Native fish populations of the Waiau River (Southland) and the impacts of the Lake Manapouri Control Structure (the Mararoa Weir)

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prepared for Waiau River Working Party

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EXECUTIVE SUMMARY

The objectives of this study were:

- to determine the native fish fauna of the estuary, mainstem and lower tributaries of the Waiau River;
- to determine the impacts on native fish populations of the reduced flows in the river that result from impoundment of the river by the Mararoa Weir;
- to recommend optimum flows for native fish in the river, especially the upper river where flows are low;
- to determine fish species present in the Waiau River Lagoon and to optimise habitats there for all life stages.

The Waiau River has populations typical of the rivers of southern New Zealand, with 15 native freshwater species plus two marine wanderers. Most of these have obligatory sea-migratory life stages which means that an open river mouth and free passage up and down stream are pre-requisites for their occurrence in the river. Low flows in the river increase the likelihood of mouth closing which would seriously threaten the already sparse populations of migratory native fish if closure was coincident with migration seasons and longlasting. In spite of this diversity of species, the fauna is highly impoverished over much of the river as few species penetrate up beyond the estuary/lower reaches to Tuatapere, and those few that do are rarely abundant beyond the estuary.

In these characteristics the Waiau is not dissimilar to what is known for the fish faunas of the other rivers of the Southland Plains such as the Oreti, Aparima and Mataura. The sparseness of the fauna can be attributed to a failure by most fish species to enter the river in large numbers followed by their failure to migrate upstream beyond the estuary and lower reaches.

Studies of native fish habitat have shown that most species favour of cobble gravel substrates in edge habitats, usually less than 25 cm deep. Given this fact, combined with the very low species diversity in the Waiau River in its upstream reaches where flows are heavily reduced, the contention that a residual flow there of around 10 cubic metres per second, designed to optimise the trout fishery, will provide adequate habitat for native fish, is supported. There is no reason to implicate the sparseness of the fauna with impacts of flow variation and impoundment of the upper river that result from construction of the Mararoa Weir.

The Waiau River estuary supports a diverse fauna typical of New Zealand river estuaries (six freshwater/estuarine species plus two marine wanderers). Habitat conditions in the estuary remain largely unspoiled, though catchments that drain into the estuary have been heavily deforested and converted to pasture, with most swamplands drained. The fauna of the estuary would be enriched by allowing riparian lands to return to indigenous vegetation and the redevelopment of wetlands. However, the quality of these restored habitats will always be subjected to the influence of streams draining farmlands further back from the estuary. These influences may compromise the habitat values that could be restored around the estuary itself.

1.0 INTRODUCTION

This report addresses issues that relate to the impact of the Lake Manapouri Control Structure (hereinafter called the Mararoa Weir) on the fish fauna of the Waiau River. A study was commissioned by the Waiau River Working Party (WRWP) which was convened and funded by the Electricity Corporation of New Zealand (ECNZ) to identify and evaluate various possible impacts of impoundment and water diversion on the Waiau River below the Mararoa Weir. One of its goals has been to develop possible strategies for mitigating these impacts, prior to ECNZ applying for new Resource Consents that will allow continued exploitation of the waters of the upper Waiau River catchment for electricity generation at Deep Cove. Amongst potential impacts of the impoundment are those relating to native fishes in the river. The WRWP directed that studies should examine several specific aspects of the potential impacts:

1 To determine the impacts on native fish populations of greatly reduced flows in the river and to recommend optimum flows for native fish in the river;

2 To describe species present in the river's lagoon and lower reaches, and to propose methods to optimise their habitats and ensure that as far as possible suitable habitats for all life stages are provided for;

3 To describe the fish stocks of tributaries of the lower river and to relate these to the stocks and habitats of the mainstem river.

This report addresses the above questions.

1 It briefly describes the Waiau River and its catchment;

2 It provides an outline of life history strategies undertaken and habitats occupied by native fish species that occur particularly in the lower river and some tributaries;

3 It describes the distribution and abundance of these species;

4 It addresses the questions posed by the WRWP in the context of the knowledge of the river's fauna.

2.0 BACKGROUND INFORMATION ON THE FISH FAUNA OF THE RIVER

Relatively little archival information is available on the native fish populations of the Waiau River. Hayes *et al.* (1992) prepared a summary of existing knowledge of the fauna, listing 16 species known from the river, based largely on about 40 data records on the river in the New Zealand Freshwater Fish Database (McDowall and Richardson 1983). In addition to these data, the Southland Fish and Game Council (SF&GC), which is responsible for managing the salmonid fisheries of the Waiau River, routinely collects information on the fish fauna of the river, including native fishes; data derived from the Council's records were discussed by Hayes *et al.* (1992) and are included in this report. Prior to this study, there

had been no systematic attempt to identify or describe the native fish fauna of the Waiau. Common and scientific names for fish species discussed in this report are given in Table 1.

TABLE 1. List of fish species discussed.

Family	Scientific name	Common name
Geotridae	*Geotria australis**	lamprey
Anguillidae	*Anguilla australis**	shortfinned eel
	*Anguilla dieffenbachii**	longfinned eel
Retropinnidae	*Retropinna retropinna**	common smelt
	*Stokellia anisodon**	Stokell's smelt
Galaxiidae	*Galaxias maculatus**	inanga
	*Galaxias brevipinnis**	koaro
	*Galaxias postvectis**	shortjawed kokopu
	*Galaxias argenteus**	giant kokopu
	*Galaxias fasciatus**	banded kokopu
	Galaxias vulgaris	common river galaxias
	Galaxias anomalus	roundhead galaxias
	Galaxias sp.	flathead galaxias
	Galaxias paucispondylus	alpine galaxias
Pinguipedidae	*Cheimarrichthys fosteri**	torrentfish
Eleotridae	*Gobiomorphus cotidianus**	common bully
	*Gobiomorphus huttoni**	redfinned bully
	*Gobiomorphus hubbsi**	bluegilled bully
	Gobiomorphus breviceps	upland bully
	Gobiomorphus gobioides	giant bully
Pleuronectidae	*Rhombosolea retiaria**	black flounder
	Rhombosolea leporina	yellowbelly flounder
Mugilidae	*Aldrichetta forsteri*	yelloweyed mullet
Parastacidae	*Paranephrops zealandicus*	koura

* species is diadromous, having more or less obligatory migrations to and from the sea

3.0 THE WAIAU RIVER

The Waiau River (Southland) originates in two small lakes at the head of the Eglinton Valley, close to the catchment's divide with the Hollyford River. Lake Fergus drains into Lake Gunn, and thence into the Eglinton River, which is a major source of water for Lake Te Anau. Numerous other streams and several small rivers such as the Clinton and Upokororo contribute water to Lake Te Anau from the surrounding mountains; however, cumulatively these inflows mean that the river draining from Lake Te Anau and into Lake Manapouri is substantial, amounting to about 285 cumecs (Riddell *et al.* 1993). No other substantial rivers

flow into Lake Manapouri, but discharge from the lake, resulting from inflows from Lake Te Anau and the numerous small rivers draining the mountainous catchment of Manapouri, amounts to 403 cumecs. The Mararoa River joins the Waiau not far downstream from the Lake Manapouri outlet, and has a flow of about 34 cumecs (Riddell *et al.* 1993). Because most of its water originates in lakes, the Waiau historically had relatively stable flows of clean water. Flooding in the Mararoa was its major source of both violent flow fluctuations and sediment loads. In spite of the quite significant impacts of the Mararoa, the Waiau could be regarded as a lake outlet river, with most of the resulting beneficial characteristics of such a river to the fish fauna (Jowett 1993).

The Waiau River was impounded, just downstream of its confluence with the Mararoa River, by the Mararoa Weir to store water for use in electricity generation at the Manapouri power station. This power station draws water from Lake Manapouri at West Arm, passes it through subterranean turbines, and discharges it into Deep Cove, Doubtful Sound, in Fiordland, west of Lake Manapouri. As a result of impoundment of the Waiau, flows down the old Waiau River bed, formerly more than 400 m^3/s, were reduced to a residual flow of less then 0.3 m^3/s at the Mararoa Weir. This small flow was intended to service a fish pass constructed in the dam, to allow the up- and downstream passage of fish.

Although, since the construction of the weir, and under normal flow conditions, the river bed is nearly dry immediately below the Mararoa Weir, it gradually increases in flow as tributaries join the river, the main upper ones being: Excelsior Creek (1 km downstream, flow 1.4 m^3/s); Whare Creek (2 km, 1.1 m^3/s); Redcliff Creek (11 km, 1.6 cumecs); Borland Burn (20 km, 9.9 m^3/s) and Monowai River (22 km, 14 m^3/s) (Fig. 1). By the time the river has been joined by the Monowai River, flows have risen to about 34 m^3/s, then a substantial river even though it has less than 10 percent of the former natural flows of the Waiau. Flows continue to be augmented by mostly quite small tributaries, such as the Wairaki, Orauea, Lill Burn, Alton Burn, and others, so that non-augmented flows at the river mouth are around 78 m^3/s. (All flow data from Riddell *et al.* 1993.)

Management rules for the river permit the discharge of turbid flood waters from the Mararoa River across the Mararoa Weir into the Waiau, to avoid entry of these flood waters into Lake Manapouri. In addition, when the levels of Lakes Manapouri and Te Anau reach certain heights, management criteria for the lakes require that excess water be discharged down the Waiau, to avoid the flooding of beaches and shoreline forests in the lakes. Thus, although the nominal flow of the upper river is very low, at times it is greatly augmented by releases of water from above the Mararoa Weir, as a result of which the annual mean flow in the river at the Tuatapere is about 165 m^3/s. Because river impoundment at Mararoa leads usually to a much reduced base flow in the river, and yet the high flood flows are still discharged into the river (flood maxima under control may be little different from those before control), an outcome of control is that flow fluctuations are now much greater in magnitude than they formerly were.

4.0 THE WAIAU LAGOON

The Waiau River has a large, narrow, tidal lagoon, some 7 km long (Fig. 2). The lagoon has, at present, two distinct arms, one to the east of the mouth (ca. 4.5 km long) the other to the west (ca. 2.5 km long - Fig. 2). The relative sizes of these two arms will vary with the position of the river mouth, though overall lagoon length is unlikely to have varied much

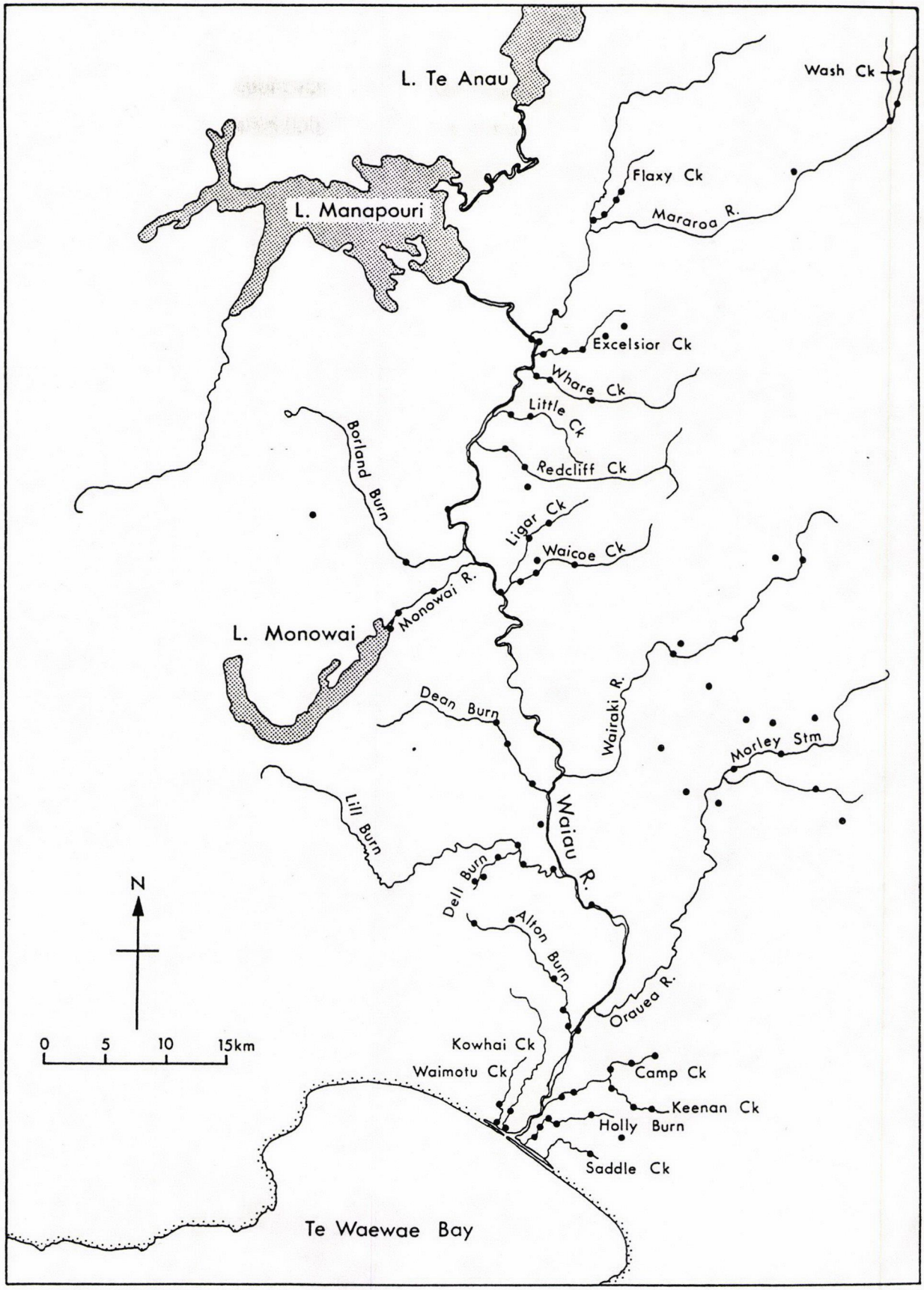


FIGURE 1. Waiau River catchment (● localities at which fish sampling has been undertaken in the river mainstem and tributaries).

