.

Table 13. Catch rates of whitebait by 91 interviewees fishing on 13 days in Lake Onoke and the Ruamahanga River, 1991.

A. Catch rate by method

Method of netting	Catch rate (g/h)							
	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
All reaches combined p=0.393								
scoop net	14	130.7	91.7	24.0	16.7	333	83.3	166.7
set net	44	95.8	62.5	21.1	0.25	889	31.3	100.0
Lake Onoke p=0.0202								
scoop net	14	130.7	91.7	24.0	16.7	333	83.3	166.7
set net	21	65.8	50.0	14.7	0.25	250	25.0	71.4
Lower river								
set net	4	46.7	33.3	18.4	20.0	100	22.5	70.8
Upper river								
set net	19	139.2	83.3	44.6	2.0	889	50.0	142.9

B. Catch rate by date

Method of netting	Catch rate (g/h)							
	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
Lake Onoke scoop netting p=0.3537								
910913	2	91.7	91.7	8.3	83.3	100.0	83.3	100.0
910922	3	211.1	250.0	84.1	50.0	333.3	50.0	333.3
910925	3	104.2	83.3	31.8	62.5	166.7	62.5	166.7
911002	1	83.3	83.3	0.0	83.3	83.3	83.3	83.3
911019	4	92.0	104.2	28.0	16.7	142.9	50.0	133.9
911109	1	250.0	250.0	0.0	250.0	250.0	250.0	250.0
Lake Onoke set netting p=0.2664								
910922	5	73.6	66.7	8.0	55.6	100.0	62.5	83.3
910925	3	48.1	41.7	12.0	31.3	71.4	31.3	71.4
911002	1	35.7	35.7	0.0	35.7	35.7	35.7	35.7
911005	1	62.5	62.5	0.0	62.5	62.5	62.5	62.5
911019	7	60.1	25.0	31.9	19.2	250.0	22.7	50.0
911109	2	175.0	175.0	75.0	100.0	250.0	100.0	250.0
911120	2	0.6	0.6	0.4	0.3	1.0	0.3	1.0
Lake Onoke both methods p=0.1714								
910913	2	91.7	91.7	8.3	83.3	100.0	83.3	100.0
910922	9	118.2	66.7	33.9	50.0	333.3	62.5	100.0
910925	6	76.1	67.0	19.7	31.3	166.7	41.7	83.3
911002	2	59.5	59.5	23.8	35.7	83.3	35.7	83.3
911005	1	62.5	62.5	0.0	62.5	62.5	62.5	62.5
911019	11	71.7	31.3	22.3	16.7	250.0	22.7	125.0
911109	3	200.0	250.0	50.0	100.0	250.0	100.0	250.0
911120	2	0.6	0.6	0.4	0.3	1.0	0.3	1.0
Lower river can't test								
910922	1	20.0	20.0					
910925	1	41.7	41.7					
911002	1	25.0	25.0					
911109	1	100.0	100.0					
Upper river p=0.2968								
910913	4	351.7	196.4	181.2	125.0	888.9	133.9	569.4
910925	1	83.3	83.3	0.0	83.3	83.3	83.3	83.3
911002	2	8.8	8.8	6.8	2.0	15.6	2.0	15.6
911019	1	41.7	41.7	0.0	41.7	41.7	41.7	41.7
911027	5	70.4	62.5	16.1	31.3	125.0	50.0	83.3
911028	5	150.0	166.7	48.6	0.0	250.0	83.3	250.0
911120	3	81.0	62.5	22.1	55.6	125.0	55.6	125.0
All reaches and methods combined p=0.0602								
910913	6	265.0	133.9	127.0	83.3	888.9	100.0	250.0
910922	10	108.4	64.6	31.9	20.0	333.3	55.6	100.0
910925	8	72.7	67.0	15.1	31.3	166.7	41.7	83.3
911002	5	32.3	25.0	13.9	2.0	83.3	15.6	35.7
911005	1	62.5	62.5	0.0	62.5	62.5	62.5	62.5
911019	12	69.2	36.5	20.5	16.7	250.0	22.7	104.2
911027	5	70.4	62.5	16.1	31.3	125.0	50.0	83.3
911028	5	150.0	166.7	48.6	0.0	250.0	83.3	250.0
911109	4	175.0	175.0	43.3	100.0	250.0	100.0	250.0
911120	5	48.9	55.6	23.1	0.3	125.0	1.0	62.5

Table 14. Whitebaiters' expectations of (A) daily and (B) seasonal catches in Lake Onoke and the Ruamahanga River.

A. Expected daily catch

Reach	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
Excellent day means for three reaches p=0.4884								
Lake Onoke	46	3120	2000	473.0	500	16000	1000	4000
Lower river	6	4333	4000	802.8	2000	8000	4000	4000
Upper river	26	3769	4000	490.1	500	8000	1000	4000
All reaches	78	3429	4000	329.2	500	16000	1000	4000
Good day means for three reaches p=0.2769								
Lake Onoke	48	1008	1000	132.5	250	5000	500	1000
Lower river	6	1375	1000	539.1	250	4000	1000	1000
Upper river	28	1405	1000	241.8	250	4000	500	1000
All reaches	82	1171	1000	120.0	250	5000	500	1000
Average day means for three reaches p=0.9824								
Lake Onoke	47	497	500	101.6	125	5000	250	500
Lower river	6	521	500	113.7	125	1000	500	500
Upper river	28	521	500	55.0	125	1000	250	625
All reaches	81	507	500	62.1	125	5000	250	500
Poor day means for three reaches p=0.1242								
Lake Onoke	44	176	125	11.0	0	250	125	250
Lower river	4	219	250	31.3	125	250	188	250
Upper river	28	228	188	27.3	0	500	125	250
All reaches	76	197	125	12.2	0	500	125	250

B. Expected seasonal catch

Reach	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
Good season means for three reaches p=0.7936								
Lake Onoke	42	7857	4000	1447	500	45000	2000	8000
Lower river	6	6667	4000	1978	4000	16000	4000	8000
Upper river	29	9069	4000	1858	500	39000	1000	16000
All reaches	77	8221	4000	1059	500	45000	2000	8000
Average season means for three reaches p=0.7354								
Lake Onoke	45	3361	1000	706	250	27000	500	4000
Lower river	6	2750	1500	1167	500	8000	1000	4000
Upper river	29	4155	1000	1082	250	25000	500	4000
All reaches	80	3603	1000	561	250	27000	500	4000
Poor season means for three reaches p=0.9298								
Lake Onoke	36	1125	500	317	125	8000	250	1000
Lower river	6	1208	750	572	250	4000	500	1000
Upper river	28	982	500	294	125	8000	250	1000
All reaches	70	1075	500	204	125	8000	250	1000

Table 15. Time spent whitebaiting by interviewees in Lake Onoke and the Ruamahanga River in 1991.

A. Both methods combined for the three reaches

Date	Time spent fishing (h)							
	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
Lake Onoke p=0.1041								
910913	2	1.4	1.4	0.13	1.25	1.50	1.25	1.50
910922	9	4.1	4.0	0.64	1.25	7.50	3.00	5.00
910925	6	4.4	3.5	1.13	1.50	8.00	1.50	7.00
911002	2	2.5	2.5	1.00	1.50	3.50	1.50	3.50
911005	1	2.0	2.0	0.00	2.00	2.00	2.00	2.00
911019	11	5.4	5.5	0.67	0.50	8.00	4.00	7.00
911109	3	2.0	0.5	1.50	0.50	5.00	0.50	5.00
911120	2	1.5	1.5	0.50	1.00	2.00	1.00	2.00
Lower river can't test								
910922	1	6.3	6.3					
910925	1	3.0	3.0					
911002	1	5.0	5.0					
911109	1	5.0	5.0					
Upper river p=0.2662								
910913	4	4.4	4.3	1.03	2.0	7.0	3.0	5.8
910925	1	1.5	1.5	0.00	1.5	1.5	1.5	1.5
911002	2	4.8	4.8	3.25	1.5	8.0	1.5	8.0
911019	1	6.0	6.0	0.00	6.0	6.0	6.0	6.0
911027	5	2.5	2.5	0.50	1.0	4.0	2.0	3.0
911028	6	2.1	2.5	0.64	0.0	4.0	0.5	3.0
911120	3	3.5	4.0	0.76	2.0	4.5	2.0	4.5
All reaches combined p=0.0912								
910913	6	3.4	3.0	0.91	1.25	7.0	1.5	4.5
910922	10	4.4	4.3	0.61	1.25	7.5	3.0	6.0
910925	8	3.7	3.0	0.90	1.50	8.0	1.5	5.5
911002	5	3.9	3.5	1.22	1.50	8.0	1.5	5.0
911005	1	2.0	2.0	0.00	2.00	2.0	2.0	2.0
911019	12	5.3	5.8	0.62	0.50	8.0	4.5	6.8
911027	5	2.5	2.5	0.50	1.00	4.0	2.0	3.0
911028	6	2.1	2.5	0.64	0.00	4.0	0.5	3.0
911109	4	2.8	2.8	1.30	0.50	5.0	0.5	5.0
911120	5	2.7	2.0	0.66	1.00	4.5	2.0	4.0

B. Time spent fishing in Lake Onoke

Date	Time spent fishing (h)							
	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
All dates combined p=0.7228								
scoop net	14	3.7	3.5	0.69	0.50	8.0	1.5	6.0
set net	21	4.0	4.0	0.50	0.50	8.0	2.0	5.5
Scoop netting p=0.0007 911019 not equal to the rest								
910913	2	1.4	1.4	0.13	1.25	1.5	1.25	1.5
910922	3	4.0	4.0	0.58	3.00	5.0	3.00	5.0
910925	3	2.3	1.5	0.83	1.50	4.0	1.50	4.0
911002	1	1.5	1.5	0.00	1.50	1.5	1.50	1.5
911019	4	7.1	7.3	0.43	6.00	8.0	6.50	7.8
911109	1	0.5	0.5	0.00	0.50	0.5	0.50	0.5
Set netting p=0.4079								
910922	5	4.7	4.5	1.05	1.25	7.5	4.0	6.0
910925	3	6.0	7.0	1.53	3.00	8.0	3.0	8.0
911002	1	3.5	3.5	0.00	3.50	3.5	3.5	3.5
911005	1	2.0	2.0	0.00	2.00	2.0	2.0	2.0
911019	7	4.2	5.0	0.79	0.50	6.5	2.5	5.5
911109	2	2.8	2.8	2.25	0.50	5.0	0.5	5.0
911120	2	1.5	1.5	0.50	1.00	2.0	1.0	2.0
Set netting in all reaches on all dates								
	45	3.8	4.0	0.32	0.00	8.0	2.0	5.0

of small sample sizes and large standard errors, mean time spent fishing per day was not different among days (ANOVA, $p>0.091$). Whitebaiters spent the same mean time fishing regardless of whether they used scoop or set nets (ANOVA, $p=0.7228$, Table 15B). In Lake Onoke, mean time spent scoop netting varied more widely (0.5-7.1 h) than did mean time spent set netting (1.5-6.0 h). Total seasonal catch of whitebait, estimated from counts of whitebaiters and their catch, was about 1,700 kg (Table 16).

Whitebaiters were asked to comment on how whitebaiting had changed over recent years. Of 63 respondents who gave usable answers, 56% said there had been no change, 32% said there had been a decline, and 13% said there had been an improvement. Several of those who thought catches had improved remarked on extensive drain clearance 8-10 years ago that appeared to have reduced catches. Their interpretation was that the whitebait populations recovered as their habitat improved. Of the respondents who thought their catches had declined, two thought the increase in whitebaiters they had seen was responsible. One respondent blamed set nets left illegally unattended in fishing positions. Whitebaiters were also asked about their use of other recreational fisheries in the lower Wairarapa. Of the 91 respondents, 50 did not use other fisheries. Of the 41 who did use other fisheries, 78% fished for flounder, 27% for trout, 17% for perch, 7% for eels, and 5% for kahawai. Some respondents used more than one fishery (19 of the 41), so percentages sum to >100%.

3.3.2 Other recreational fisheries

A total of 60 telephone interviews were conducted between December 1991 and March 1992 (Appendix 8). In contrast to whitebaiters, the majority of users of other recreational fisheries were from the nearby towns of Carterton, Greytown, and Featherston (15-23%) rather than the Hutt Valley (5%, Table 17A). No usable response was given by 15% of the respondents. There were many more male respondents (51) than there were female (5). Mean age of respondents was 47 years (Table 17B), and was not different between men and women (ANOVA, $p=0.407$). Most respondents were in the 30-39 age class (Figure 9A). The average length of fishing experience of respondents was 16 years (Table 17B), and was related to age (regression analysis, $r^2=0.117$, $p=0.010$, $N=55$). The majority of respondents (58%), however, had relatively little fishing experience ($\leq$9 years, Figure 9D).