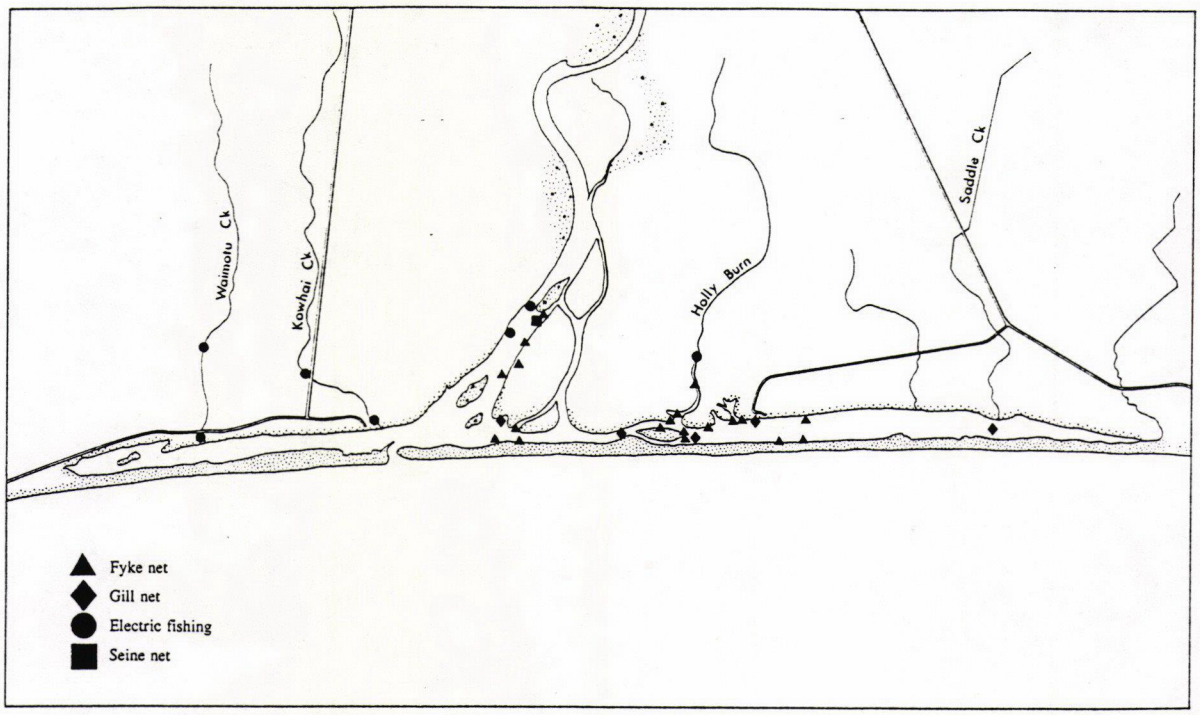


FIGURE 2. Waiau River lagoon (localities at which sampling has been undertaken are indicated).

in many decades. At present the mouth is displaced a little west from where the mainstem reaches the lagoon, but it is known to move quite widely along the coast, depending on the effects of prevailing winds and oceanic currents, and on the behaviour of floods in the river. Much of the eastern arm of the lagoon (for about 2.5 km) is backed by a high terrace with only a narrow gravelly shelf at its foot forming the inland lagoon margins. This terrace then turns northwards to form the margins of the lower Waiau valley and floodplain, and the lagoon banks are formed by low, rough pasture, grading to the west into low, somewhat entrenched, swampy lagoon channels with rush and flax vegetation. At times the lagoon margins are formed by shelving, stable, well cemented cobble/gravel/sand/clay banks, and at times, especially along the eastern channel, there are stable clay banks about a metre high, topped with rushes and some flax. Gravel banks along the seaward side of the lagoon are often more embedded in mud and sand than those on the landward side, probably because of the wave washing of the landward shore during the frequent and strong southwesterly winds that occur there. The broad and high coastal gravel bar that separates the lagoon from the sea is of considerable age in human terms, though not in geological terms. There is well developed vegetation along much of the bar, with luxuriant growths of flax, lupins, rushes and grasses in places. Some parts of the eastern bar are bare gravel, where there are at some sites substantial breeding colonies of blackbilled and blackbacked gulls (Sagar 1994). The eastern end of the eastern arm of the lagoon forms a long (ca. 3 km), shallow pond which is connected to the river's mainstem by a much narrower and shallower channel (Fig. 2). It forms a substantially independent water body; its levels fluctuated in synchrony with oceanic and mainstem tidal fluxes, though probably delayed by about 1-1½ hours owing to its distance from the mainstem via the narrow connecting channel. While water levels are influenced by some backing up of water from the mainstem at high tide there appears to be minimal influence of sea water in the eastern lagoon.

The extent of the isolation of the eastern lagoon from the mainstem can be seen from a pair of salinity transects carried out along the length of the eastern arm. These were conducted at approximately low and high tides (3 and 5 December 1993). The low tide transect showed a cell of elevated salinity water (13 ppt) at the bottom (below 3 m depth) towards the eastern end of the lagoon, but elsewhere along the transect salinities were always low, typically $\leq$ 2 ppt at all depths in the lagoon. Another series of measurements along this transect at high tide failed to locate the cell of higher salinity water at the eastern end, which suggests that it may be very small, and showed salinity levels along the transect to be even lower, typically <2 ppt. At these salinity levels the salinometer was at the limits of its accuracy and the differences between the two transects are of minor significance. If anything, backing up of mainstem river water into the eastern arm at high tide depressed salinities from about 2 ppt to often less than 1 ppt. In both transects, at both high and low tides, once into the mainstem of the river, salinity levels were less than 1 ppt, and sometimes failed to register a reading indicating entirely fresh water and showing the dominant influence of the river flows on the estuarine hydrology at that point. Overall, it can be concluded that:

1) There is no evidence for a sea water wedge penetrating into the western end of the eastern lagoon through the lagoon channel, nor into the lower river;

2) The water of the eastern lagoon is only slightly brackish, and this brackishness can probably be attributed mostly to windswept sea spray crossing the lagoon bar or some seepage through it, especially when a heavy surf dumps sea water high on the gravel bar.

Salinities in the lagoon are probably low enough to allow all but the most salinity-sensitive freshwater fish to live there, and also low enough to prevent most properly marine fish from permanently occupying the area. Only euryhaline marine fish (those tolerant of highly variable salinities) are likely under these circumstances.

An extensive area of low, flat, apparently stable bar forms the seaward margin of the eastern lagoon channel, and this is well vegetated with dense stands of flax, lupins and rushes. Even the much narrower coastal bar just east of, and where, the mainstem flows impinge on it, is well vegetated with flax and sedges.

Inflows to the eastern lagoon are slight, including several small streams that tumble down the steep terrace alongside the upper lagoon, and enter it with no meandering, low gradient reaches. The Holly Burn is a further small stream, which drops off the same series of terraces as these turn back up the Waiau valley several kilometres back from the sea and then winds across low elevation, and low gradient, rough, pasture to join the eastern lagoon through a slow flowing, meandering tidal stream. Though no flow estimations have been undertaken, the inflows from streams into the eastern arm appear to be small in proportion to the volume of water there.

The western arm of the lagoon is also backed by terraces to the west, but these turn up the river valley a little west of Waimotu Creek, and from there east to the mainstem river, the valley adjacent to the lagoon is mostly low lying pasture, elevated above the river bed by 1-2 metres, with banks of steep clay or shelving gravel. The western bar is largely bare shingle for a considerable distance, to about the lagoon confluence with Waimotu Creek (ca. 1.5 km from the mouth), where there is an abrupt junction between bare gravel and well-grassed gravel banks, suggesting that in quite recent years the mouth had moved this far west and then retreated east again. The western third of the western arm of the lagoon is well-clothed with a low sward of grasses and rushes.

The western lagoon is more open to the river than the eastern one, lacking the constricting, shallow and narrow channel described for the western part of the eastern lagoon (again probably because the mouth has been further west of its present position much more recently than it has been further east). This is important in interpreting the differences between the fish faunas of tributaries flowing into the two lagoons (see section 10.6). Two small tributary streams (Waimotu and Kowhai Creeks), which drain low elevation pasture and some patches of bush on the lower slopes of surrounding hills, enter the western arm of the lagoon.

The mainstem of the river flows down across the Waiau Plains into and across the axis of the lagoon and into the sea (Fig. 2). River rapids were still visible at high tide less than 1 km upstream in the mainstem, and at low tide an additional rapid forms a few hundred metres down stream; thus the mainstem part of the estuary is relatively swift flowing. The entire river has moderate slope, with no low gradient, slow-flowing meandering reach across a flat flood plain that characterises the lower reaches of many rivers. Even at high tide, there is a strong downstream flow of water out of the mainstem, across the axis of the lagoon, and to sea through the river mouth. Thus, there appears to be no time at which water in the lagoon reach of the mainstem has an upstream flow generated by tidal rise, nor is the water ever stationary. The extent of "lagoon habitat" in the mainstem is thus small, is always wholly fresh water, and flows downstream and to sea at all times.

The river discharges to sea through a mouth that is reported to vary widely in position, so that hydrological conditions in the lagoon also will vary widely. Though the mouth clearly migrates back and forth along the lagoon bar, the well-developed vegetation along much of the bar suggests considerable stability in mouth position, or at least a limited range of mouth movement, probably over several decades. Certainly, the vegetation on the flat shelf on the seaward side of the channel that drains the eastern lagoon has the appearance of considerable age and stability. Although local people can remember when the river mouth was located towards the eastern end of the lagoon, this was many decades ago, and mouth movement in recent years appears to have been quite limited in extent. This is important to understanding and evaluating the habitats and fish populations in the lagoon.

At the time of study (December 1993) the river mouth was open, and was situated only slightly west of the point at which the mainstem entered the lagoon. With the greatly reduced flows at times in the river, as a result of the Mararoa Weir, there is an increased likelihood that the river mouth will close, when river outflows cannot generate sufficient energy to displace gravels and sands swept into the river mouth by oceanic wave action and coastal drift. Mouth closure is an important issue for the fish populations of the river owing to the high proportion of species that must spend part of their lives at sea, and which therefore must migrate in and out of the river through its mouth.

5.0 SAMPLING

Habitats in the Waiau lagoon were sampled during early December 1993 using a variety of techniques. Most sampling was undertaken in the eastern arm which was considered to provide the best fish habitat in the lagoon. Fyke nets were set typically in the evening, left overnight, and cleared the following morning. Various conformations were used, to suit water flows and depths, including: a single fyke with a single leader; a pair of fykes with a single leader joining them; a single fyke with paired V-wings; and a pair of fykes with V-wings typically set together to fish in opposite directions. All but one of the fykes had mesh of 25 mm stretch mesh, the exception having 12 mm stretch mesh. Fyke nets were set, unbaited:

- in diverse locations in the ponded upper lagoon;
- in the channel;
- in lagoon backwaters;
- in streams and channels entering the lagoon, along the coastal bar in the vicinity of the mainstem flows;
- upstream in the mainstem along channel banks and as far up the mainstem as the second rapid present at low tide; and
- in small channels and tributaries joining the mainstem.