Half of the respondents fished with two companions, though one or three were also common (Figure 9C). On their fishing trips, 50% saw other fishers. Some respondents were not specific about the number they saw, but saw "a few" other fishers (18% of respondents). Of the respondents who were specific about the number of others they saw, the most common response was that they saw no others (Figure 9D). One person fishing at Lake Ferry on Lake Onoke who stated that he usually saw 32 others. The mean number of visits per year was 25 (Table 17B), but the distribution was skewed by a small number of users (16%) who made $\geq$50 visits per year (Figure 9E). Distribution of length of visits was bimodal, with peaks at 3 and 12 h. Visits lasting 12 h were common among people using set nets. These fishers usually set their nets in the afternoon or evening, and retrieved them the next morning, about 12 h later.

The species fished most commonly fished were brown trout, perch, and flounder, which were all fished for by >20% of the respondents (Table 18). The majority of respondents (37 out of 60) fished for more than one species. This was especially the case with people fishing for flounder, of which 21 out of 29 reported that they fished for several species at once.

Table 16. Calculated total seasonal catch by whitebaiters fishing Lake Onoke and the Ruamahanga River in the 1991 whitebait season.

Nets per day for each reach (Table 8)

	Mean	S.E.	N	Length of reach (km)	Total scoop nets	Total set nets
Lake Onoke	7.04	2.17	13	3	7.9	13.2
lower river	0.39	0.12	14	5	0.0	2.0
upper river	0.92	0.42	15	13	0.0	12.0

Fishing effort (season lasts for 120 days)

	Total scoop nets	Total set nets
Lake Onoke	945	1589
lower river	0	234
upper river	0	1435

Hours fished per day (Table 14)

		Scoop	Set
scoop	3.7 h/day	3498	6356
set	4.0 h/day	0	936
		0	5741

Total catch from catch rates (g/h) (Table 12)

	scoop	set	Catch (kg) scoop	Catch (kg) set
Lake Onoke	130.7	65.8	457	418
lower river		46.7	0	44
upper river		139.2	0	799
Total catch (kg/season)				1718

Number of whitebait, assuming 0.4 g each

	scoop	set
Lake Onoke	1142882	1045607
lower river	0	109278
upper river	0	1997798
Total catch (number/season)		4295565

Table 17. A) place of origin and B) demography of recreational fishers using Lakes Onoke and Wairarapa and their tributaries, and the lower Ruamahanga River, for fisheries other than whitebait in 1991 and 1992.

A) Place of origin

Home town	Number of respondents	Percentage of respondents
Carterton	14	23.3
Greytown	14	23.3
Featherston	9	15.0
Masterton	5	8.3
Martinborough	4	6.7
Hutt Valley	3	5.0
Johnsonville	1	1.7
Akatarawa	1	1.7
No response	9	15.0
Total	60	100

B) Demography of recreational fishers interviewed

	Sample size	Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
Age in years	59	47.3	46.0	2.39	11	75	33	63
Years' fishing	57	16.3	9.0	2.27	1	70	3	25
Number of companions	56	2.2	2.0	0.12	1	4	1	3
Number others seen	35	1.6	1.0	0.35	0	8	0	2.5
Frequency of visits	56	25.1	16.0	3.91	2	156	8	24
Length of visits (h)	56	7.8	9.5	0.59	1	12	3	12

Table 18. Number of respondents that fished for each of 12 fish species other than whitebait in Lakes Onoke and Wairarapa and their tributaries, and in the lower Ruamahanga River, in 1991 and 1992.

Fish species	Number of respondents	Percentage of respondents
Brown trout	36	28.1
Perch	30	23.4
Flounder	28	21.9
Kahahwai	12	9.4
Red Cod	6	4.7
Eels	5	3.9
Yelloweyed mullet	4	3.1
Hoki	3	2.3
Trevally	1	0.8
Gurnard	1	0.8
Quinnat salmon	1	0.8
Common smelt	1	0.8
	128	100.0

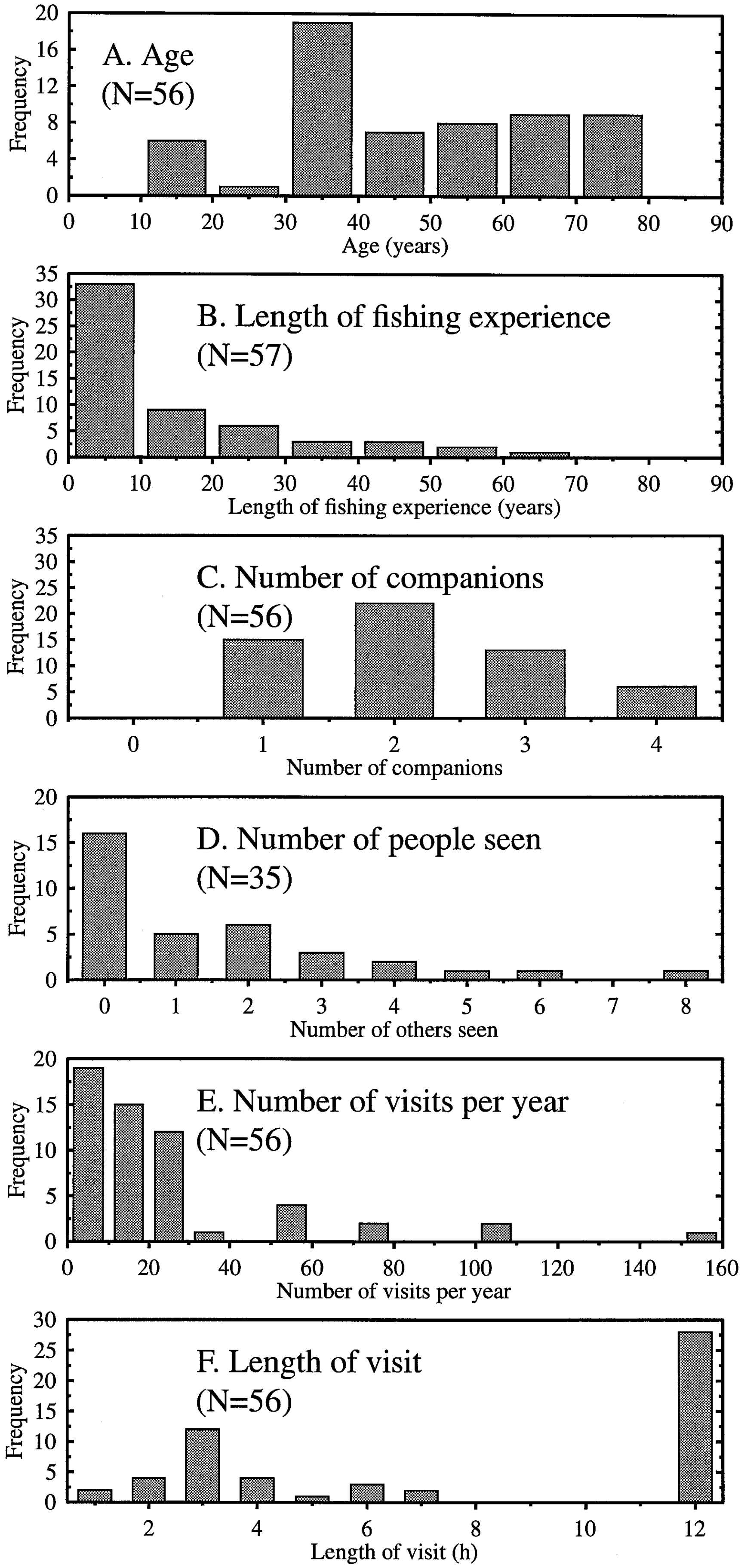


Figure 9. Frequency of A) ages, B) length of fishing experience, C) number of companions, D) number of other people seen, E) number of visits per year, and F) length of visits for recreational users of fisheries other than whitebait in the Lake Wairarapa wetlands, 1991-1992.

Table 19. A) Location of fishing activity used by recreational fishers and B) fishing effort in Lakes Onoke and Wairarapa and their tributaries, and the lower Ruamahanga River, for fisheries other than whitebait in 1991 and 1992.

A) Location of fishing activity

Location	Number of responses	Percentage of responses
Ruamahanga River		
Above deviation	25	32
Deviation	12	15
Below deviation	9	12
All of these areas	2	3
Total	43	55
Lake Onoke		
Lake Ferry	9	12
Western lake	4	5
Onoke Spit	1	1
All of these areas	7	9
Total	21	27
Lake Wairarapa		
Lake reserve	5	6
Tauherenikau mouth	4	5
Barrage gates	3	4
Abbots Creek	2	3
Yatch club	2	3
All of these areas	2	3
Total	14	18
Total all areas	78	100

B) Fishing effort

Location	Number of respondences	Mean number of hours per visit	Mean number of visits per year	Mean number of hours fishing per respondent per year	Total days fishing per year
Ruamahanga River	37	6.6	19.9	131.3	202
Lake Onoke	13	8.9	24.8	220.7	119
Lake Wairarapa	12	7.5	26.5	198.8	99

Fishing took place predominantly in the Ruamahanga River (55% of responses) and in Lake Onoke (27% of responses, Table 19A). Lake Wairarapa, with 14% of responses, appeared to be used less than the other locations. There were more responses in this analysis than the total number of respondents because many fishers (20 out of the 60 interviewed) fished at more than one location. Mean fishing effort per day was greatest in Lake Onoke, probably as a result of set netting in which nets were left in place overnight (Table 19B). Lake Wairarapa received the greatest mean number of visits per year, though because of the longer fishing days in Lake Onoke, the mean number of hours fishing per respondent was highest in Lake Onoke (Table 19B). The greatest mean number of fishing days per year, however, were spent in the Ruamahanga River, which received about twice the number of total fishing days of Lakes Onoke and Wairarapa.

Gill netting and spinning were the most popular fishing methods used (Table 20). Fly fishing and bait fishing were next most popular methods. For trout, spinning was the most popular method, with fly fishing second. Trout were also caught by gill net, an illegal method, presumably as a by-catch of set netting for flounder. Spinning was also the most common method of catching perch, though 18% of responses also mentioned catching perch in gill nets, presumably as a by-catch. Trolling was used for both trout and perch. Flounder were caught exclusively by gill netting. Kahawai were primarily caught in gill nets (Table 20), generally by the same respondents who fished for flounder.

Kahawai and flounder were the species most commonly caught in nets set overnight, at a mean catch rate of 6-7 per net for each species (Table 21A). Though most respondents reported catching 4-6 flounder per net per night, a few caught many more (14-18 per net per night, Figure 10A). Most common stretched mesh sizes for gill and set nets were 135-140 mm, and 95-100 mm (Figure 10B).

After selecting responses that gave single species at single locations, the location of species capture was analysed. Trout and perch were caught predominantly in the Ruamahanga River (Table 21B). Flounder and kahawai were caught principally in Lake Onoke, but flounder were also caught in the Ruamahanga River. Species generally thought of as marine (red cod, hoki, trevally, and gurnard) were caught only in Lake Onoke. Yelloweyed mullet were reported to be caught in Lake Onoke and the Ruamahanga River, but were not caught in Lake Wairarapa. Only one respondent caught flounder in Lake Wairarapa (Table 21B). From estimates of numbers caught per visit by each fisher, and total number of visits per year, crude estimates of total annual catch by respondents can be made (Table 21C). From these estimates it appears that at least 13 tonnes of flounder, 1.9 tonnes of kahawai, 1.3 tonnes of trout, 0.8 tonnes of yelloweyed mullet, 0.8 tonnes of perch are caught in Lakes Wairarapa and Onoke and the lower Ruamahanga River each year. These estimates are conservative because not all fishers in the area were surveyed.

3.3.2.1 Changes in the fisheries. Comments were solicited about the state of the fisheries in the last five years, specifically about any changes that had taken place. Of the 60 respondents, 63% of those who gave usable answers believed that fisheries had declined, compared to 6% who thought fisheries had improved, and 31% who thought there had been no change (Table 22). The majority (63%) of fishers for flounder, who generally caught other species as well, presumably as a by catch, believed there had been a decline in the catches over the last five years. Additional comments were made by 9 respondents that catches of flounder had fallen, e.g., from 40-60 to fish per night to the present mean of 6 (Table 22A).

Table 20. Methods used by recreational fishers of Lakes Onoke and Wairarapa and their tributaries, and the lower Ruamahanga River, for fisheries other than whitebait in 1991 and 1992.

Method	All species		Trout		Perch		Kahawai	
	Number of responses	Percentage of responses	Number of responses	Percentage of responses	Number of responses	Percentage of responses	Number of responses	Percentage of responses
Gill net	33	33.7	5	11	6	18	7	64
Spinning	31	31.6	19	40	19	56	1	9
Fly fishing	13	13.3	13	28	0	0	0	0
Bait	10	10.2	6	13	5	14	2	18
Trolling	5	5.1	4	8	4	12	0	0
Surf casting	2	2.0	0	0	0	0	1	9
Spear fishing	2	2.0	0	0	0	0	0	0
Whitebait net	1	1.0	0	0	0	0	0	0
Fyke net	1	1.0	0	0	0	0	0	0
Total	98	100	47	100	34	100	11	100

Table 21. Fish species caught in Lakes Onoke and Wairarapa and their tributaries, and the lower Ruamahanga River, by recreational fishers other than whitebaiters in 1991 and 1992. A) number per set net per night, B) number of fish of each species by location, and C) annual catch of fish by species.

A. Number of fish per set net per night (eels caught by fyke netting)

Species	Sample size	Number of fish caught per respondent per net per night						
		Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
Flounder	23	6.2	6.0	0.89	1.5	17.5	3.0	8.0
Kahawai	2	6.8	6.8	3.25	3.5	10.0	3.5	10.0
Perch	3	3.5	3.5	0.87	2.0	5.0	2.0	5.0
Trout	3	3.2	1.0	2.42	0.5	8.0	0.5	8.0
Yelloweyed mullet	2	2.5	2.5	1.00	1.5	3.5	1.5	3.5
Eels	1	33.0	33.0	0.00	33.0	33.0	33.0	33.0

B. Number of fish of each species by location

Species	Number of fish for all respondents			
	Lake Onoke	Ruamahanga River	Lake Wairarapa	All locations combined
Trout	0	22	1	23
Flounder	12	9	1	22
Perch	1	14	2	17
Kahawai	10	1	0	11
Red Cod	6	0	0	6
Eels	0	3	1	4
Hoki	3	0	0	3
Yelloweyed mullet	2	1	0	3
Trevally	1	0	0	1
Gurnard	1	0	0	1
Salmon	1	0	0	1
Common smelt	0	1	0	1
	37	51	5	95

C. Annual catch of fish by species

Species	Sample size	Total catch (kg)	Annual catch per respondent (kg)						
			Average	Median	Standard error	Minimum	Maximum	Lower quartile	Upper quartile
Flounder	18	13410	745	216	262	11	4056	85	703
Kahawai	4	1904	476	219	326	27	1440	87	865
Trout	18	1281	71	31	19	5	244	20	123
Yelloweyed mullet	1	788	788	788	0	788	788	788	788
Perch	9	781	87	41	56	1	532	11	59
Eels	1	24	24	24	0	24	24	24	24

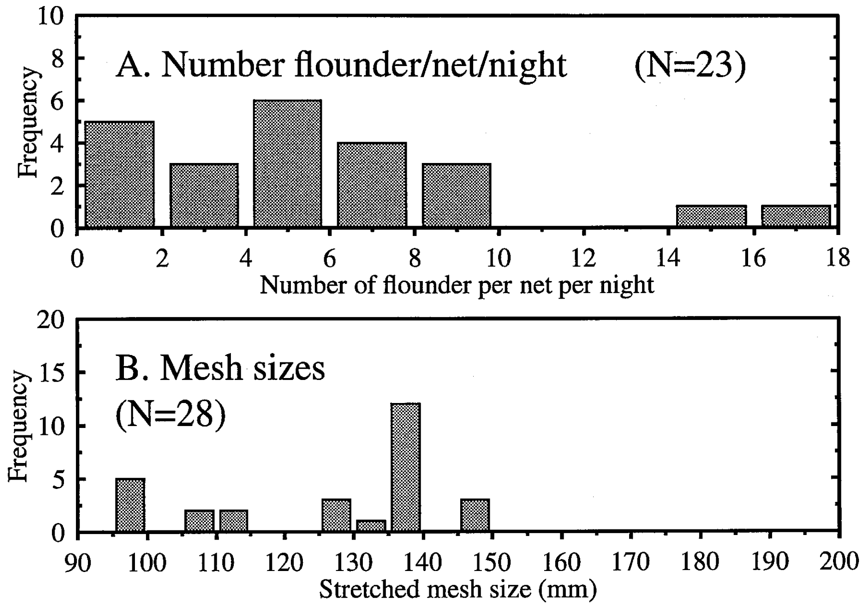


Figure 10. Frequencies of A) number of flounder caught per net per night, and B) stretched mesh sizes of set nets used by recreational fishers in the Lake Wairarapa wetlands, 1991-1992.

Table 22. Comments by users of recreational fisheries other than whitebait in the lower Ruamahanga and Lakes Wairarapa and Onoke about the state of the fisheries in the last 5 years.

Fishery type	Fishery in the last 5 years			No response	Total
	Declined	Improved	No change		
Number of respondents					
All fisheries	30	3	15	12	60
Flounder and others	10	2	4	3	19
Trout alone	11	1	4	5	21
Trout and others	18	1	5	7	31
Perch alone	0	0	4	0	4
Percentage of respondents					
All fisheries	62.5	6.3	31.3		
Flounder and others	62.5	12.5	25.0		
Trout alone	68.8	6.3	25.0		
Trout and others	75.0	4.2	20.8		
Perch alone	0.0	0.0	100.0		

The one respondent who fished for flounder in Lake Wairarapa fished at the northern end near the mouth of the Tauherenikau River believed the catch had declined dramatically. He had fished for 17 years (beginning in 1974), and before 1988 used to catch 24-36 flounder in 6 drags of a gill net (4-6 fish per drag). Of this catch, an average of two fish (6-8%) were yellowbelly flounders, and the rest were black flounders. The same fisher also used to set gill nets overnight, catching 30-50 flounder (15-25 per net per night). His best catches were between March and May. The catch declined very rapidly after 1988, and is now about 2-3 flounder per net in gill nets set overnight. Size of flounder has also diminished.

A respondent who fished at the north end of Lake Wairarapa recalled catching up to (though not consistently) 40-50 flounder per drag seining with a gill net. Catches declined after the Ruamahanga River was diverted past the lake, and netting now catches no flounder, or occasionally one or two per drag.

Another respondent had fished the eastern shore of Lake Wairarapa just north of Allsops Bay near the island at the mouth of the old inlet of the Ruamahanga River since about 1965. His recollected that catch rates from that period were about 60 black flounder per net per night. Catches declined rapidly after the diversion of the Ruamahanga River, but been stable in the last 10 years at about 4-5 fish per net per night.

Lake Wairarapa was once fished commercially for flounder by several fishers. Murray Nix fished at the island site from about 1964. He consistently caught 300 flounder per night using 6 set nets (a catch rate of 50 fish per net per night) before the diversion of the Ruamahanga River. Immediately after diversion, his catches dropped, and to catch 300 flounder, he had to use 25 nets (12 fish per net per night). A year after diversion he stopped commercially fishing for flounder in Lake Wairarapa.

Respondents who fished for flounder believed there was a need to decrease to allowable daily catch from 30 to 10 per person per day, and that there should be more information to fishers, e.g., notices stating mesh permitted catch and mesh sizes. Most also believed the Ranger at Lake Onoke did his job well.

Trout fishers also believed the fishery had declined in the last five years. Of those fishing for trout alone, or trout and other species (generally perch), who gave usable responses, 69-75% thought the fishery had declined, compared to 21-25% who thought there had been no change (Table 22A). The four people who fished for perch alone were unanimous in there perception that there had been no change in the fishery. Perch appear to be small in the Wairarapa; one respondent said the average size of fish was 250-270 mm FL.

3.3.3 Eel fishery

Eels fishers questioned as part of the survey of recreational fisheries commented on decline in the fishery. Three of the five eel fishers made comments, and all believed there had been a reduction in the number of eels.

3.4 DISCUSSION

3.4.1 Whitebait fishery

3.4.1.1 Catch composition. In common with many other New Zealand rivers (e.g., McDowall and Eldon 1980, Stancliff et al. 1988a, Rowe et al. 1992), inanga (*Galaxias maculatus*) juveniles dominated the whitebait catch in Lake Onoke and the Ruamahanga River (Table 7). This result should be interpreted with caution, however, because of the small sample size(N=8). The Motu River in the Bay of Plenty, North Island, is somewhat unusual in having a catch dominated by koaro (Rowe et al. 1992). Data collected in this study is insufficient to determine whether catch composition varies with time of the season (e.g., McDowall and Eldon 1980), or with distance upstream.

Catch composition usually varies with season. Inanga dominated the early run in the West Coast of the South Island, whereas banded kokopu increased in proportion in November (McDowall and Eldon 1980). In the Waikato River, inanga also dominated the early part of the season, but an increase in proportion of banded kokopu occurred September, when they reached 14-23% of the total catch (Stancliff et al. 1988a). September was also the time of greatest abundance of banded kokopu in Bay of Plenty rivers (Rowe et al. 1992). Koaro were most abundant in September and October in the Waikato River, but never comprised >0.2% of the total catch. In the Bay of Plenty, koaro peaked in abundance in mid-September and again in mid-October. Giant kokopu were rarely present in the Waikato River, and made up only 0.04% of the catch in October, the only time in 2 seasons that they were found. In the Bay of Plenty, giant kokopu were not found.

In the Wairarapa, in contrast, koaro and giant kokopu comprised much more of the samples (6.4% and 3.6% respectively, Table 7) than in the Waikato River. The predominance of set netting over scoop netting in the upper and lower Ruamahanga River (Table 8) may result in overestimation of the proportion of inanga compared koaro (D.K. Rowe, pers. comm.). Banded kokopu were relatively unimportant in the Wairarapa (0.5% of the catch), but this may be a function of the time of sample collection and small number of samples taken. If the number of returning whitebait reflect the amount of adult habitat, as Rowe et al. (1992) have speculated, the Ruamahanga River system appears to provide habitat for koaro and giant kokopu.

3.4.1.2 Number of whitebaiters. Whitebaiters fished from the mouth of Lake Onoke to at least 21 km upstream in the Ruamahanga River. Lake Onoke had more whitebaiters than any other reach (up to 22 whitebaiters per kilometre). Heavy use was not confined to weekends, and up to 183 whitebaiters were in the lower 21 km of the river and Lake Onoke at any one time, with 91% of these actually fishing (Table 8). If this is considered peak use, then the number of whitebaiters on the Ruamahanga River system was greater than the Waitaki River, east coast South Island (peak count 39, Pierce 1987), and similar to the popular whitebait rivers such as the Mokau and Waitara in north Taranaki (Taranaki Catchment Commission 1981), the Rangitikei River on the west coast of the North Island (Hicks and Watson 1985), and the Rakaia River on the east coast of the South Island (Unwin and Davis 1983). For all reaches of the Ruamahanga combined, the mean count ($\pm$95% confidence intervals) is 35.4$\pm$27.2 (Table 9). This is similar to the mean number of whitebaiters in the Rangitaiki, the most popular whitebaiting river in the Bay of Plenty (Saxton et al. 1987). The most popular river in the North Island is the Waikato River, where it is estimated up to 1000 whitebaiters may be present on peak days (Stancliff et al. 1988a).

3.4.1.3 Methods. Methods used in whitebaiting (set nets and scoop nets) have been well described (McDowall 1984, Hardy 1986). In the Waimakariri, a South Island east coast river with much heavier use (mean number of whitebaiters 156 per day) than the Ruamahanga River, set nets were used by 71.5% of whitebaiters, and scoop nets by 28.5%. These proportions are similar to the proportions of whitebaiters with each net type in Lake Onoke (80% and 20% respectively). When nets actually in the water were considered, however, not all scoop netters were active at any one time. The number of set nets in the water was, however, higher than the number of whitebaiters with that net type. This paradox arose through illegal fishing activity, with a small proportion of unattended set nets, or whitebaiters with more than one set net each. Both are illegal. Scoop nets were used in Lake Onoke, particularly near the mouth, presumably because they produced a higher catch rate than set nets (Table 13A).

3.4.1.4 The whitebait catch. Tide river, weather, and wind conditions influenced the number of people counted in the three sections. Bad weather was avoided, and in fresh winds whitebaiters used scoop nets more than set nets. The time when set nets were most heavily used was an incoming tide on a fine, calm day, with low flow conditions in the river. Whitebaiters used scoop nets on an incoming tide, in fresh winds or calm, on a falling flood in the river (Table 7B).