Gill nets of monofilament nylon, with stretch mesh of 115 mm, were set one each in the upper lagoon (20 m long) and in the channel (30 m long), for about 2.5 hours during the day. Further, longer sets, and nighttime sets, were avoided owing to potential mortalities to trout in the lagoon (a matter of concern to SF&GC). Seine net hauls were undertaken, using a net 40 m long and 2 m deep, constructed of 12 mm knotless mesh, and hauled along lagoon margins in diverse habitats, but where substrates made hauling and beaching the net practicable. Electric fishing was undertaken in the two lower rapids in the mainstem. Sites of all these samplings are indicated in Figure 2.

Sampling of the fish fauna in the mainstem and tributaries, upstream of the estuary was undertaken with a battery-powered, variable voltage and pulse frequency, back portable, electric fishing machine. Mode of operation varied a little with conditions. Typically, it was undertaken by sweeping the electrode down stream onto a push net used as a stop net. However, at times, when conditions required it, we worked upstream, retrieving stunned fish with small dip nets.

Fish distributions are presented for the estuary, and river and tributaries, in Figures 3-21. In these figures, where appropriate, are included maps of the entire lower Waiau (A), of the Waiau Estuary (B), and of the distribution of the species in the South Island, based on data in the New Zealand Freshwater Fish Database (C). Figures 1 and 2 indicate where any data are available for the fish fauna of the estuary and river mostly downstream of the Mararoa Weir (small round dots - •). These two figures were used as templates for showing all fish species distributions. In Figures 3-21 different symbols were placed over the small dots where the relevant species were found at the various localities. Thus, the presence of the small round dot (•) in these distribution maps indicates that the relevant species were not found at these localities. I emphasise here that absences of species are of considerable significance to understanding fish distributions in the Waiau, and of the fauna of the river as a whole.

Sampling in both the estuary, and the river and its tributaries, was not intended as quantitative. Substantial replication of effort at sites, standardisation of gear types, and measuring of habitat parameters and catches would have been required especially in a diverse and constantly varying habitat like the Waiau lagoons, and this was beyond the scope of the study; the aim was to identify those fish that made use of the lagoon, mainstem river and tributaries, and to understand their distributions and general abundance in the various habitats there, as a basis for identifying important components of the fauna and the habitats used by them.

6.0 A NOTE ON THE IDENTITY OF WHITEBAIT

There is a significant whitebait fishery at the mouth of the Waiau (McDowall 1993); whitebait are the juvenile stages of five species of *Galaxias*. They share some fundamental life history characteristics, as follows: Spawning is either in fresh water, or in the tidal estuary, and occurs mostly in autumn and early winter. The larvae, about 10 mm long, move to sea on hatching. They spend a period of 4-6 months in the sea (McDowall *et al.* 1994), over the winter, and begin to return to fresh water in spring, making up the much sought-after whitebait runs. Those whitebait that escape capture move up stream seeking habitats in which to feed and grow. In one species (inanga) the adults mature the following autumn, spawn and die. In the others (koaro, banded, shortjawed and giant kokopu), maturity is typically not attained until about 18 months or more after entering fresh water as whitebait; in addition, the adults typically survive spawning to mature again in later years (McDowall 1984, gives a detailed popular account of the whitebait fishery).

7.0 THE FISH FAUNA OF THE WAIAU LAGOON/ESTUARY, AND THE RIVER AND ITS TRIBUTARIES

In the following text the fish fauna of the river is discussed in the following sequence.

- For each species a brief account is given of its customary habitat types and the life history strategy it undertakes, to provide a background for understanding its distribution and abundance in the Waiau;
- Occurrence of each species in the estuary is described;
- Occurrence in the mainstem and tributaries is described.
- Synthesis and interpretation of sections 1 and 2 are then provided to form a basis for understanding the river's fauna, and interpreting it in the context of:
    - the impacts of the Mararoa Weir and flow diversion of the river;
    - the fish fauna of the other rivers in Southland; and
    - the general distributions and abundances of native fish elsewhere in New Zealand.

In all instances the distributions are indicated in Figures 3-21. A general account of the New Zealand freshwater fish fauna can be found in McDowall (1990) where details passed over briefly or omitted from this report, can be found.

Species present in the lagoon/estuary/tidal river, the mainstem river, and the river's tributaries are listed in Table 2, where it is also indicated whether the species' habitat is primarily (X) or secondarily (x) in one of these general water types. Species that are diadromous (i.e. which are migratory, and spend a significant and regular part of their life cycles in the sea) are also indicated there.

Overall, 17 native species were recorded in the Waiau River system below the Mararoa Weir, 14 of them occurring in the lagoon, tributaries and channels leading into it, and the lower mainstem upstream about as far as tidal influence. These lagoon species included 12 native species generally regarded as freshwater fish and two marine wanderers that commonly enter river estuaries. In the lagoon, itself, however, there were only eight species, most of which also penetrated up stream in either the mainstem or the tributaries. By far the most species-rich faunas encountered anywhere in the Waiau were found in the lower reaches of the two small tributaries that flow into the western lagoon - Waimotu and Kowhai Creeks. Possible reasons for this high diversity, and the lower diversity elsewhere are discussed below (see sections 10.2, 10.6).

7.1 Lamprey (*Geotria australis*)

(Occurs New Zealand wide). Lampreys spend much of their lives at sea, where they grow from a small juvenile (ca. 100 mm long) to adult size (often > 600 mm). Adult lampreys migrate into rivers during the late winter and spring, and move upstream through the

Table 2. Distribution of species in the Waiau River estuary, mainstem and tributaries.

	G.aus	*A.die*	*A.aus*	*R.ret*	*G.mac*	whbt	*G.arg*	whbt	lndlk	*G.fas*	whbt	*G.brev*	whbt	*G.vul*	*C.fos*	*G.hut*	*G.cot*	lndlk	*G.hub*	*G.bre*	*Rh.ret*	*R.lep*	*A.for*	*Paran*
River mouth (passage)*	x	x	x	x	-	x	-	?	-	-	x	-	x	-	x	x	x	-	x	-	x	x	x	-
Estuary mainstem	x	x	-	-	-	x	-	?	-	-	x	-	x	-	x	-	X	-	x	-	x	-	x	-
Estuarine lagoons	-	X	x	X	X	X	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	x	x	-
Estuarine tributaries lower	-	X	x	x	x	x	-	-	-	-	-	-	x	-	x	x	X	-	x	-	-	-	-	-
Estuarine tributaries upper	-	x	x	-	-	-	-	-	-	-	-	-	x	x	-	X	X	-	-	-	-	-	-	x
Mainstem at Tuatapere	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-
Tributaries to Tuatapere	-	x	-	-	-	-	-	-	-	-	-	x	-	-	-	x	x	-	-	-	-	-	-	x
Mainstem at Clifden	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	x	x	-	-	-	-	-	-	-
Tributaries to Clifden	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	-	x
Mainstem at Blackmount	-	x	-	-	-	-	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Tributaries to Blackmount	x	x	-	-	-	-	-	-	-	-	-	x	-	X	x	-	-	-	-	x	-	-	-	-
Mainstem at Mararoa	x	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-
Tributaries to Mararoa	x	x	-	-	-	-	-	-	-	-	-	-	-	X	x	-	-	x	-	x	-	-	-	x

* = diadromous species that migrate to and from the sea

G.aus = *G. australis*
A.die = *A. dieffenbachii*
A.aus = *A. australis*
R.ret = *R. retropinna*
G.mac = *G. maculatus*
whbt = whitebait
G.arg = *G. argenteus*
lndlk = landlocked
G.fas = *G. fasciatus*
G.brev = G. brevipinnis
G.vul = *G. vulgaris*
C.fos = *C. fosteri*
G.hut = *G. huttoni*
G.cot = *G. cotidianus*
G.hub = *G. hubbsi*
G.bre = *G. breviceps*
Rh.ret = *R. retiaria*
R.lep = *R. leporina*
A.for = *A. forsteri*
Paran = *Paranephrops*

estuaries and mainstem, into small, higher elevation, bouldery tributaries, often mostly in forest. Spawning is thought to take place there, after which the adults die (Kelso and Glova 1993). The larval ammocoete stage lives in silty/sandy margins of streams and rivers (Kelso 1993; Kelso and Todd 1993), where they are filter feeders on micro-organisms for several years, before they metamorphose into the adult form, move downstream, and leave the rivers for the sea during the winter and spring. After several years there, living as parasites of marine fish, they grow to adulthood and return to freshwater to spawn, completing the cycle.

Lamprey were encountered in few locations (Fig. 3). Ammocoetes have been recorded from the lowermost riffle in the mainstem, the lower reaches of the Dell Burn, and possibly from lower Excelsior Creek. Adult lampreys are known from the fish pass in the Mararoa Weir (Southland Acclimatisation Society 1972, 1978), and from the Monowai River Dam (Field-Dodgson 1981).

The Southland Acclimatisation Society (1972) reported that very substantial lamprey runs are known to take place in the Waiau River, and claimed that they are known to spawn in some tributaries. The basis for this last statement is unclear, since the spawning site of the New Zealand lamprey has never been described; possibly it was on the basis of encounters with ammocoete larvae.

7.2 Longfinned eel (*Anguilla dieffenbachii*)

(Occurs New Zealand wide). Longfinned eels enter rivers from the sea during the spring, as small, transparent glass eels, about 60-75 mm long; often they settle in the lower riffles and runs of rivers where they become pigmented and a sandy-brown colour (then known as elvers), and they feed and grow in the riffles and runs. Further movements upstream may be either as well-coordinated migrations (Jellyman 1977), or as a general tendency by the small eels to move upstream. As they grow, habitat preferences change to marginal or bottom cover in pools and runs. Longfinned eels penetrate the most remote and distant limits of New Zealand's river systems, climb falls of prodigious height, and generally occupy any suitable waters, but mostly bouldery/rocky streams and rivers especially where marginal cover is plentiful. Longfins feed and grow in these habitats over many years, taking 15 or more years to mature, some still being present at more than 50 years of age. Eventually, they move downstream and to sea to spawn, mostly during autumn; the post-spawning adults all die (Jellyman and Todd 1982).

Longfinned eels are widespread in the Waiau River (Fig. 4). Note that this figure also includes all data points from which unidentified eels were recorded (triangle - mostly SF&GC records), on the grounds that shortfinned eels are typically fish of lowland estuarine and swampy lake habitats (Jellyman and Todd 1982; McDowall 1990) and were rarely recorded anywhere in the Waiau: see below. Longfinned eels were generally and widely present in the estuary and tributaries, and occurred in many locations throughout the river as far upstream as sampling was undertaken. They are also known above the Mararoa Weir, occurring as far upstream as Lakes Gunn and Fergus at the upper limits of the catchment, and also in Te Anau and Manapouri through which they would have to migrate to reach Gunn and Fergus. Longfins also penetrate the Mararoa River to reach streams draining into the upper shores of the Mavora Lakes. Clearly, longfins have been able to migrate past the Mararoa Weir.

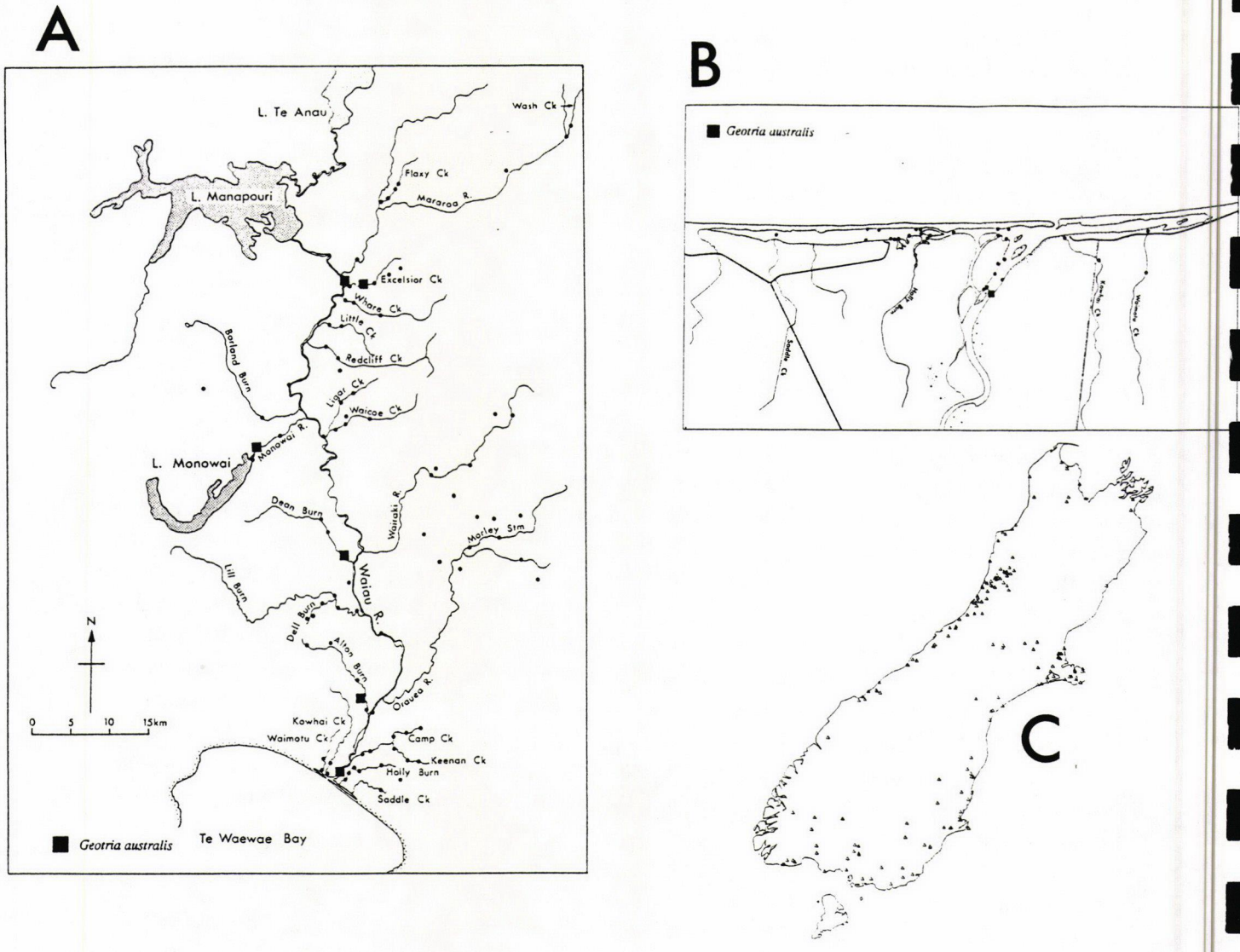


FIGURE 3. Distribution of lamprey, *Geotria australis*: Occurrence in A: mainstem; B: estuary; C: South Island