Total catch estimates in this survey, though rather crude, are similar to catches in the Rakaia River in 1979 and 1980 estimated from whitebaiters' diaries (1,350 kg and 1,724 kg respectively, Unwin and Davis 1983). Catch rates per whitebaiter in this study (mean 47-139 g/h, Table 13A) were similar to those of diarists fishing the lower Waitaki (7-229 g/h, mean 100 g/h, Pierce 1987), but lower than for diarists fishing Rakaia (mean 286-667 g/h, Unwin and Davis 1983). Diarists, however, are often more skilled than the majority of fishers, so can bias results towards high catch rates. Creel surveys, as used in this study, are generally more reliable.

The majority of whitebaiters (56%) felt there had been no change in their catches in recent years, though a substantial proportion (32%) thought catches had declined, blaming increased fishing effort and permanently set nets. The effect of the harvest of whitebait on adult populations is not well known, but the most thorough study of catches of whitebait on consecutive years (West Coast of the South Island), and of formerly unexploited populations (the Cascade River, West Coast South Island, 1959-1967) suggest that fishing has not affected future catches (McDowall and Eldon 1980). Stancliff et al. (1988a) allude to habitat modification as a cause of the decline in whitebait catches rather than fishing pressure. Eighty-three percent of the wetlands of the Waikato catchment disappeared between 1860 and 1976. However, in certain circumstances, a large proportion of the whitebait run can be caught by whitebaiters. In Awakino River, northern Taranaki, 1-45% (mean 19%) of marked whitebait were caught by whitebaiters on 1-3 successive days (Boubée et al. 1992). Because whitebait are small and therefore relatively weak swimmers, incoming and outgoing tides sweep fish upstream and downstream. This appears to increase the vulnerability of a run to capture. On one occasion, more marked whitebait were caught the second day after marking than on the first. Run size determined by recapture of marked fish was 140,000 to 3,400,000 whitebait (56-1,370 kg) per day (mean 1,097,120 or 438.8 kg). Catches in the Awakino River showed peaks coinciding with full moon and new moon.

Total catch for the 1991 season by whitebaiters in Lake Onoke and the Ruamahanga River was estimated to be about 4.3 million whitebait (Table 16). If 19% of the whitebait entering the Ruamahanga River system were captured, this estimate would indicate a total run size of about 22.6 million whitebait.

3.4.2 Other recreational fisheries

There is a widespread perception among users of recreational fisheries that catches have declined. This applies to both flounder and trout fisheries. Catches of black flounder in Lake Wairarapa appear to have declined from 40-60 per net per night to a maximum of 4-5 per net per night. The time of the initial decline appears to be about 1974, when the Ruamahanga River was diverted past Lake Wairarapa. Within the last three years, flounder catches in Lake Onoke and the Ruamahanga River, where the majority of fishing now takes place, have also declined.

Peak use in flounder fisheries generally occurs in spring and summer in the lower Waitaki, and is likely to be similar in the Lake Wairarapa wetlands. Many fishers seem the do most of their fishing during summer holidays in the area. Catches of flounder in Lake Wairarapa were certainly high before 1974 (40-60 per net), but catches throughout the lakes and Ruamahanga have since declined to about 6 fish per net similar to estimates for the lower Waitaki (Pierce 1987).

Kahawai are caught in Lake Onoke, probably largely as a by catch of flounder fishing. Thus most kahawai in Lake Onoke were caught by netting, in contrast to the lower Waitaki (Pierce 1987), the Rangitikei River (Hicks and Watson 1985), and the Motu River (Rowe 1983) where most were caught by spinning. Unlike the fishery at the mouth of the Motu River, which is focused on kahawai (Ritchie et al. 1982), the kahawai caught in Lake Onoke appear to be largely a by-catch of the flounder fishery. Red cod were also caught in nets, though in the Waitaki they caught with baited hooks by rod fishers.

3.4.3 Eel fishery. Fishers comments about a reduction in the number of eels, combined with the evidence for a decline in the size of eels (Chapter 2) seem to point to a fishery in crisis. The cause of the decline in the eel fishery is not known, but is likely to be overfishing.

CHAPTER 4. RECOMMENDATIONS FOR FISH PASSAGE

4.1 BARRAGE OPERATION

The barrage gates themselves are in the closed position for most of the time to maintain water levels in Lake Wairarapa (Lake Wairarapa Co-ordinating Committee 1991). In 1986, periods of inflow to the lake occurred for <10% of the time for any month from November to April. For May to October, inflows were predicted to occur 10-23% of the time in any one month. The period of maximum inflow coincides with spring upstream migration of juveniles, but inflows occur for only limited periods during summer and autumn, when black flounder, grey and yelloweyed mullet, and kahawai migrate upstream.

A dramatic decline in the flounder catch in Lake Wairarapa appears to have occurred, and the largest and most sudden drop happened at the completion of the diversion scheme. At this time (1974) the Ruamahanga River was diverted past Lake Wairarapa and barrage gates on the lake outlet came into operation. Catch rates appear to have fallen from a lake-wide value of 40-60 flounder per net per night to a maximum of 15-25 flounder per net per night at the north end of Lake Wairarapa, and 4-5 flounder per net per night elsewhere in the lake. The best catches appear to have been associated with freshwater inflows to the lake. Though the species were not recorded, flounder in Lake Wairarapa are mostly, if not exclusively, black flounder; yellowbelly flounder are rarely caught there (Stevens pers. comm.). Abundance of black flounder in Lake Onoke and the lower Ruamahanga River is also likely to have declined as a result of the river diversion and barrage gates installation. Yellowbelly flounder have probably not been significantly affected by the diversion as they are a more coastal and estuarine species than the black flounder.

The closure of the barrage gates, and indeed the diversion of the Ruamahanga River past Lake Wairarapa, has dramatically reduced the amount of water coming from the lake outlet in to the Ruamahanga River. Migratory fish have a powerful sense of smell (chemosense), and some species are hypothesised to follow the scent of their species to suitable habitat (Nordeng 1977). Migratory fish swimming upstream also use the physical downstream flow of water to orient themselves (rheotaxis). For both its chemosensory and rheotactic role, flowing water is essential to provide cues for fish migrating upstream to follow. In this sense, water flowing out of lake Wairarapa is "attraction water". The effect of the diversion of the Ruamahanga River past Lake Wairarapa, and the prolonged closure of the barrage gates in summer, can be expected to reduce the number of fish entering Lake Wairarapa even if the fish pass were capable of passing as many fish as the original river channel, which is very likely not the case.

Catch rates of flounder seem to have been stable following the diversion of the Ruamahanga River in 1974 until about 1988. After 1988, catches in northern Lake Wairarapa catch rate again fell to their present level of about 2-3 flounder per net per night. This second fall in catch rates appears from fishers comments to have occurred in Lakes Onoke and Wairarapa and the Ruamahanga River simultaneously. A majority of fishers using all locations have reported a decline in catches in the five years preceding the summer of 1991/1992.

Opening the barrage gates in spring when juvenile eels and galaxiids migrate upstream, and in summer, the main time of migration of fish such as black flounder, mullet, and kahawai in to freshwater, would allow more fish into Lake Wairarapa. Restoration to prediversion fish populations is unlikely because the flow of the Ruamahanga River now no longer comes out of Lake Wairarapa. However, opening the barrage gates for as long as possible in September and October, and from January to April, would allow the maximum number of eels, galaxiids, mullet, flounder, and torrentfish access to Lake Wairarapa.

Automation of the 4 unautomated barrage gates would be a valuable change to operation of the barrage gates. All six gates could then be opened remotely. Juvenile whitebait generally migrate at the surface and at the shallow margins (Stancliff et al. 1988b), and the opening of only the two automated central gates forces fish away from the banks into deep water where they are vulnerable to predation. If only two more of the six gates were to be automated, then the two gates nearest each bank should be modified.

4.2 LAKE ONOKE BAR OPENING

During this investigation the bar at the entrance to Lake Onoke was never closed. From the responses of recreational fishers, and the catches of diadromous fish in this survey, there appears to be no significant barrier to the entry of fish to the Ruamahanga River system and its lakes attributable to the Lake Onoke bar. The present regime of mechanical bar opening does not seem to affect the existing fisheries values of the Lake Wairarapa wetlands. However, local Maori, whose main affiliation is with the Ngati Kahungunu, once made use of times of bar closure that coincided with the downstream migration of adult eels. In late summer, autumn, and early winter, eels migrate down to the sea to breed. The species and sexes arrive in sequence; male shortfinned eels arrive first in Lake Ellesmere, in February and March, followed shortly afterwards by the females. Male longfinned eels arrive in April, and females may arrive as late as May or June (Jellyman and Todd 1982). When the migrating eels were trapped by a closed bar, they could be caught easily in substantial numbers. Migrant eels trapped by the Lake Onoke bar were an important source of food for local Maori (McIlraith 1957). Similar fisheries existed at Lake Ellesmere in the South Island (McDowall 1990). The beginning of the regime of regular bar opening by mechanical means was greeted by considerable hostility, as an excerpt from McIlraith clearly illustrates:

> "On one occasion, a day was arranged for cutting an opening. Many people including police representatives, lawyers, and members of the Featherston River Board and large numbers of Maoris gathered at the edge of the lake. The Maoris had erected a wire fence to prove their rights to the spit.
>
> The pakeha men were directed to start opening the lake and almost immediately Maoris (obviously well coached by their lawyers) walked up to each shoveller and caught hold of the handle. Trying to prevent the Maoris from obstructing the workers, the pakehas joined hands in a circle around the men in the trench. Immediately a number of Maori women dived under the men's hands and plunged into the drain, kicking and scratching furiously, and bring down large quantities of sand. The project was abandoned."

The bar is now breached by bulldozer if the outlet of Lake Onoke is blocked for more than a few days at a time. This change from the natural condition has eliminated the traditional Maori fishery. However, mechanical opening probably also allows more diadromous fish to migrate in and out of Lake Onoke. This is a direct trade-off with the values of the historic Maori eels fishery.

4.3 FLAPGATE ON POUNUI LAGOON

Sampling upstream and downstream of the Pounui Lagoon flapgates gave a more reliable estimate of the upstream migration problem faced by fish in Lake Onoke than does sampling upstream and downstream of the barrage gates. Because Pounui Lagoon is so much smaller than Lake Wairarapa sampling was more representative of the fish present. The flapgates at Pounui Lagoon drastically change fish abundance in Pounui Lagoon compared to Lake Onoke. The cause is probably in part the physical barrier of the flapgates and the high water velocities when the gates are open, and in part low salinities in Pounui Lagoon unfavourable to some species. The flapgates restrict the entry of saline water as well as fish. Eels, galaxiids, and common smelt are well able to withstand low salinities, so there reduced numbers in the lagoon are probably due to the physical barrier. Triplefins, stargazers, mudflat crabs, *Palaemon* shrimps, and yelloweyed mullets are generally not found far from estuaries, and thus for these species absence from Pounui Lagoon may be caused by a combination of the physical barrier and low salinities.

Apart from automating their action, removal of the flapgates entirely is the only obvious solution to the barrier they present to upstream fish migration. The flapgates were originally installed to prevent flooding of the land behind the stopbank. As the land around Pounui Lagoon is now owned by the Department of Conservation, there should be no serious detriment in removal of the flapgates. The result will be improved access for eels and giant kokopu whitebait to Lake Pounui, a habitat of known value for both species (Jellyman 1979b, Jellyman 1989, Jellyman and Ryan 1983), access for inanga whitebait to valuable habitat for them, improved access for redfinned bullies and *Paratya* shrimps to Pounui Stream, and reintroduction of estuarine species to the lagoon.

4.4 MANAGEMENT OF WATER LEVEL IN LAKE WAIRARAPA

Brown mudfish occupy wetlands at lake margins, e.g., Donalds Block (Site 20, Figure 1), and their habitat has been severely reduced in the lower Wairarapa. Therefore maintenance of their remaining habitat is imperative. The fish need water in autumn and winter for breeding and survival, but tolerate, and are likely to need, dry conditions in summer (Barrier 1993). They withstand periods without water by aestivating in a damp burrow and breathing air. Black mudfish, a closely related species that also aestivates, appears to require low water level in summer. Dry summer conditions have been speculated to reduce the competition from fish such as eels and mosquitofish that cannot aestivate. The seasonal water levels required by brown mudfish are almost the exact opposite of the current operating regime, in which lake levels are maintained artificially high in summer, and lowered in winter for flood protection.

An assumption implicit in inferences of migration drawn from comparisons of catches upstream and downstream of a barrier is that fish and shrimps would be equally likely to be in both areas in the absence of the barrier. There are two obvious flaws in this assumption. Firstly, the habitats may not be the same even without the barrier. Higher densities of shortfinned eels, common bullies, mysid shrimps, and possibly common smelt, on the upstream side of the Lake Wairarapa barrage gates than on the downstream side probably reflect more favourable habitat on the upstream side (Table 4A). Secondly, the barrier itself may create differences in habitat upstream and downstream. However, within the limits of the methods used, there is strong evidence that both the barrage gates on the Lake Wairarapa outlet and the flapgates at the entrance to Pounui Lagoon restrict upstream fish migrations.

4.5 RECOMMENDATIONS

1) To protect and enhance the present fishery values of Lake Wairarapa:

A) Keep the barrage gates open as often and long as possible between August and April to maximise the number of migratory fish entering and leaving Lake Wairarapa.

Comment:
Juvenile galaxiids and eels migrate into freshwater in spring, and adult black flounder migrate upstream from mid-summer to autumn. Torrentfish migrate into freshwater in spring and autumn, and bullies migrate in late spring and in summer. Adult eels migrate downstream to the sea to spawn from February to June. Upstream migration of juveniles of redfinned bullies, torrentfish, koaro, and banded kokopu may be impeded by the barrage gates. Black flounder abundance in Lake Wairarapa has also been reduced by the barrage and diversion. The barrage gates should be open for the maximum time possible between August and April.

B) Automate, at a minimum, two additional barrage gates (those closest to the banks of the outlet channel), and preferably all four gates that cannot now be operated remotely. Open all gates simultaneously.

Comment:
The two gates that are automated at present are in the centre of the barrage. Migrant juveniles generally follow shallow margins, and thus are at present forced into deep water to find the open gates, where they are vulnerable to predation. Opening the two outside gates would allow migrant juveniles to travel the shortest distance necessary through deep water. In addition, water velocities will be lower if all six gates are raised simultaneously than if only two are raised at once. Automating all the gates would allow this, resulting in the lowest possible velocities, and thus facilitate upstream migration of juveniles.

C) At times when gates are open, ensure they are open to the surface or above to allow the passage of surface-swimming juveniles with the least disturbance.

Comment:
This will facilitate upstream migration of juveniles galaxiids and eels, which swim at the surface at the peak of their migration when close to the sea.

D) Restore some flow to Lake Wairarapa via the Ruamahanga Cutoff.

Comment:
The Ruamahanga Cutoff, through which the Ruamahanga River once flowed into Lake Wairarapa, is now a remnant channel of still water. Restoring flow to Lake Wairarapa through the Ruamahanga Cutoff would improve value of the channel as fish habitat, and would add to the attraction water flowing out of Lake Wairarapa through the barrage gates. This attraction water is necessary to maximise fish migrations into Lake Wairarapa. Provided some gated structure that could be opened during low flow was installed at the Ruamahanga River end of the Cutoff, it could be closed to prevent flooding at high flow.

2) To protect and restore the present fishery values of Pounui Lagoon and Lake Pounui, remove the flapgates completely from the culverts that drain Pounui Lagoon, allowing access of fish whose migrations from Lake Onoke are now prevented or restricted.

Comment:
Fish such as yelloweyed mullet and flounder are denied access to potentially valuable habitat by flapgates that now control flow into Pounui Lagoon. Upstream migrations of juvenile eels and giant kokopu into Lake Pounui may also be affected. Removal of the flapgates would recreate the original intertidal wetland, and would greatly improve fish access.

3) To protect the present fishery values of Lake Onoke, maintain the present bar opening regime, recognising that while it maintains the present-day fisheries for flounder, kahawai, red cod, mullet, and hoki, it has also eliminated the historic Maori eel fishery.

Comment:
A traditional fishery for adult eels migrating downstream to the sea spawn between February and June was once used by the local Maori, and was an important food source. Closure of the bar by storms prevented the migration of eels, making their capture simple; the historic fishery is not possible while the bar is open.

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Appendix 1. Species recorded in the Lake Wairarapa wetland between May 1922 and March 1985 by the Freshwater Fish Database (FFD). Date format YYMMDD, where Y=year, M=month, and D=day. -, not recorded. Barrier status: 1, downstream of Pounui Lagoon flapgate; 2, upstream of Pounui Lagoon flapgate; 3, downstream of Lake Wairarapa barrage gates; 4, upstream of Lake Wairarapa barrage gates. Species as Table 1. Sites as Figure 1. es; electroshocking.

Site number	Site name	Date	FFD number	Capture method	Barrier status	Species	Number
5	Pounui Stream	820000	4632	net	2	galmac	-
5	Pounui Stream	820000	4632	net	2	retret	-
5	Pounui Stream	850300	7401	net	2	galmac	11
5	Pounui Stream	850300	7401	net	2	gobcot	1385
12	Burlings Stream	610802	1079	es	4	angaus	-
12	Burlings Stream	610802	1079	es	4	angdie	-
12	Burlings Stream	610802	1079	es	4	chefos	-
12	Burlings Stream	610802	1079	es	4	geoaus	1
12	Burlings Stream	610802	1079	es	4	gobsp	-
12	Burlings Stream	790710	2807	es	4	angaus	-
12	Burlings Stream	790710	2807	es	4	angdie	-
12	Burlings Stream	790710	2807	es	4	chefos	-
12	Burlings Stream	790710	2807	es	4	galbre	-
12	Burlings Stream	790710	2807	es	4	gobhut	-
12	Burlings Stream	790710	2807	es	4	parnep	-
12	Burlings Stream	790710	2807	es	4	saltru	-
12	Burlings Stream	720815	55588	es	4	galbre	5
12	Burlings Stream	730927	55589	es	4	gobcot	-
13	Brocketts Stream	790710	2808	es	4	angaus	-
13	Brocketts Stream	790710	2808	es	4	angdie	-
13	Brocketts Stream	790710	2808	es	4	chefos	-
13	Brocketts Stream	790710	2808	es	4	gobhut	-
13	Brocketts Stream	790710	2808	es	4	saltru	-
16	Otauira Stream	720200	55521	-	4	perflu	7
16	Otauira Stream	400826	55524	-	4	geoaus	1
18	Tauherenikau River	220524	55522	-	4	prooxy	2
24	Tauanui River	650226	424	-	3	chefos	-
24	Tauanui River	650226	424	-	3	galmac	-
24	Tauanui River	650226	424	-	3	gobbre	-
24	Tauanui River	650226	424	-	3	gobhut	-
24	Tauanui River	650226	424	-	3	parnep	-
24	Tauanui River	650226	555649	-	3	gobhut	-
25	Turanganui River	480327	555652	-	3	chefos	2
25	Turanganui River	480327	555652	-	3	gobcot	3
25	Turanganui River	480327	555652	-	3	gobhut	3

Appendix 2. Fish and invertebrate species found by electroshocking in tributaries upstream of the Lake Wairarapa barrage gates and in tributaries that could not have been affected by the gates, and in upstream of the Pounui Lagoon flapgates (species codes as in Table 1).

Site number	Species code	Number	Length fished (m)	Width fished (m)	Area fished (m^2)	Fish density (no./100 m^2)
Not affected by barrage gates						
24	angaus	1	40	5.0	200	0.50
22	angaus	7	40	1.5	60	11.67
21	angaus	38	70	3.0	210	18.10
25	angdie	3	50	9.0	450	0.67
21	angdie	8	70	3.0	210	3.81
22	angdie	7	40	1.5	60	11.67
24	angdie	29	40	5.0	200	14.50
25	anggla	1	50	9.0	450	0.22
21	chefos	5	70	3.0	210	2.38
22	galbre	1	40	1.5	60	1.67
25	galfas	1	50	9.0	450	0.22
25	galmac	1	50	9.0	450	0.22
24	galmac	1	40	5.0	200	0.50
25	gobbre	1	50	9.0	450	0.22
21	gobbre	1	70	3.0	210	0.48
25	gobcot	9	50	9.0	450	2.00
21	gobcot	10	70	3.0	210	4.76
24	gobcot	24	40	5.0	200	12.00
22	gobcot	14	40	1.5	60	23.33
25	gobhut	4	50	9.0	450	0.89
22	gobhut	3	40	1.5	60	5.00
24	gobhut	12	40	5.0	200	6.00
25	parnep	1	50	9.0	450	0.22
24	parnep	1	40	5.0	200	0.50
24	saltru	5	40	5.0	200	2.50
22	saltru	34	40	1.5	60	56.67
Upstream of barrage gates						
18B	angaus	2	40	2.0	80	2.50
16	angaus	16	80	2.0	160	10.00
8	angaus	17	14	3.5	49	34.69
16	angdie	1	80	2.0	160	0.63
10	angdie	12	200	2.0	400	3.00
9	angdie	4	41	3.0	123	3.25
15	angdie	5	30	5.0	150	3.33
12	angdie	19	70	5.0	350	5.43
8	angdie	5	14	3.5	49	10.20
13	angdie	25	30	4.0	120	20.83
10	chefos	1	200	2.0	400	0.25
13	chefos	1	30	4.0	120	0.83
12	chefos	3	70	5.0	350	0.86
8	galmac	1	14	3.5	49	2.04
10	gobcot	30	200	2.0	400	7.50
18A	gobcot	55	150	2.0	300	18.33
8	gobcot	13	14	3.5	49	26.53
12	gobcot	113	70	5.0	350	32.29
15	gobcot	52	30	5.0	150	34.67
18B	gobcot	30	40	2.0	80	37.50
13	gobcot	54	30	4.0	120	45.00
16	gobcot	144	80	2.0	160	90.00
12	gobhub	1	70	5.0	350	0.29
18A	parnep		150	2.0	300	
9	parnep	8	41	3.0	123	6.50
18A	retret	1	150	2.0	300	0.33
16	retret	1	80	2.0	160	0.63
12	saltru	2	70	5.0	350	0.57
10	saltru	4	200	2.0	400	1.00
15	saltru	3	30	5.0	150	2.00
13	saltru	5	30	4.0	120	4.17
8	shrimp		14	3.5	49	
Upstream of Pounui Lagoon flapgates						
5	angaus	1	20	7.0	140	0.71
5	angdie	2	20	7.0	140	1.43
5	anggla	5	20	7.0	140	3.57
5	galmac	14	20	7.0	140	10.00
5	gobcot	5	20	7.0	140	3.57
5	gobhut	4	20	7.0	140	2.86
5	parnep	3	20	7.0	140	2.14
5	saltru	1	20	7.0	140	0.71
5	shrimp		20	7.0	140	

Appendix 3. Form used to survey numbers of whitebaiters in the Ruamahanga River and Lake Onoke, and the methods they used to catch whitebait in the 1991 season.

COUNT OF WHITEBAITERS ON THE
RUAMAHANGA RIVER, 1991

FORM/SAMPLE NUMBERS ASSOCIATED WITH THIS SHEET:___________

LOCATION: LAKE ONOKE SHORE   LOWER RIVER   UPPER RIVER

DATE: ______________________ TIME: __________

DISTANCE UPSTREAM FROM MOUTH: _________________ KM/METRES

STATE OF LAKE ONOKE RIVER BAR:

COMPLETELY OPEN   PARTIALLY CLOSED   COMPLETELY CLOSED

IF BAR OPEN, TIME SINCE OPENING: ________________ DAYS

SIZE OF OPENING: ________________________________ METRES

IF BAR CLOSED, TIME SINCE CLOSURE: ________________ DAYS

TIDE: INCOMING   OUTGOING   SLACK WATER (circle one)

RIVER CONDITION: LOW WATER   RISING FLOOD   FALLING FLOOD
(circle one)

WEATHER: FINE   OVERCAST   RAIN   (circle as appropriate)

WIND: CALM   FRESH   STRONG   DIRECTION: ___________

NUMBER OF VEHICLES:_______________

NUMBER OF WHITEBAITERS WITH SCOOP NETS: _______________

NUMBER OF WHITEBAITERS WITH SET NETS: _______________

NUMBER OF SCOOP NETS IN THE WATER: ____________________

NUMBER OF SET NETS IN THE WATER: ____________________

NUMBER OF WHITEBAITERS INTERVIEWED:

SCOOP NETTERS: ____________________

SET NETTERS: ____________________

NUMBER OF CATCH SAMPLES TAKEN: ____________________
(mix catch thoroughly, then remove one cupful ($\geq$ 300 fish)

Appendix 4. Form used to survey the catch of individual whitebaiters in the Ruamahanga River and Lake Onoke.