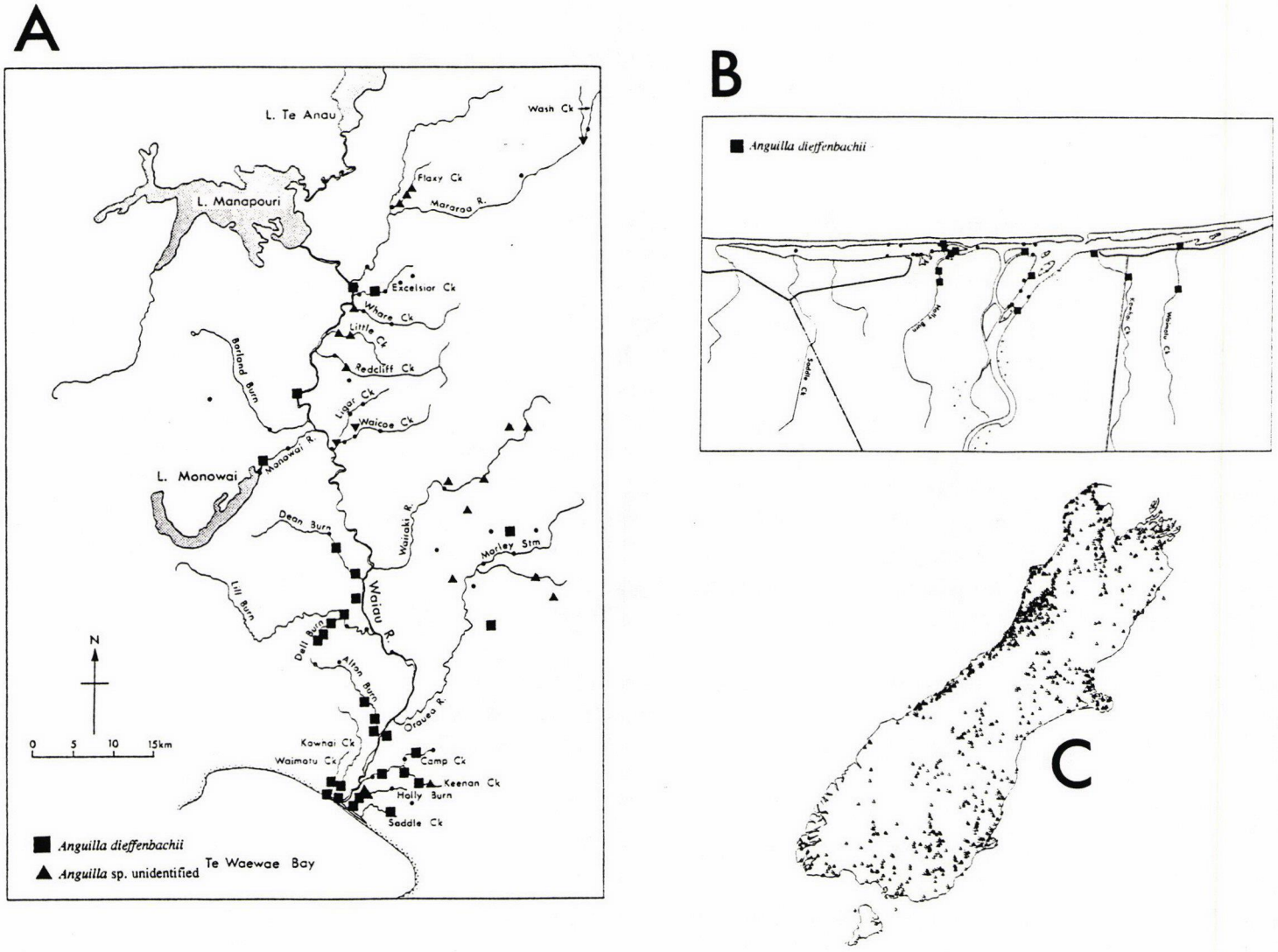


FIGURE 4. Distribution of longfinned eel, *Anguilla dieffenbachii*: Occurrence in A: mainstem; B: estuary; C: South Island

However, longfins were absent from an unusually large number of sites sampled in the river below the weir (Fig. 4 - see • for locations where they were absent), and were surprisingly sparse in most locations. They have reportedly been heavily harvested by commercial fishers over recent years (as is true of most New Zealand lakes, rivers and streams) and this is probably why they were not especially abundant. However, large numbers of small eels can be expected from the lowermost bouldery riffles of most New Zealand rivers (e.g. the Rakaia - Davis 1980, Davies *et al.* 1983), but they were absent from the first upstream riffle in the Waiau and sparse in the second; they were only occasional in the mainstem at Tuatapere, not one eel was taken from extensively searched cobble/gravel riffles in the mainstem at Clifden, about 27 km up stream, and only two after similar search at Blackmount (55 km up stream). However, they were very abundant in pool and riffles immediately below the old concrete river crossing a little below the Mararoa Weir, and were also abundant in Excelsior Creek, which joins the Waiau nearby.

7.3 Shortfinned eel (*Anguilla australis*)

(Occurs New Zealand wide.) Shortfinned eels have a life history that closely resembles that of the longfin; apart from the adults migrating to sea somewhat younger and smaller, and a little earlier in the year, they behave in the same way. Habitats occupied, however, are different, with shortfins typically occupying estuaries and low elevation swampy lakes and lagoons. However, shortfins may penetrate well inland, and their lack of abundance in inland localities may be due more to the inavailability of suitable habitats than to the lack of inland penetration; shortfinned eels may occur well inland if there are suitable habitats. (Both species, for instance, occur in Fish Lake, at elevation 1008 m, and 145 km upstream from the sea, in the Wairau River, in Marlborough.) Though broadly New Zealand-wide in range, shortfins are in general sparsely distributed and uncommon in many southern South Island waters, being much less frequent than longfins (McDowall 1990).

During sampling for this study, shortfins were taken only in the estuary (Fig. 5), though Hayes *et al.* (1992) noted records of shortfins from Lake Mistletoe, a small tarn close to Lake Te Anau, about 150 km upstream in the Waiau River system.

7.4 Common smelt (*Retropinna retropinna*)

(Occurs New Zealand wide). Common smelt spend most of their lives at sea. Sub-adults and adults enter river estuaries during the spring and summer, and feed and grow mostly in the lower reaches, where they spawn in the summer and autumn. When in fresh water they live in large, roving shoals, in open waters, or in the slower moving tributaries. The tiny larvae hatch and move immediately to sea. Common smelt occur mostly at low elevations and close to the sea (though significant inland penetration has been recorded in the Waikato, Wanganui, and Manawatu Rivers which are rivers that have long, slow-flowing, low elevation reaches). Though typically diadromous, common smelt establish landlocked populations, which are known in many parts of New Zealand. These populations undergo their entire life cycles in fresh water, with the larval stage being lake rather than sea dwelling.

Common smelt were taken in the Waiau in large numbers by seine hauls in diverse parts of the estuary (Fig. 6); they occasionally turned up in fyke nets or were gilled in their leaders.

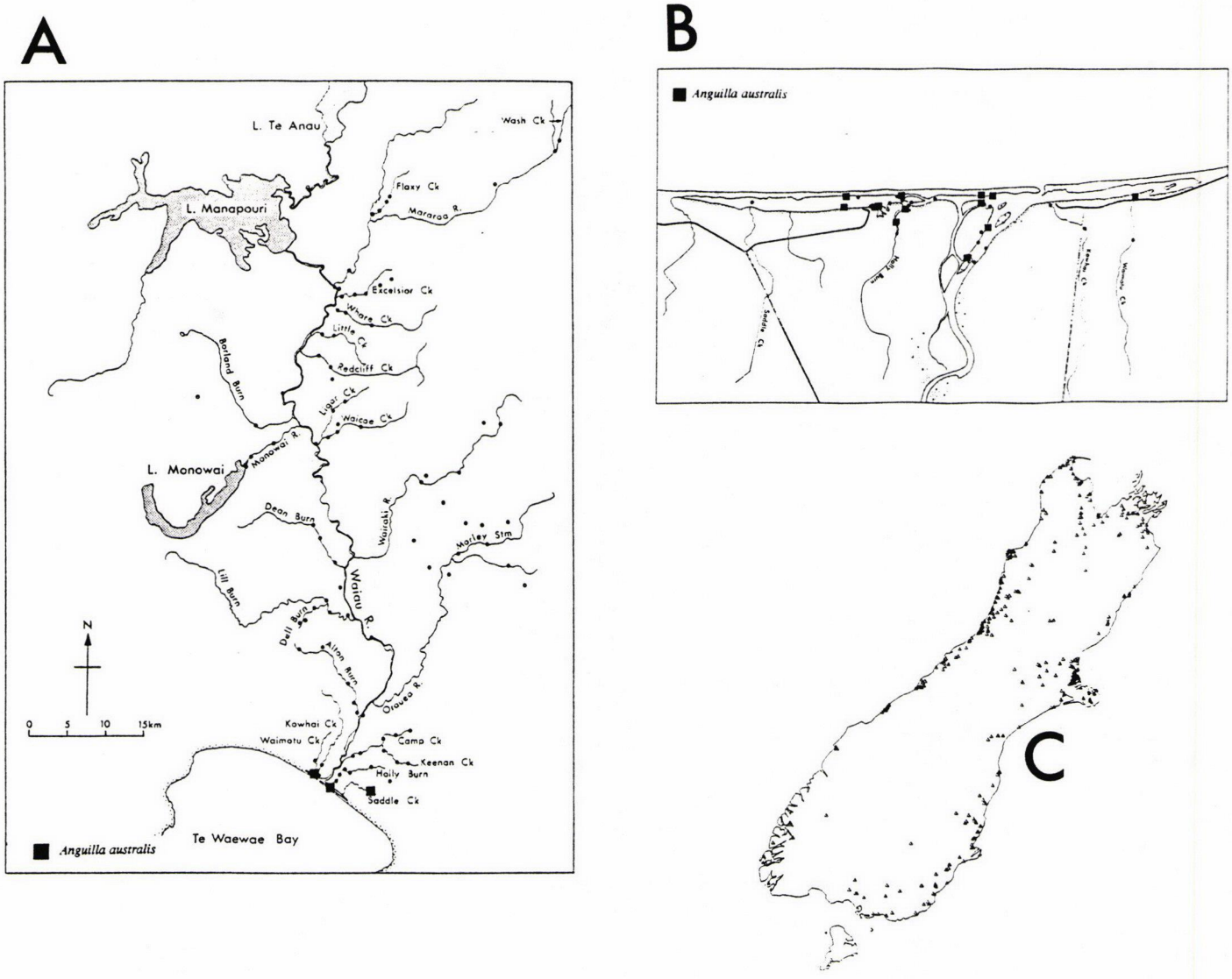


FIGURE 5. Distribution of shortfinned eel, *Anguilla australis:* Occurrence in A: mainstem; B: estuary; C: South Island

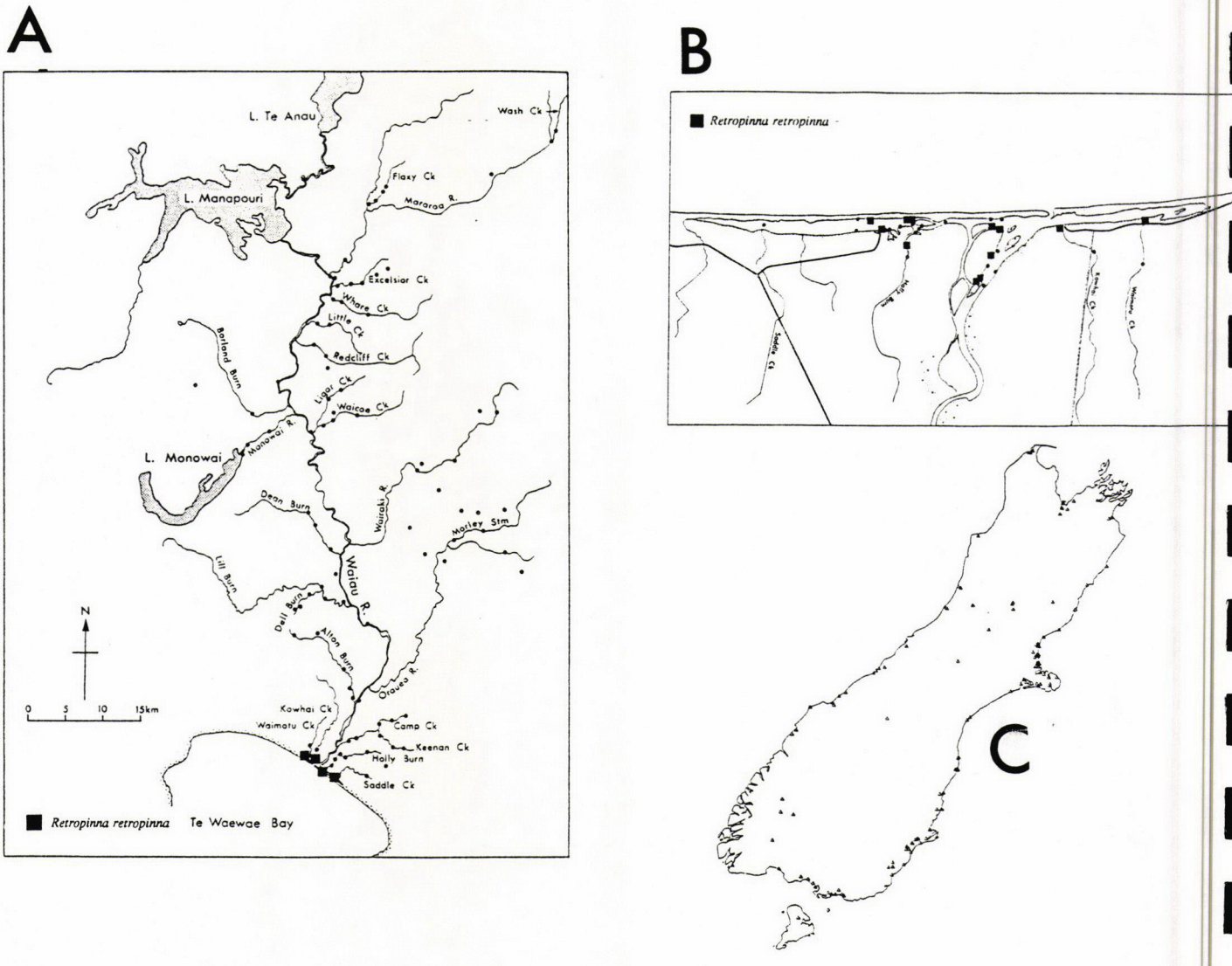


FIGURE 6. Distribution of common smelt, *Retropinna retropinna:* Occurrence in A: mainstem; B: estuary; C: South Island.

They occurred in small numbers in the lower reaches of some of the lagoon tributaries, such as Waimotu and Kowhai Creeks, at sites just beyond the estuary, but were absent at localities several kilometres up these same streams. And though smelt moved up into the lowermost reaches of these streams in the western lagoon, none were found in the Holly Burn, though seine hauls showed them to be common in the eastern lagoon near its confluence with the Holly Burn. No smelt were taken from within or near the first or second riffles in the mainstem, nor anywhere further up the river. Landlocked populations are known from Lakes Te Anau, Henry and Thomas in the Waiau catchment (McDowall 1979), and probably also Manapouri.

7.5 Stokell's smelt (*Stokellia anisodon*)

Stokell's smelt has been recorded from the Waiau in the past (Stokell 1941, 1972; McDowall 1979), but the validity of these records is dubious (Bonnett 1992a). On the basis of material collected both in the Waiau, and elsewhere in the eastern/southern South Island, the species is now considered to be present only in rivers from North Canterbury to North Otago; it seems more likely that Stokell's (1941) fish came from the Waiau-ua in North Canterbury (McDowall, In Press).

7.6 Inanga (*Galaxias maculatus*)

(Occurs New Zealand wide). Inanga are the adults of most of New Zealand's whitebait, and are diadromous, with larval life spent in the sea. The larvae return to rivers as the familiar whitebait, during the spring, when they are the target of the whitebait fishery. Those whitebait that escape capture move upstream into slack-water habitats, such as gently flowing streams, lagoons, and backwaters, where they grow to maturity over the summer, and mature. Some inanga may penetrate upstream if flow velocities are not too daunting, and may occur in the margins of moderately swiftly-flowing waters, where the shoals disperse and the fish are more often found singly amongst marginal cover. In autumn, they migrate back downstream into the river estuaries, and spawn amongst vegetation along the estuary margins when these are flooded by high spring tides. When the eggs hatch, the larvae move to sea to complete the life cycle.

Substantial whitebait runs enter the Waiau River, the bulk of which are probably inanga (see section 8.). In the lower Waiau, inanga were occasionally found in the body of the estuary (Fig. 7), but large shoals of post-whitebait inanga were present in at least some, of the tributaries/channels leading into the lagoon. These shoals, in small channels and tributaries that join the lower mainstem, are probably typical of the system as a whole. They were common in the lower reaches of Kowhai and Waimotu Creeks, near the western lagoon, and present in small numbers in the lower Holly Burn feeding the eastern lagoon, but lacking from locations a few kilometres up all of these streams.

7.7 Koaro (*Galaxias brevipinnis*)

(Occurs New Zealand wide): Koaro are also adult whitebait, though their juveniles make up only a minority part of the whitebait fishery (see section 8). When koaro whitebait enter

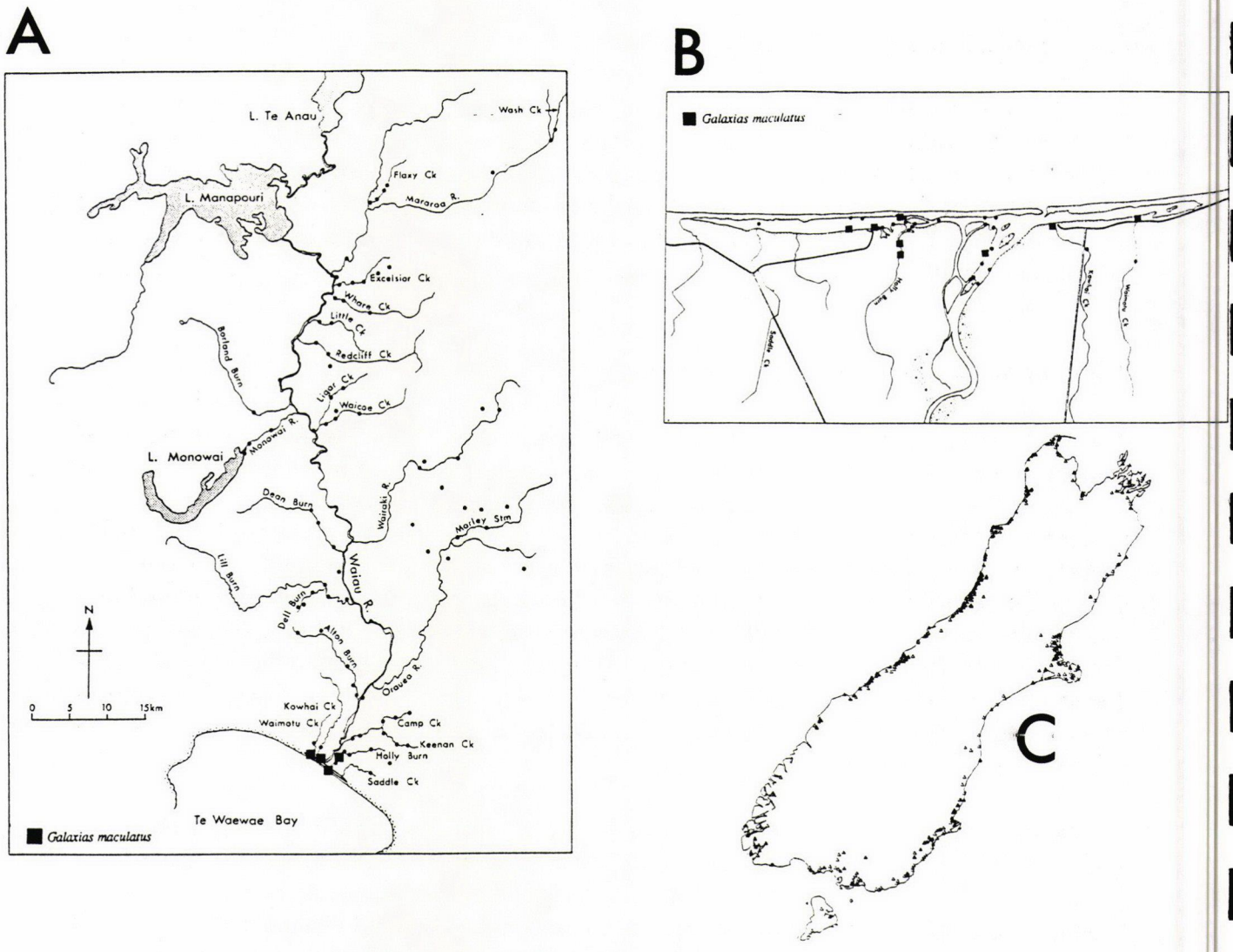


FIGURE 7. Distribution of inanga, *Galaxias maculatus:* Occurrence in A: mainstem; B: estuary; C: South Island.

rivers, they tend to become bottom dwelling quite quickly, and may be found in the cobble/gravel riffles of the lower rivers (McDowall and Eldon 1980). They are vigorous migrants in rivers, and move upstream into small to moderate-sized, swiftly-flowing boulder/cobble streams, typically where there is strong forest cover. They live, and are thought to breed, there (in late autumn and winter) (McDowall *et al.* 1994), with the larvae carried downstream through the river systems and to sea, where they spend the winter feeding and growing to the whitebait stage.

Koaro were found in the Waiau estuary, lower mainstem and tributaries only as follows (Fig. 8): two koaro post-whitebait from the second rapid in the lower Waiau; another from a riffle in Camp Creek just above the main road bridge, about 3 km upstream from the confluence with the Waiau and about 7 km from the river mouth; these records are consistent with the above-mentioned habit of the pigmented post-whitebait becoming benthic and riffle-dwelling soon after leaving the sea. A small group of adult koaro (four only), was taken from a small remnant of native forest in Camp Creek about 6 km further upstream (13 km from the river mouth); and another single adult was taken in a small, unnamed tributary that enters the mainstem a few kilometres upstream of the Lill Burn (38 km inland). We neither saw nor captured koaro anywhere else in the system, though landlocked populations are known from Lakes Manapouri, Te Anau, Gunn and Fergus, and the Mavora Lakes (Hayes *et al.* 1992) in the upper river.

In these populations, the usually marine larval stage is replaced by a lake-living larval stage. There is no reason to think that there is any continuing connection between these lake stocks of koaro and the whitebait runs at the river mouth - they probably form separate, reproductively-isolated populations.

Koaro whitebait constituted 7.6% of a sample of 1580 whitebait taken at the mouth of the Waiau (date of capture unknown - however, we are presently unable to distinguish whitebait of koaro from those of shortjawed kokopu, a rare species anywhere in New Zealand, and it is possible that some of this 7.6% were shortjawed kokopu). This figure shows that substantial numbers of koaro are entering the river, but other than the above few fish, we were unable to determine where they were finding habitats in which to grow to maturity, in spite of widespread sampling in forested and pasture streams in the lower catchment and in areas where koaro where expected to occur.