QUESTIONNAIRE FOR RUAMAHANGA RIVER
WHITEBAIT SURVEY, 1991

AGE: ______ FORM/SAMPLE NO. _________

SEX: M/F SAMPLE TAKEN YES/NO

1. LOCATION: (circle one)

LAKE ONOKE SHORE LOWER RIVER UPPER RIVER

2. DATE: ________________________ 3. TIME: ___________

4. DISTANCE UPSTREAM FROM MOUTH: ___________________ KM/METRES

5. TIDE: INCOMING OUTGOING SLACK WATER (circle one)

6. WHAT IS YOUR HOME TOWN: __________________________________

7. HOW MANY YEARS HAVE YOU FISHED FOR WHITEBAIT? ____________

8. ON A TYPICAL WHITEBAIT TRIP, HOW MANY OTHER PEOPLE DO YOU NORMALLY TRAVEL WITH? _________________

9. HOW OFTEN DO YOU NORMALLY GO WHITEBAITING? (circle one)

OTHER COMMENT:

DAILY

SEVERAL DAYS a WEEK

WEEKENDS ONLY

ONCE A FORTNIGHT

ONCE A MONTH

SCHOOL HOLS ONLY

10. WHAT IS THE AVERAGE LENGTH OF STAY FOR YOUR WHITEBAIT TRIPS? (circle one)

HALF DAY OR LESS

FULL DAY

UP TO TWO DAYS

MORE THAN TWO DAYS
(GIVE ACTUAL TIME)

____

Appendix 4 (continued)

FORM NO. _______

11. HOW MUCH WHITEBAIT HAVE YOU CAUGHT TODAY?
(tick one) TIME SPENT FISHING TODAY SO FAR ______ HOURS

A. LESS THAN ONE CUPFUL
B. 1 CUPFUL = APPROX 250 g = APPROX 0.5 LB
C. PINT = APPROX 500 g = APPROX 1 LB
D. QUART = APPROX 1000 g = APPROX 2 LB
E. 0.5 BUCKET = APPROX 4000 g = APPROX 10 LB
F. 1 BUCKET = APPROX 8000 g = APPROX 20 LB
G. 2 BUCKETS = APPROX 16000 g = APPROX 40 LB
H. MORE THAN TWO BUCKETS (state amount) _______

12. HOW IS THE FISHING TODAY? (circle one)

EXCELLENT GOOD AVERAGE POOR TOO EARLY TO SAY

13. HOW MUCH DO YOU EXPECT TO CATCH ON THE FOLLOWING TYPES OF FISHING DAYS? (select letters referring to amounts as in 11. above)

EXCELLENT GOOD AVERAGE POOR

_________ ____ _______ ____

14. WHAT CONDITIONS PROVIDE THE BEST FISHING CONDITIONS?

TIDE: INCOMING - FIRST HALF SECOND HALF
(circle one)
OUTGOING - FIRST HALF SECOND HALF

RIVER FLOW: NORMAL RISING FLOOD FALLING FLOOD

WEATHER: FINE OVERCAST RAIN

15. HOW MUCH WHITEBAIT DO YOU GENERALLY CATCH
IN A SEASON? (select amount choice from 11. above -
circle one letter for each type of season)

1. GOOD SEASON A B C D E F G H

2. AVERAGE SEASON A B C D E F G H

3. BAD SEASON A B C D E F G H

16. HOW MANY YEARS HAVE YOU FISHED THIS RIVER? ____________

17. WHEN WAS YOUR LAST GOOD WHITEBAIT SEASON FOR THIS RIVER?

DATE: _________

ANY COMMENTS ON OTHER SEASONS:

Appendix 4 (continued)

FORM NO. ______

18. WHAT OTHER RIVERS DO YOU FISH?________________________

19. HOW HAS THE WHITEBAITING IN THIS RIVER CHANGED OVER THE YEARS?

DECLINED IMPROVED NO CHANGE

COMMENTS OF COMPARISON WITH OTHER RIVERS: ________________

____

20. DATE OF CHANGE (year): ______________________________

21. APPROXIMATELY WHAT PROPORTION OF LAST YEAR'S CATCH DID YOU SELL? (circle one)
ALL HALF SOME NONE

22. WHAT NAMES DO YOU GIVE TO THE DIFFERENT TYPES OF WHITEBAIT IN YOUR CATCH?

23. DO YOU PREFER ONE TYPE OF WHITEBAIT TO ANOTHER? YES NO

24. IF YES, WHICH TYPE DO YOU PREFER THE MOST, AND WHICH THE LEAST?

MOST ___________________________

LEAST ___________________________

25. DO YOU INCLUDE SMELT (WHICH SMELL OF CUCUMBER) IN YOUR WHITEBAIT CATCH?
YES NO

26. IF YES, WHAT PROPORTION OF YOUR CATCH IS GENERALLY SMELT?

ALL HALF SOME NONE

27. METHOD USED:

SCOOP NET SET NET OTHER ____________________

28. WHY DO YOU GO WHITEBAITING?

FOOD ENJOYMENT COMMERCIAL REASONS

OTHER (specify): __________________________________

29. DO YOU KNOW THE WHITEBAIT REGULATIONS?

YES NO VAGUELY

30. DO YOU FEEL THEY ARE USEFUL IN MANAGING THE FISHERY?

YES NO VAGUELY

WHY? ____

Appendix 4 (continued) FORM NO. _______

31. DO YOU USE OTHER FISHERIES IN THE LAKE WAIRARAPA, LAKE ONOKE, AND RUAMAHANGA RIVER?

YES NO

32. IF YES, WHICH FISHERIES DO YOU USE? ____________________

____

33. WOULD YOU MIND CONTRIBUTING FURTHER INFORMATION ABOUT THESE FISHERIES? (if yes, take name, address and phone number)

Appendix 5. Form used to survey recreational fishers by telephone about their catch and activities in the Ruamahanga River and Lake Onoke.

TELEPHONE SURVEY OF RECREATIONAL FISHING
IN LAKE WAIRARAPA 1991-1992

NAME: GENDER:

ADDRESS: AGE:

WHAT SPECIES DO YOU FISH FOR?

WHERE DO YOU FISH? (location as accurately as possible):

HOW OFTEN DO YOU FISH? (e.g., number of times per year):

WHEN DO YOU USUALLY FISH?:

DATES:

TIME OF DAY OF TIDE:

WHAT METHODS DO YOU USUALLY USE? (e.g., gill net (size of mesh), spinning, baited rod and line, fly fishing, etc - be specific about methods used for different species):

WHAT IS THE USUAL SIZE OF YOUR CATCH? (answer preferably in terms of number, weight, and size of fish):

HOW MANY YEARS HAVE YOU FISHED?

HOW MANY PEOPLE ARE THERE IN YOUR PARTY USUALLY?

HOW MANY OTHER PEOPLE DO YOU GENERALLY SEE FISHING?

HOW HAVE CATCHES CHANGED?

1) OVER THE LAST FIVE YEARS:

2) BEFORE AND AFTER 1975:

COMMENTS:

Appendix 6. Numbers of whitebaiters in the Ruamahanga River and Lake Onoke, and the methods they used to catch whitebait in the 1991 season.

Loc. (location): lo, Lake Onoke; lr, lower river; ur, upper river. **Tide:** in, incoming; ou, outgoing; sl, slack; lw, low water. **River:** rf, rising flood; ff, falling flood. **Weather:** f, fine; o, overcast, r, rain. **Wind:** c, calm; f, fresh; s, strong.

Date	Loc. lo lr ur	Time (h)	Distance from mouth (km)	Tide in ou sl	River lw rf ff	Weath-er f o r	Wind c f s	No. scoop nets	No. set nets	No. scoop nets fishing	No. set nets fishing
910811	lo	1430-1650	0-1.6	in	ff	f	c	2	30	1	20
910811	lr	1400-1430	3-8	in	ff	o	f	0	0	0	0
910811	ur	1300-1400	8-20	in	ff	o	f	0	0	0	0
910824	ur	1040	12.5-20	in	lw	f	f	1	1	0	1
910824	lr	1100	3-12.5	in	lw	f	f	0	2	0	2
910824	lo	1300	0-3	in	lw	f	c	15	20	15	25
910907	ur	1300	12-21	in	ff	f	s	0	12	0	12
910907	lr	1530	3-12	in	ff	f	f	0	6	0	6
910907	lo	1600	0-3	ou	ff	o	f	3	2	3	2
910913	ur	1100	8-20	in	lw	f	c	0	38	0	40
910913	lr	1200	3-8	sl	lw	f	f	0	4	0	4
910913	lo	1400	0-3	ou	lw	f	f	3	0	3	0
910922	ur	1000	12.5-21	in	ff	o	f	0	0	0	0
910922	lr	1515	3-12.5	in	ff	o	f	0	3	0	3
910922	lo	1145-1445	0-3	in	ff	o	f	25	37	25	36
910925	ur	1030-1200	12.5-27	ou	ff	o	f	0	3	0	3
910925	lr	1200-1300	3-12	ou	ff	o	f	0	5	0	6
910925	lo	1315-1500	0-3	in	ff	o	f	12	15	12	17
911002	ur	1100	12.5-20	in	ff	o	s	0	5	0	5
911002	lr	1130	3-12.5	in	ff	o	s	0	2	0	2
911002	lo	1400	0-3	ou	ff	o	f	3	6	3	7
911003	ur	1100	12.5-20	in	ff	o	s	0	0	0	0
911003	lr	1200	3-12	in	ff	o	s	0	0	0	1
911003	ur	1300	0-3	in	ff	o	s	0	0	0	0
911005	lo	1000	0-3	in	ff	r	s	0	3	0	3
911005	lr	1100	3-12	in	ff	r	s	0	0	0	0
911005	ur	1200-1400	12-20	in	ff	r	s	0	0	0	0
911019	lo	1000-1400	0-3	in	ff	f	f	23	40	23	43
911019	lr	1400-1500	3-12	in	ff	f	f	0	0	0	0
911019	ur	1500	18	in	ff	f	f	0	5	0	5
911027	ur	1100-1300	12.5-21	in	lw	f	f	0	64	0	72
911027	lr	1210-1400	3-12.5	in	lw	f	f	0	0	0	0
911027	lo	1400-1530	0-3	in	lw	f	f	0	0	0	0
911028	ur	1100-1445	12.5-21	ou	lw	o	f	0	35	0	36
911028	lr	1500	3-12	ou	lw	o	s	0	0	0	0
911028	lo	1530	0-3	ou	lw	o	s	0	0	0	0
911109	ur	1400-1500	12.5-21	ou	ff	o	f	0	0	0	0
911109	lr	1100-1130	3-12.5	ou	ff	o	f	0	3	0	3
911109	lo	1145-1400	0-3	ou	ff	o	f	3	4	3	4
911120	ur	0910	12.5-27	ou	lw	o	f	0	2	0	5
911120	lr	1000-1100	3-12.5	ou	lw	f	f	0	0	0	0
911120	lo	1100-1400	0-3	ou	lw	f	f	2	9	2	9

Appendix 7. Creel survey of whitebaiters fishing the Ruamahanga River and Lake Onoke, their catch, and their demography.

Sex: m, male; f, female. **Loc (location):** lo, Lake Onoke; lr, lower Ruamahanga River; ur, upper Ruamahanga River. **Tide:** in, incoming; ou, outgoing; sl, slack. **Home town:** hutt, Hutt Valley, mast, Masterton; lferr, Lake Ferry; cart, Carterton; mart, Martinborough; grey, Greytown; whanga, Whangamoana; paih, Paihiatua; feath, Featherston; levin, Levin; well, Wellington; taur, Tauranga; pirino, Pirinoa; john, Johnsonville; wainui, Wainuiomata. **Method:** set, set netting; sco, scoop netting. **Expected catch:** ex, excellent; go, good; av, average; po, poor.