7.8 Giant kokopu (*Galaxias argenteus*)

(Occurs New Zealand wide.) The juveniles of giant kokopu are also whitebait, with a life history that closely resembles that of koaro (see above). Giant kokopu are secretive fish of swamplands and lagoons, and low elevation, slow-flowing streams, especially in waters in which there is plenty of instream cover, overhung banks, and the like (they abound, for instance, in Lake George, a little east of the Waiau). They typically do not penetrate long distances inland and are not strong climbers of falls and rapids. As is true of koaro, giant kokopu can establish landlocked populations, which occur widely across Southland, (e.g. in old Mataura River oxbows near Freshford) as well as elsewhere in New Zealand (McDowall 1990).

From their general distribution, their occurrence in the rivers of Fiordland to the west of the Waiau and Lake George to the east, and elsewhere in southern New Zealand and Stewart

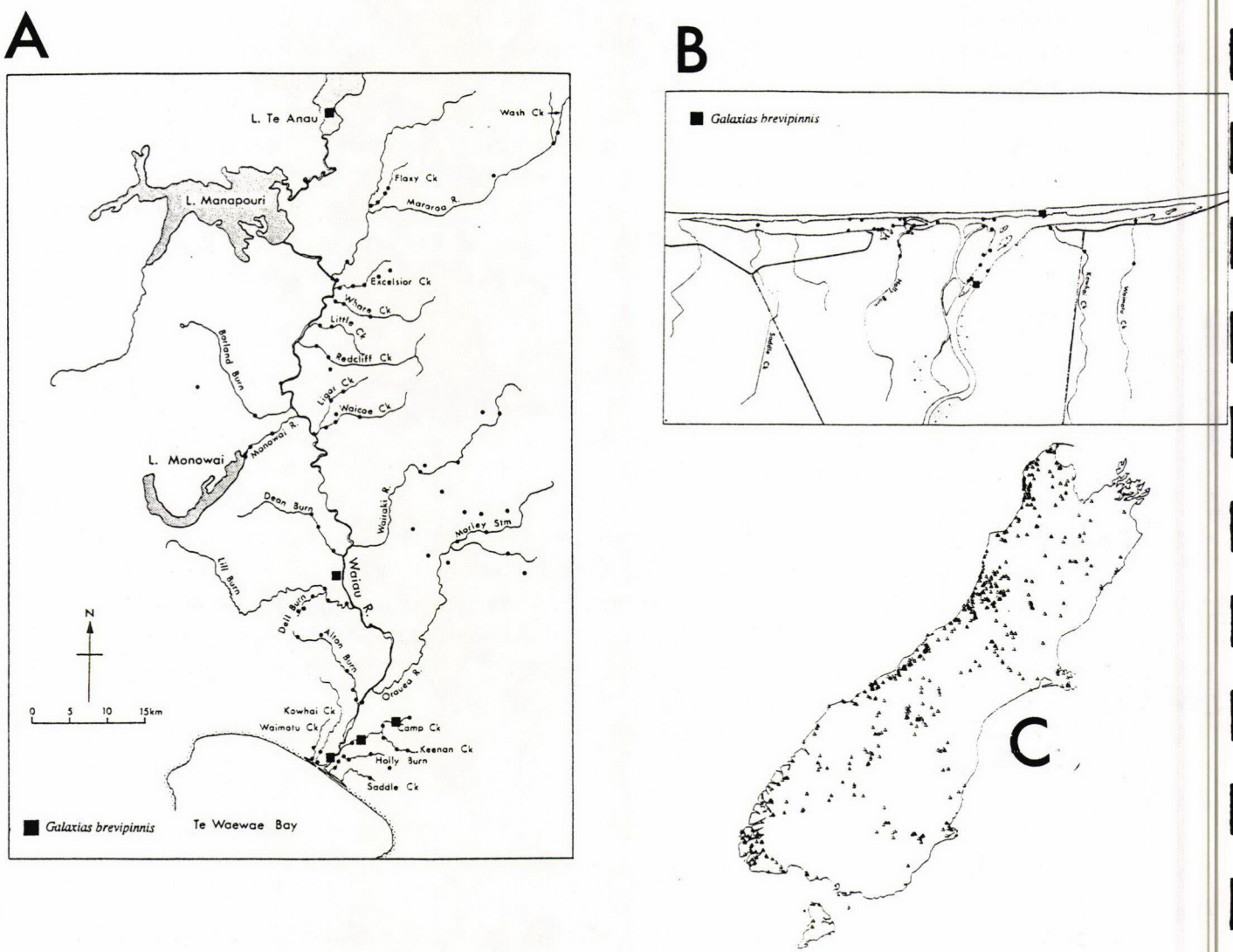


FIGURE 8. Distribution of koaro, *Galaxias brevipinnis:* Occurrence in A: mainstem; B: estuary; C: South Island.

Island (Fig. 9), giant kokopu would be expected in the Waiau. However, we found no giant kokopu during our sampling anywhere in the system. The species has been recorded from Lake Monowai (almost certainly a landlocked stock), and also from the Monowai River just below the dam (most likely expatriates of the Lake Monowai landlocked stock). They are also present and presumably landlocked in Lake Mistletoe, a small lake associated with upper Lake Te Anau, not far from the Eglinton River. The samples of whitebait taken at the Waiau River mouth contained 4.7% of "kokopu" whitebait, probably including both giant and banded kokopu. (They had been frozen and their condition prohibited precise identification, but it is likely that at least some of these were giant kokopu.)

7.9 Banded and shortjawed kokopu (*Galaxias fasciatus* and *G. postvectis*)

These two further large galaxiids are also whitebait species (there are five, in all - McDowall 1984, 1990) that live typically in small to moderate-sized, bouldery streams in native forest. They are New Zealand-wide in occurrence, both occur at least in the rivers of southern Fiordland, and at least banded kokopu on Stewart Island. Both would be expected to occur in the Waiau but we found none of either species there. It seems likely that some of the "kokopu" and koaro whitebait taken at the Waiau River mouth (discussed in section 8) were banded and perhaps shortjawed kokopu. If they were, we found no trace of adult populations in the system (Figs. 10 and 11).

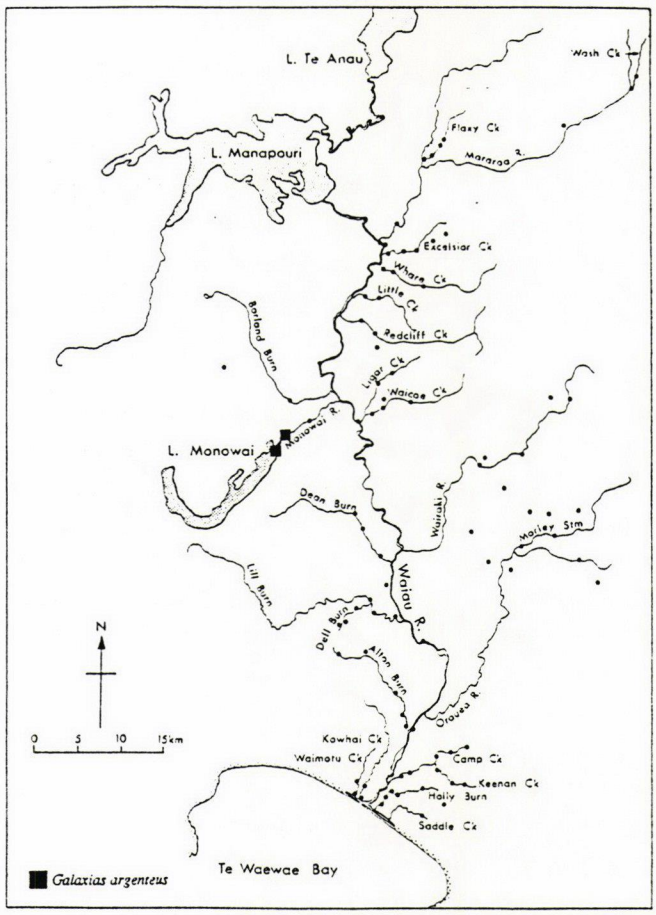
The Southland Acclimatisation Society "provisionally identified" a fish taken from the Te Anau hatchery water race as banded kokopu (it was not identified as such by me, as suggested in Hayes *et al.* 1992). This record is of dubious validity and there have been no further suggestions that banded kokopu are present there; the fish could well have been a giant kokopu, or a koaro, both of which are known in Lake Te Anau or associated waters. And, as suggested by Hayes *et al.* (1992), if the fish was a banded or giant kokopu it could have been derived from a landlocked stock of this species in Lake Te Anau and Mistletoe.

7.10 Common river galaxias (*Galaxias vulgaris)*

Found in the Otago and Southland. There are two quite distinct forms of "common river galaxias" in Southland, including the Waiau, and their identity and nomenclature are in need of study. While hitherto referred to as "*Galaxias vulgaris*" it is apparent that neither of these Southland "common river galaxias" are the same as "true" common river galaxias from Canterbury. This question aside, for the present, the two forms are referred to here as "flathead" and "roundhead" for the obvious reason that the dorsal profile in the head of one form is flat, with no curve from the interorbital to the tip of the snout, while in the other there is a distinctly rounded snout with a convex profile from the interorbital to the tip of the snout. Both forms are widespread in the Waiau. Unlike all previously discussed species, both of these forms are found only in fresh waters, having no sea-migratory juvenile stages. Post-larvae and juveniles of both forms were sometimes encountered around the margins of pools when collecting during December 1993, indicating a spring spawning, as is true for other fish of this general type (McDowall 1990).

Roundhead galaxias is almost certainly the same as the fish described from central Otago as *Galaxias anomalus* by Stokell (1959). They occur mostly in lower elevation streams with,

A



B

NO RECORDS FROM ESTUARY

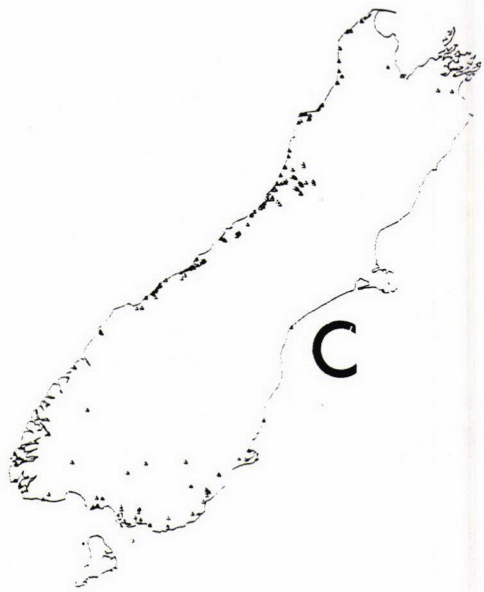


FIGURE 9. Distribution of giant kokopu, *Galaxias fasciatus:* Occurrence in A: mainstem; B: estuary; C: South Island.

A

NO RECORDS FROM MAINSTEM AND TRIBUTARIES

B

NO RECORDS FROM ESTUARY EXCEPT AS WHITEBAIT

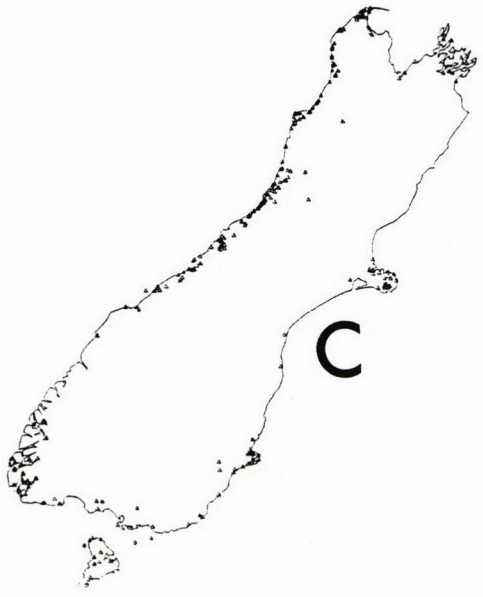


FIGURE 10. Distribution of banded kokopu, *Galaxias fasciatus:* Occurrence in A: mainstem; B: estuary; C: South Island.