No.	Date	Day	Sex m f	Loc lo lr ur	Time	Tide in ou sl	Home town	Age	Years fishing	Years fishing Ruamahanga	No. travelling companions	Frequency	Stay	Method	Total days' fishing	Catch today (g)	Hours fished today	Catch rate (g/h)	Expected daily catch (g)				Expected season's catch (g)		
																			ex	go	av	po	go	av	po
1	910811	su	m	lo	1430	in	hutt	46	10	10	3	8	0.5	set	4	125				1000	500	250		4000	
2	910811	su	f	lo	1452	in	mast	36	4	4	5	4	1.0	set	4	125				250			16000		
3	910811	su	f	lo	1505	in	hutt	55	10	5	2	50	1.0	set	50	250			4000	1000	250	125	16000	8000	
4	910811	su	m	lo	1530	in	lferr		3	3	2	50	0.5	set	25	125			4000		250			4000	
5	910811	su	m	lo	1605	in	hutt	34	1	1	3	8	2.0	set	16	125			4000	1000	5000	250		4000	
6	910811	su	m	lo	1620	in	lferr	61	12	12	0	120	1.0	set	120	125			16000	1000	250	125	4000	1000	
7	910811	su	m	lo	1640	in	cart	34	18	5	4	8	1.0	set	8	125			1000	250	125		16000	4000	1000
8	910824	sa	m	ur	1040	sl	whanga	54	5	5	0	50	1.0	set	50	125				1000	500	125	4000	1000	
9	910824	sa	m	lr	1100	sl	grey	23	15	15	1	8	0.5	set,sco	4	125			4000	250	125		4000	500	250
10	910824	sa	f	lo	1135	in	cart	27	3	3	1	8	1.0	set	8	125			4000	1000	500	250	8000	4000	250
11	910824	sa	m	lo	1200	in	mart	28	0	0	1		1.0	sco	0	125				1000					
12	910824	sa	f	lo	1206	in	hutt	62	10	10	1	120	1.0	sco	120	125			4000	1000	500	125	8000	4000	
13	910824	sa	f	lo	1220	in	grey	65	50	50	0	120	0.5	sco	60	125			4000	1000	250	125	45000	27000	8000
14	910824	sa	m	lo	1255	in	mast	67	12	12	1	8	7.0	set	56	125			1000	500	250	125	4000	1000	250
15	910824	sa	m	lo	1310	in	hutt		8	5	0	3	4.0	set	12	125			4000	1000	250	125	8000	4000	
16	910824	sa	m	lo	1330	in	mast	50	2	2	2.5	5	1.0		5	125			500	250	125			250	
17	910824	sa	m	lo	1340	in	mast	65	20	20	2	10	1.0	set	10	250			1000	500	250	125	8000	4000	1000
18	910907	sa	m	ur	1315	in	well	37	13	15	1	6	1.0	set	6	125			4000	1000	500	125	4000	1000	500
19	910907	sa	f	ur	1340	in	paih	27	0	0	1	3	1.0	set	3	125			4000	1000	500	125	4000	1000	500
20	910907	sa	m	ur	1410	in	grey	72	67	25	0	120	1.0	set	120	250			8000	4000	1000	125	16000	8000	1000
21	910907	sa	m	ur	1450	in	porir	62	50	0	3	16	2.0	set	32	125				500	250	125	500	250	125
22	910907	sa	f	lr	1530	in	grey	33	20	16	1	20	1.0	set	20	500			4000	1000	500	125	4000	2000	1000
23	910907	sa	m	lo	1610	ou	mart	26	20	20	2	8	1.0	sco	8	125			1000	5000	500	125	1000	500	250
24	910907	sa	m	lo	1630	ou	grey	30	10	10	2	50	1.0	set	50	125			4000	1000	500	250	8000	4000	1000
25	910913	fr	m	ur	1015	in	grey	31	1	1	0	8	0.5	set	4	125									
26	910913	fr	m	ur	1030	in	cart	69	60	45	0	3	1.0	set	3	4000	4.5	888.9	4000	1000	500	250	16000	8000	1000
27	910913	fr	m	ur	1130	in	lferr	56	30	8	4	64	1.0	set	64	250	2.0	125.0	8000	4000	1000	500	16000	8000	1000
28	910913	fr	m	ur	1200	in	grey		20	0	1	50	1.0	set	50	1000	4.0	250.0	4000	1000	750	500	8000	4000	1000
29	910913	fr	m	ur	1300	ou	feath	75	60	60	0	100	1.0	set	100	1000	7.0	142.9	1000	500	250	125	8000	4000	1000
30	910913	fr	f	lo	1430	ou	hutt	62						sco	0	125	1.3	100.0							
31	910913	fr	m	lo	1445	ou	mast	67	56	56	1	120	1.0	sco	120	125	1.5	83.3	16000	4000	1000	125	36000	8000	
32	910922	su	f	lo	1145	in	hutt	38	4	4	1	50	0.5	set	25	125	1.3	100.0	4000	1000	500	250	1000	500	250
33	910922	su	m	lo	1200	in	feath	60	30	30	1	4	0.5		2	125	2.0	62.5	4000	1000	500	250	4000	1000	500
34	910922	su	m	lo	1240	in	cart	17	5	5	1	32	1.0	sco	32	1000	3.0	333.3	4000	1000	500	250	8000	4000	1000
35	910922	su	m	lo	1250	in	paih	19	2	2	1	4	2.0	sco	8	1000	4.0	250.0	8000	4000	1000	250	1000	500	250
36	910922	su	m	lo	1300	in	grey	50	40	30	1	8	1.0	sco	8	250	5.0	50.0	4000	1000	500	250	8000	4000	1000
37	910922	su	f	lo	1315	in	cart	62	35	35	1	72	1.0	set	72	500	6.0	83.3	4000	1000	500	250	27000	16000	8000
38	910922	su	f	lo	1350	in	levin	52	5	4	3	30	1.0	set	30	250	4.5	55.6	1000	500	250	125	8000	4000	1000
39	910922	su	m	lo	1410	in	well	49	25	10	1	16	2.0	set	32	250	4.0	62.5	1000	500	250	125	1000	500	250
40	910922	su	m	lo	1445	in	hutt	49	10	10	1	16	2.0	set	32	500	7.5	66.7	1000	500	250	125	4000	1000	500
41	910922	su	m	lr	1515	in	mart	76	65	20	1	50	0.5	set	25	125	6.3	20.0	4000	1000	500	250	8000	4000	1000
42	910925	fr	f	ur	1110	ou	cart	67	50	50	1	1	1.0	set	1	1			4000	1000	500	250	1000	500	250
43	910925	fr	m	ur	1140	ou	mast	67	50	40	0	28	1.0	set	28	125	1.5	83.3					8000	4000	1000
44	910925	fr	m	lr	1200	ou	mast	71	25	25	1	8	1.0	set	8	125	3.0	41.7	4000	1000	500	250	4000	1000	500
45	910925	fr	f	lo	1315	in	grey	45	30	15	1	8	1.0	sco	8	250	4.0	62.5	4000	1000	500	250	4000	1000	500
46	910925	fr	m	lo	1330	in	hutt	29	0	0	1	120	0.5	sco	60	250	1.5	166.7	4000	1000	500	250			
47	910925	fr	m	lo	1345	in	grey	37	25		1	4	0.5	sco	2	125	1.5	83.3	1000	500	250	125	500	250	125
48	910925	fr	m	lo	1400	in	taur	38	4	3	1	1	2.0	set	2	125	3.0	41.7	4000	1000	500	250	4000	1000	500
49	910925	fr	m	lo	1430	in	pirino	60	3	3	1	50	0.5	set	25	250	8.0	31.3	4000	1000	500	250	8000	4000	1000
50	910925	fr	m	lo	1445	in	cart		10	10	2	4	1.0	set	4	500	7.0	71.4	1000	500	250	125	1000	500	250
51	911002	we	f	ur	1130	in	john	72	10	2	1	8	3.0	set	24	3	1.5	2.0	4000	1000	250	125	16000	4000	1000
52	911002	we	m	lr	1155	in	mart	63	50	50	1	16	1.0	set	16	125	5.0	25.0	8000	4000	1000		16000	8000	4000
53	911002	we	m	lo	1400	ou	hutt	65	5	5	1	4	6.0	set	24	125	3.5	35.7	500	250	125	0	2000	1000	500
54	911002	we	m	lo	1430		hutt	62	4	4	2	22	1.0	sco	22	125	1.5	83.3	2000	1000	500	3	8000	1000	500
55	911002	we	m	ur	1520	ou	mast	42	30	4	1	4	1.0	set	4	125	8.0	15.6	1000	250		125	1000	500	250
56	911005	sa	m	lo	1100	in	feath	59	2	2	1	3	1.0	set	3	125	2.0	62.5	2000	1000	500	125	2000	500	250
57	911019	tu	m	lo	1100	in	pirino	61						set	0	125	5.5	22.7							
58	911019	tu	f	lo	1105	in	pirino	49	1		2	30	1.0	set	30	125	5.5	22.7	2000	1000	500	250			
59	911019	tu	m	lo	1120		wainui	56	35	30	1	2	3.0	set	6	125	2.5	50.0	1000	500	250	125	2000	500	250
60	911019	tu	m	lo	1145		hutt	40	2	2	6	4	1.0	set	4	125	0.5	250.0	2000	1000	500	125	2000	500	250
61	911019	tu	f	lo	1200	in	mart	72	12	12	1	50	1.0	set	50	125	4.0	31.3	500	400	250	125	4000	1000	500
62	911019	tu	f	lo	1215	in	mart	71	30	30	1	50	1.0	set	50	125	5.0	25.0	1000	500	250	125	6000	4000	1000
63	911019	tu	m	lo	1250	in	grey		5	5	1	50	1.0	set	50	125	6.5	19.2	1000	500	250	125	6000	4000	1000
64	911019	tu	f	lo	1330	in	hutt	62						sco	0	500	6.0	83.3							
65	911019	tu	f	lo	1235	in	hutt							sco	0	125	7.5	16.7							
66	911019	tu	m	lo	1240	in	hutt	40	15	15	3	7	1.0	sco	7	1000	7.0	142.9	2000	1000	500	250	4000	1000	500
67	911019	tu	m	lo	1350	in	mast	43	10	10		32	1.0	sco	32	1000	8.0	125.0	4000	1000	500	250	16000	8000	4000
68	911019	tu	m	ur	1500	in	hutt	50	30	2	1	32	1.0	set	32	250	6.0	41.7	4000	1000	500	250	8000	4000	1000
69	911027	su	m	ur	1100	in	cart	35	7	7	3	32	1.0	set	32	125	2.0	62.5	4000	1000	500	250	1000	500	250
70	911027	su	f	ur	1120	in	mast	41	1	1	2	32	1.0	set	32	125	1.0	125.0	500	350	250	125	1000	500	250
71	911027	su	f	ur	1130	sl	eket	42	20	3	1	4	2.0	set	8	125	2.5	50.0	2000	1000	350	250	1000	500	250
72	911027	su	m	ur	1145		well	45	3	3	1	6	1.0	set	6	250	3.0	83.3	4000	1000	500	250	4000	1000	500
73	911027	su	m	ur	1205	ou	grey	81	60	60	1	3	1.0	set	3	125	4.0	31.3	2000	1000	500	250	1000	500	250
74	911028	mo	m	ur	1100	ou	feath	48	20	15	1	32	0.5	sco,set	16	0	0.5	0.0	4000	1000	500	250	4000	1000	500
75	911028	mo	f	ur	1110	ou	feath	50	5	5	0	4	0.5	set	2	125			500	250	125	0	500	250	125
76	911028	mo	m	ur	1140	ou	cart	35	0		3	4	0.5	set	2	1									
77	911028	mo	m	ur	1155	sl	grey	14	12	12	1	32	1.0	set	32	500	3.0	166.7	8000	4000	1000	500	27000	16000	8000
78	911028	mo	m	ur	1200		cart	52	20	0	1	32	1.0	set	32		0.0		1000	500	250	125			
79	911028	mo	m	ur	1323	ou	mart	19	4	4	1	32	1.0	set	32	250	3.0	83.3	4000	1000	500	250	8000	4000	1000
80	911028	mo	m	ur	1345	ou	mart	37	10	10	2	32	1.0	set	32	125			8000	4000	1000	500	34000	16000	1000
81	911028	mo	m	ur	1405	ou	cart	47	12	12	10	4	0.5	set	2	500	2.0	250.0	1000	500	250	125	4000	1000	500
82	911028	mo		ur	1431	ou	cart	43	30	30	3	32	1.0	sco,set	32	1000	4.0	250.0	8000	4000	1000	125	16000	4000	500
83	911109	sa	m	lr	1118	ou	mart	58	8	8	1	5	1.0	set	5	500	5.0	100.0	2000	1000	500	250	4000	1000	500
84	911109	sa	f	lo	1152	ou	mart	48	15	15	2	1	1.0	set	1	125	0.5	250.0	1000	500	250	125	1000	500	250
85	911109	sa	m	lo	1210	ou	hutt	37	32	3	0	32	1.0	sco	32	125	0.5	250.0	2000	1000	500	250	16000	8000	4000
86	911109	sa	f	lo	1350	ou	pirino		20	20	2	3	1.0	set	3	500	5.0	100.0	2000	1000	500	250	1000	500	250
87	911120	we	m	ur	1106	ou	cart	62	2	2	1	8	0.5	set	4	125	2.0	62.5			125		8000	1000	250
88	911120	we	m	ur	1130	ou	mast	27	10	10	1	24	1.0	set	24	250	4.5	55.6	1000	500	250	125	4000	1000	500
89	911120	we	m	ur	1200	ou	grey	72	30	30	2	50	1.0	set	50	500	4.0	125.0	4000	2000	1000	500	39000	25000	4000
90	911120	we	m	lo	1330	in	hutt	65	25	20	1	50	1.0	set	50	0.5	2.0	0.3	2000	1000	500	250	2000	500	250
91	911120	we	m	lo	1335	in	hutt	39	3	1	3	3	0.5	set	1.5	1	1.0	1.0	1000	500	250	125	500	250	125

Appendix 8. Telephone survey of recreational fishers using Lakes Onoke and Wairarapa and the lower Ruamahanga River.