A

NO RECORDS FROM

MAINSTEM AND

TRIBUTARIES

B

NO RECORDS FROM

ESTUARY

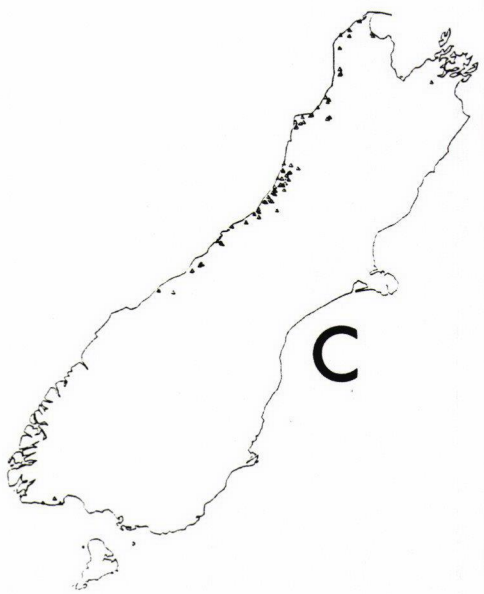


FIGURE 11. Distribution of shortjawed kokopu, *Galaxias postvectis:* Occurrence in A: mainstem; B: estuary; C: South Island.

for instance, one population in Saddle Creek at about 50 m altitude, which drains directly into the Waiau Lagoon (Fig. 12). Usually, it occurs in small streams, often winding, gently flowing, and deeply entrenched, with muddy/gravel substrates, often in bush. The flathead galaxias is an undescribed species. It is rather more inland in distribution, and was found more often in open, unstable, shingly/gravel streams that were swiftly flowing. It occurs occasionally in the Waiau mainstem, most likely as a result of juveniles being swept there from the tributaries. The two forms were never taken together from the same waters, although roundhead galaxias from the Dell Burn were only a few kilometres from flathead galaxias in the Lill Burn (Fig. 12). Both their distributions and habitat types overlap broadly.

7.11 Alpine galaxias (*Galaxias paucispondylus*)

(Occurs widely in the South Island east of the Southern Alps.) The alpine galaxias is a species of small gravelly streams and larger river margins, at moderate to high elevations; it is entirely freshwater dwelling with no sea migrations (Bonnett 1992b).

In the Waiau it has been recorded only in a tributary of the Mararoa River upstream of North Mavora Lake, and its occurrence is not relevant to the impacts of the Mararoa Weir in the Waiau River.

7.12 Torrentfish (*Cheimarrichthys fosteri*)

(Occurs New Zealand wide.) Torrentfish occupy distinctive habitats, typically shallow, swift, broken, white-water rapids with coarse cobbly substrates (Jowett and Richardson, in press), usually relatively close to the sea (though penetration of rivers to 30-50 or more kilometres is not unusual - McDowall 1990). The life history of torrentfish is not well documented, though it is thought that reproduction takes places in downstream locations in rivers, and that probably the eggs hatch there and the larvae go to sea. It is known that juvenile torrentfish, about 20-25 mm long, make their way back into rivers from the sea during the spring and summer; they move upstream from there to occupy the swift bouldery rapids that they favour. Females are known to be distributed further upstream than males (Scrimgeour and Eldon 1989) so that substantial breeding migrations are indicated, probably involving females moving downstream to where the males live, to mate, and presumably returning upstream.

Torrentfish were found only intermittently and sparsely in the lower Waiau (Fig. 13). We expected torrentfish to abound in the mainstem above the estuary as habitats appeared suitable, but they were rare there - just one taken at each of the two lower rapid after extensive search. A few were taken from Waimotu Creek just above its confluence with the western lagoon, but none further upstream, and none at either station in Kowhai Creek. None was found in the Holly Burn (though habitats were not ideal), nor in any other Waiau lagoon tributaries. None was found at apparently suitable habitats in the mainstem at Tuatapere, nor any in Camp Creek or Alton Burn, again in spite of apparently suitable water and substrate conditions there . Eight torrentfish were taken at Clifden after prolonged search in many riffles. We caught one in the lower Lill Burn, another in the lower Dean Burn, and the species has been recorded in the Monowai River (4 seen while drift diving) and Redcliff Creek (one fish captured electric fishing - SF&GC records).

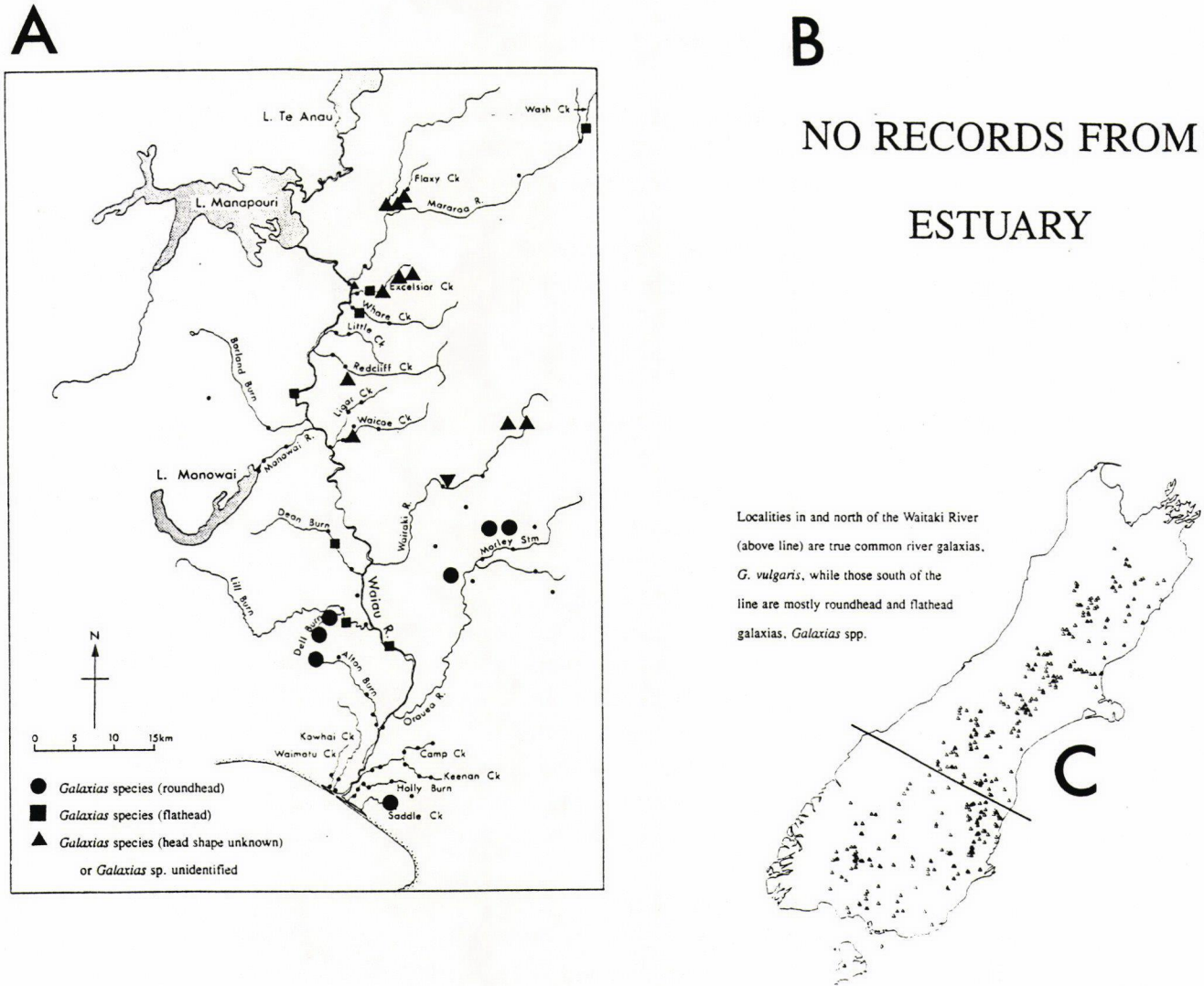


FIGURE 12. Distribution of roundhead and flathead galaxias, *Galaxias* spp. Occurrence in A: mainstem; B: estuary; C: South Island.

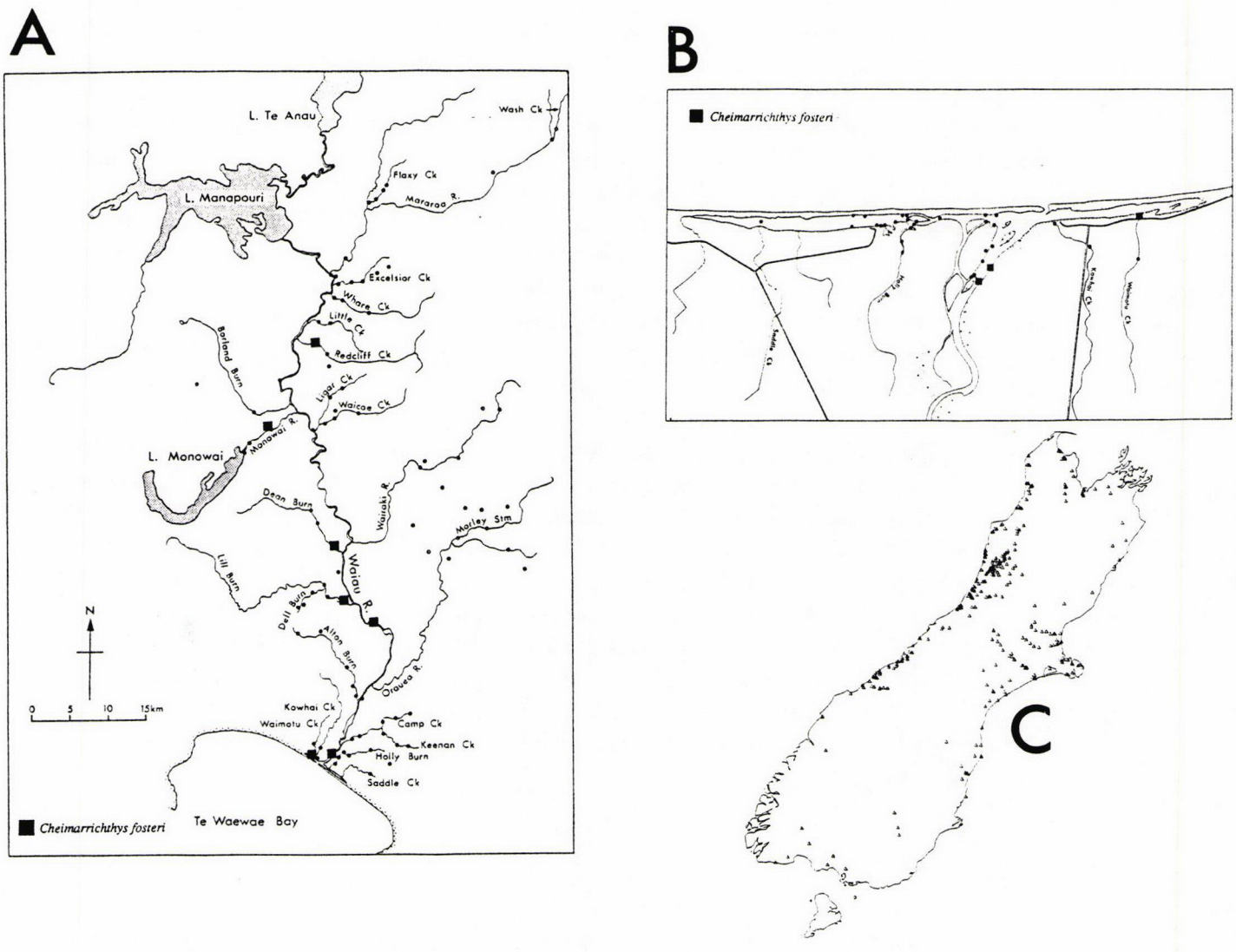


FIGURE 13. Distribution of torrentfish *Cheimarrichthys fosteri:* Occurrence in A: mainstem; B: estuary; C: South Island.

7.13 Common bully (*Gobiomorphus cotidianus*)

(Occurs New Zealand wide.) Common bullies are open-living fish of sandy and gravelly shores, in estuaries, lagoons, streams and rivers. The common bully life history typically involves the adults pairing and laying batches of eggs beneath cobbles and boulders close to normal adult habitats through the spring and summer. The larvae are believed to be swept to sea on hatching and probably spend several months there, later returning to rivers to find habitats in which to grow and mature.