Sex: m, male; f, female. **Time:** ev, evening; mo, morning; al, all day; on, overnight; da, daylight. **Species:** tr, trout; ee, eels; fl, flounder; pe, perch; ka, kahawai; rc, red cod; ye, yelloweyed mullet, sm, common smelt; ho, hoki; te, trevally; sa, quinnat salmon; gu, gurnard; mu, mullet. **Place:** ra, Ruamahanga River above deviation; rb, Ruamahanga River below deviation, lw, Lake Wairarapa; wn, northern end of Lake Wairarapa; lo, Lake Onoke; ta, Tauherenikau River; os, southern end of Lake Onoke; on, northern end of Lake Onoke; ow, western end of Lake Onoke; wi, Waiohine River; hl, Henley Lake. **Method:** sp, spinning; ba, bait; fl, fly fishing; gn, gill netting; sr, ; fn, fyke netting; wn, ; tr, trolling; ll, longline; su, surfcasting. **Change in catch in last 5 years:** dec, declined; inc, increased; noc, no change. **Change in catch before and after 1975:** noc, no change; dec, declined; inc, increased; y, yes (direction not specified).

Sex	Age	Place of origin	Years fish -ing	No. compa -nions	Others seen	Freq -uen -cy of visits	Length of visit (h)	Total time (days) assumes 7-h days	Time of day	Species	Place fished	Method	No. nets	No. fish per net	Mesh size (mm)	No. fish caught	Weight of fish (g)	Length of fish (mm)	Total weight of fish (g)	Change in catch in last 5 yrs	Change in catch before and after 1975
m	33	carterton	20	2	2	24	3	10.3	ev	tr	ra,kd	sp,ba				0.5	649	381	7788	dec	noc
m	12		2	3	4.5	24	1	3.4	mo,ev	ee,tr	ra	ba				1.5	1000		36000	dec	
m	72	carterton	3	1		78	2	22.3	ev	tr	ra	fl				2.5	1249		243555	dec	
m	16	greytown	2	3.5	0	12	6	10.3	mo	tr	ra	sp				2	908		21792	noc	
m	61	greytown	8	1	0	20	3	8.6	ev	tr	ra	fl,sp				4.5	1362		122580	noc	
m	41		20	4	1.5	6	4	3.4		tr	rb	fl				1	1000		6000	noc	
m	62	trentham	10	2.5	2.5	12	7	12.0	al	tr	ra	sp				4	1362		65376	dec	
m		masterton	10	2	0	20	2	5.7	mo,ev	tr	ra	fl,sp				1	1249		24980		
m	33	greytown	1	3	0	12	3	5.1	ev	tr	ra	fl				1	454		5448		
m	74		17	2	3.5	156	6	133.7	al	tr	ra,wn	ba				1	795		124020	dec	
m	33	carterton	20	2	0	24	3.5	12.0		tr	ra,wn,ta	sp				4.5	908		98064	inc	noc
f	72		1	2		10	12	17.1	on	fl	on	gn	6	3.5	140	210	250		525000		
m	55		30			8	12	13.7	on	fl	on,rb	gn	8	1.7	140	108	250		216000	dec	
m	62	featherston	40	2	1	6	12	10.3	on	fl	rb	gn			140	72	250		108000	dec	dec
f	33		1	4			12			fl	ra	gn		3.5							
m	38	carterton	25	3		20			al	tr	ra,ta	fl					3065			noc	
m	38	carterton	25	3		20			al	pe	ra,ta	sp					454			noc	
m	38	carterton	25	3		20			al	ee	ra,ta	ba					795			noc	
m	34	featherston				3	1	0.4		tr	ra	fl,sp				1.5	908				
m	34	featherston				3	1	0.4		pe	ra,wn,on	sp				4.5	454				
m	34	featherston				3	1	0.4		ee	ra	sr								dec	
m	34	featherston				3	1	0.4		ka,co	os	ll,su								dec	
m	35		15	3		6	12	10.3	on	fl	ra	gn	3	4.5	150	81	300		145800	dec	
m	75	carterton	60	2	8	18	2	5.1	mo	tr,pe	rb	tr,ba				8.5	454		69462	dec	
m	75	martinborough	35	2	2.5	104	3	44.6	mo,ev	tr,pe	ra	fl				3				dec	
m	67	martinborough	5	1	0	16	3	6.9	mo,ev	tr,pe	ra	sp				3	2000		96000	noc	
m	60	carterton	30	1	0	4	3	1.7	mo,ev	tr	os,on,rb,ra	sp				1	1135		4540	dec	
m	60	carterton	30	1	0	8	3	3.4	mo,ev	pe	os,on,rb,ra	sp				1	280		2240	dec	
m	34	greytown	3	1	0				ev	tr,pe	ra	sp				1.5	908			dec	
m	32	carterton	3	3	0	52	3	22.3	mo,ev	tr,pe	ra,wi,hl	fl,sp								dec	
m	72	greytown	12	1	0	78	3	33.4	da	tr,pe	ra	sp				3	795		186030	dec	
m	72	greytown	12	1	0	78	3	33.4	da	tr,pe	ra	sp				3	250		58500		
m	11	carterton		3	1	4	7	4.0	da	tr,pe	rb	sp,ba				8	250		8000		
m	58	featherston				24	3.5	12.0		tr	rb,wn	sp				2.5	795		47700		
m	58	featherston	2	1		24	3.5	12.0		pe	rb,wn	sp				1	284		6816		
m	39	greytown	35	2	0	52	5	37.1	ev	tr	ra,wn,ta	fl,sp				1	908		47216	dec	y
m	39	greytown	35	2	0	52	5	37.1	ev	pe	ra,wn,ta	sp,ba				6	500		156000	dec	y
	19	featherston	6	2	0	12	12	20.6	on	fl	ra,rb	gn	2	1.5	150	36	250		108000	noc	
m	58	martinborough					12		on	fl,tr,pe,ye	ra	gn									
m	58	martinborough					12		on	ka,rc	lo	gn									
m	58	martinborough	9	1			12		on	ee	ra	fn	1	33	127						
m	58	martinborough								sm	ra	wn									
m	36	greytown				12	3	5.1	mo,ev	tr,pe	rb	sp									
m	36	greytown	17	3	2	5	12	8.6	on	fl	wn	gn			140	9	250		11250	dec	y
m	57	carterton				24	3.5	12.0	mo	tr	rb	tr				1.5	1022		36792		
m	57	carterton				24	3.5	12.0	mo	pe	rb	tr				3.5	225		18900		
m	57	carterton	50	2	2	12	12	20.6	on	fl	rb	gn	1	9		108	250		324000	dec	y
	47	carterton	6.5	2.5		6.5	12	11.1	on	fl	rb	gn	1	8		52	250		84500	dec	
	47	carterton	6.5	2.5		6.5	12	11.1	on	ka	rb	gn	1	3.5		22.75	1000		147875	dec	
	47	carterton	6.5	2.5		6.5	12	11.1	on	pe	rb	gn	1	3.5		22.75	280		41405	dec	
	47	carterton	6.5	2.5		4.5	12	7.7	on	tr	rb	gn	1	8		36	795		128790	dec	
m	75	carterton	70	1	1.5	12	6	10.3	ev	tr	ra	fl				2	908		21792		noc
m	75	carterton	70	1	1.5	12	6	10.3	ev	pe	lo	sp									noc
m	75	carterton	70	1	1.5	12	12	20.6	on	fl	lo	gn	1	6	100	72	250		216000		noc
m	31	greytown	25	2		10	12	17.1	on	fl,tr,pe	lo,ra,rb,wn	gn,sn	2	4	140	80	250		200000	dec	
f	38	featherston				12	12	20.6	on	fl,pe	ra	gn								dec	
f	33	greytown	30	2	y	16	12	27.4	on	fl,ye,pe,tr	ra,lo	gn	1	10	100	160	250		640000	dec	
m	46	carterton	30	4	1	5	2	1.4		pe	rb,ow	sp				9	280		12600	noc	
m	46	carterton	30	4	1	5	12	8.6	on	fl	rb,ow	gn	1	1.5		7.5	250		9375	noc	
m	41	martinborough	7	1	0	2	6	1.7		pe	rb	ba				1	454		908	noc	
m	16		7	3	3	2.5	4	1.4		pe,ka	rb,os	ba				2.5	500	260	3125	dec	
f	33	featherston	8			10	12	17.1	on	fl	ra	gn	1	6.5		65	300	400	195000		
f	33	featherston	8			10				tr,pe	ra	sp									
m	39	carterton	7	3		4	2	1.1		pe	ta	sp								noc	
m	39	carterton	7	3		4	12	6.9	on	fl	rb	gn	1	3	114	12	250		12000	noc	
m	35	carterton	9	4	0	18	4	10.3		tr	ra	fl,sp				4.5	908		73548	dec	
m	28	lhutt	2	4	2	52	2	14.9	mo	ka	lo	sp				3.5	1589		289198	noc	
m	63	lhutt	5	2	y	40				ka,ho	lo	su									
m	34		2	2	5.5	24	12	41.1	on	fl	ow	gn	1	4.5	140	108	250	270	648000	dec	
m	50	johnsonville	50	1	y	24	12	41.1	on	fl,ho,rc,te,ka	os	gn	1	10	133	240	250	250	1440000	dec	
m	65	greytown	2	2	y	24	12	41.1	on	fl	os	gn	1	7.5	127	180	300		1296000	inc	
m	50	akatarawa	3	2	y	25	12	42.9	on	fl,ho,rc,ka	os	gn	1	4.5	140	112.5	250		703125		
m	67	masterton	12	2	y	3	12	5.1	on	fl,sa,gu,rc	os	gn	1	16	140	48	250		36000	noc	
m	71	masterton	20	3	y	6	12	10.3	on	fl,ka	ow	gn	1	7	114	42	250		63000	noc	noc
m	60	featherston	10	2	y	12	12	20.6	on	fl	os	gn	1	6	140	72	250		216000	inc	
m	60	masterton	57	2	32	52	12	89.1	on	fl,ka	lo	gn	1	6	150	312	250	292	4056000	noc	noc
m	70	masterton	2	3	few	24	12	41.1	on	fl,rc,mu,ka	ow	gn	1	18	127	420	250		2520000	dec	
m	35	greytown	10	1	y	30	12	51.4	on	fl	os	gn	1	10	108	300	250		2250000	noc	
m	35	greytown	10	1	y	30	12	51.4	on	ye	os	gn	1	3.5	108	105	250	381	787500	noc	
m	51	featherston	1.5	1	0	104	3	44.6	ev	tr	wn	fl				1	2270		236080		
m	51	featherston	1.5	1	0	104	3	44.6	ev	pe	wn	sp				18	284	305	531648		
m	51	featherston	1.5	1	0	104	3	44.6	ev	ee	wn	sr									
	15	greytown	4	2	6	9	4.5	5.8	mo	tr	ra,os	tr				1	500		4500	dec	
	15	greytown	4	2	6	9	4.5	5.8	mo	pe	ra,os	tr				3.5	280		8820	dec	
	15	greytown	4	2	6	9	4.5	5.8	mo	ka	os	ba				6	500		27000	dec	
m	71	greytown	45	1	0					tr,pe	ra,rb,lw,lo	sp				3				dec	noc
m	64	greytown	4	2	4	8	12	13.7	on	fl,tr,pe	wn,ta	gn	1	2	140	16	500		64000	dec	
m	41	featherston	6	1	3.5	24	3	10.3	ev	pe	wn	sp				12.5	230		69000	noc	