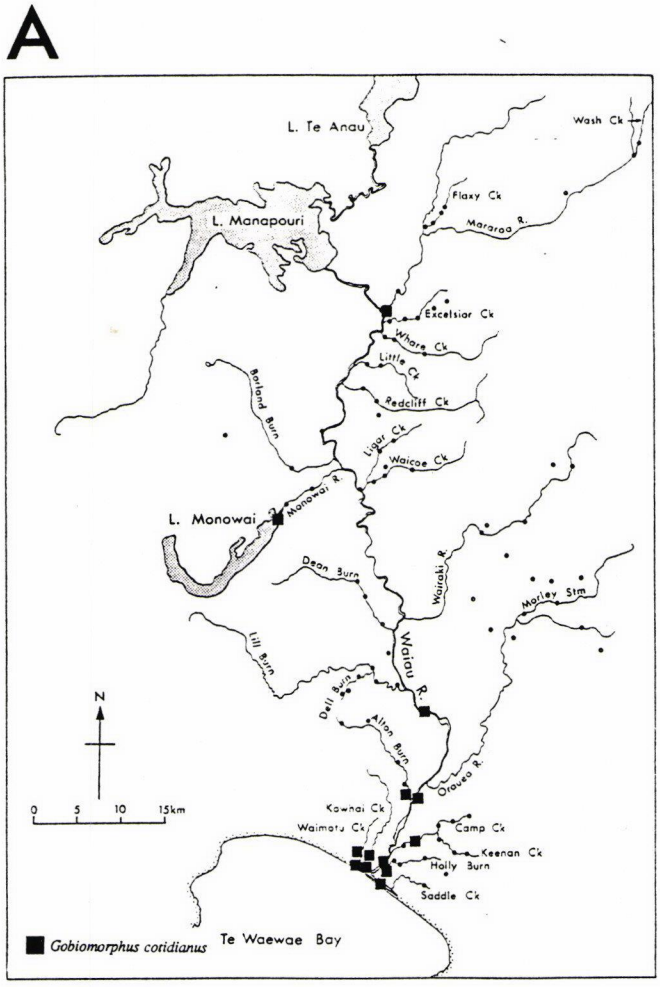
Common bullies were widespread and abundant in many parts of the Waiau estuary (Fig. 14). Seine hauls in the Waiau lagoon always captured a few common bullies from sandy/gravel shores, and the species is probably under-represented by this sampling technique, as also by fyke netting. The lower Waiau rapids also carried very large numbers of common bullies, and they occurred at virtually all sampling stations in the lower river or its tributaries. However, abundance had declined considerably by sampling locations near Tuatapere (about 11 km up stream), where common bully occurred only occasionally, rarely at Clifden and none at Blackmount. Some tributaries had good populations of common bully but always at low elevations, including the lower reaches of Waimotu and Kowhai Creeks; they were present at the lower station in Camp Creek (main road), and in the lower Holly Burn, but were absent from both tributaries upstream of these points. In tributary streams, they were present both in the open, along sandy shores and in slow flowing waters, and also from amongst cobble/boulder substrates in runs and riffles.

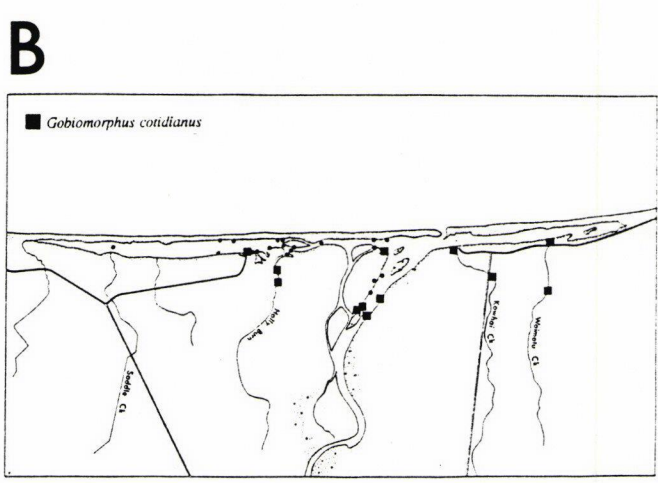
The common bully easily becomes landlocked, and populations occur in such lakes as Te Anau, Manapouri and Monowai. James (1967) observed that it was common in Manapouri and Monowai. Occasional common bullies, found in rivers in the upper reaches of the system - such as the Monowai River below the dam and the Waiau River below Lake Manapouri - are likely to be expatriates from landlocked stocks rather than fish that have moved upstream from the sea/estuary. Dr J.A.T. Boubée (NIWA, Hamilton - pers. comm.), who has worked extensively on the fish stocks of the lower Waikato River, considers it likely that some rearing of larval/juvenile common bullies in that system takes place in the lower river and estuary without any recourse to marine habitats. The same may apply to the Waiau, especially the eastern lagoon, where inflows of water from tributaries are slight and water turnover probably very slow.

7.14 Redfinned bully (*Gobiomorphus huttoni*)

(Occurs New Zealand wide.) The redfinned bully is a much more secretive fish than the common bully, and is typically taken from boulder/cobble streams and small rivers, most often towards the tails of pools, where flows are gathering pace before spilling over into a riffle and there is coarse, open substrate. Its life history is essentially the same as that of the common bully, except that spawning seems to be confined largely to the spring period. Landlocked stocks of redfinned bullies are not known.

Redfinned bullies were rarely encountered anywhere in the Waiau (Fig. 15), with a few being taken in Waimotu and Kowhai Creeks just above the lagoon, and an occasional example about a further 3 km up Waimotu. None were encountered from the two lower river rapids sites in the Waiau mainstem. One was taken from the Alton Burn, near where it joins the





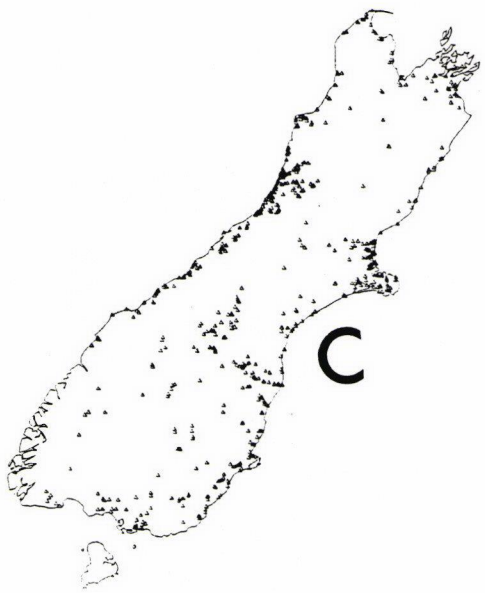


FIGURE 14. Distribution of common bully *Gobiomorphus cotidianus*: Occurrence in A: mainstem; B: estuary; C: South Island.

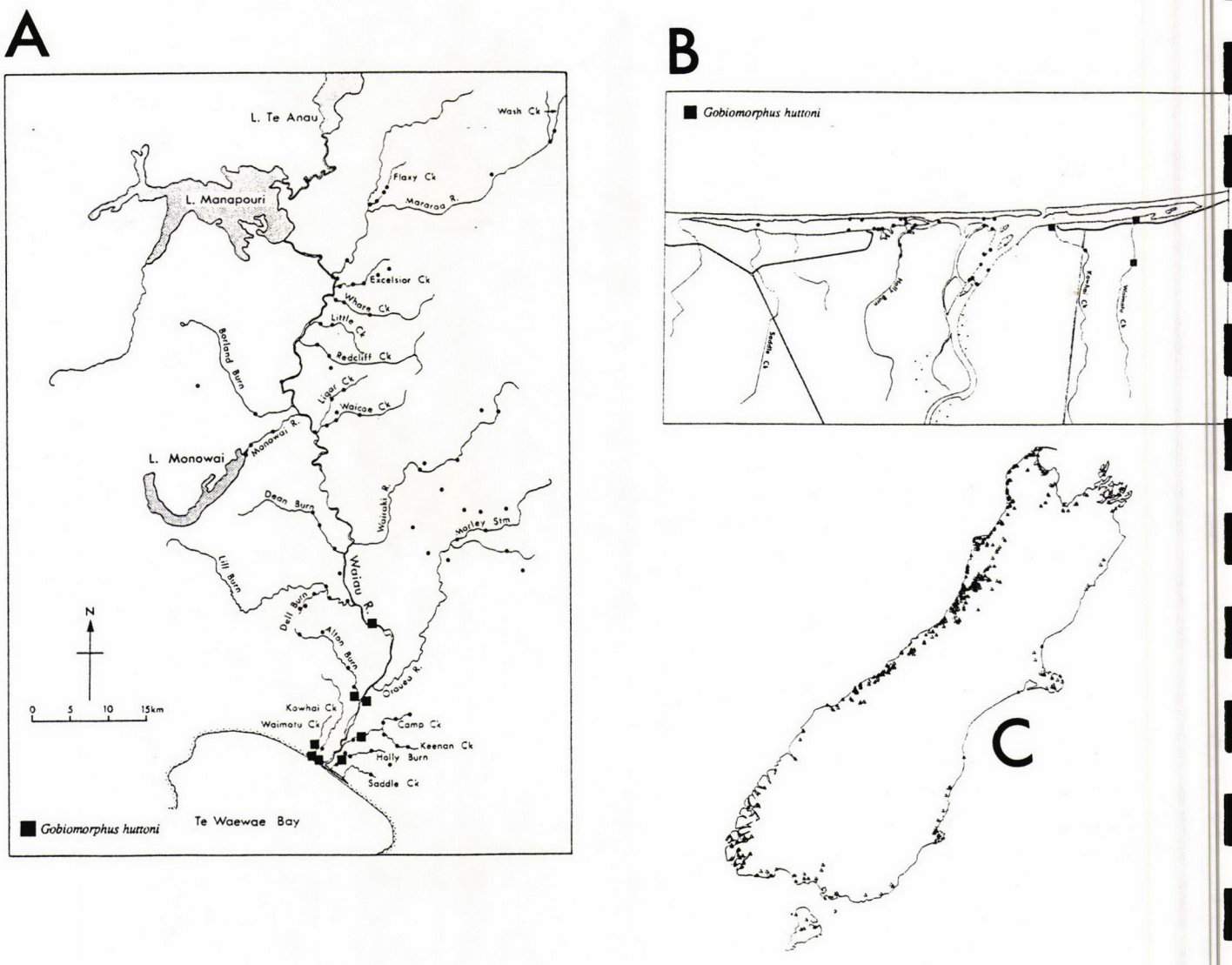


FIGURE 15. Distribution of redfinned bully *Gobiomorphus huttoni*: Occurrence in A: mainstem; B: estuary; C: South Island.

Waiau. But there were none in the lower Waiau rapids, nor at Tuatapere, nor any in Camp Creek or the Holly Burn. Several were captured in the mainstem at Clifden after a prolonged search, but none at Blackmount.

7.15 Bluegilled bully (*Gobiomorphus hubbsi*)

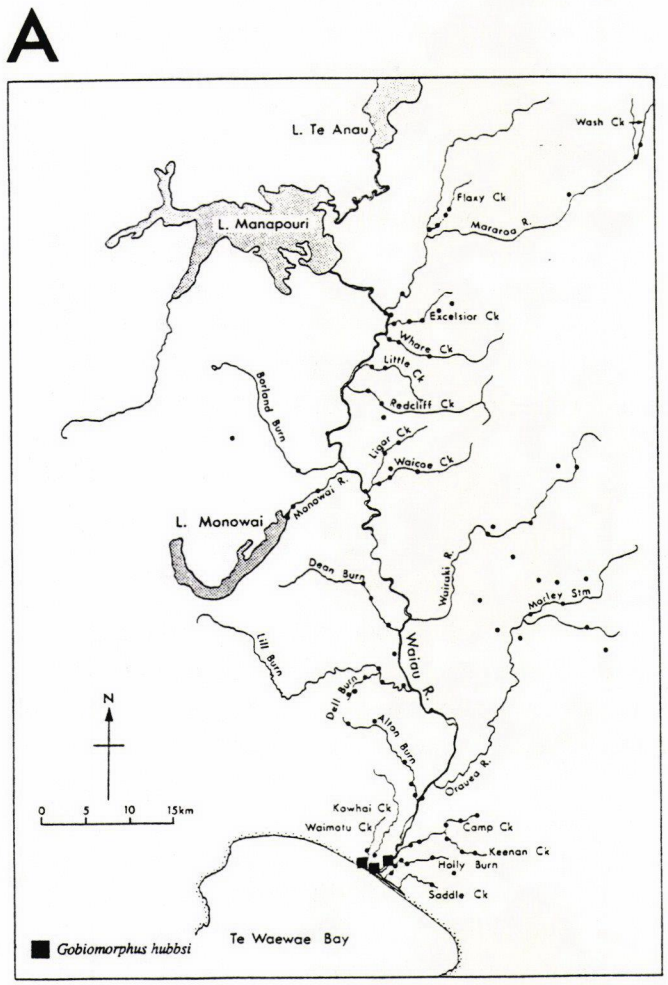
(Occurs New Zealand wide.) The habitat in which bluegilled bullies are most often found (Jowett and Richardson, in press) is similar to that of torrentfish - swiftly-flowing, rough, shallow, boulder/cobble riffles and rapids, though often more towards the river margins than torrentfish. Bluegilled bullies are thought to follow a life history pattern very similar to that of common bullies, with a prolonged, spring and summer breeding season, the eggs laid beneath boulders in the riffles, and the larvae going to sea and returning to fresh water several months later. No landlocked populations are known.

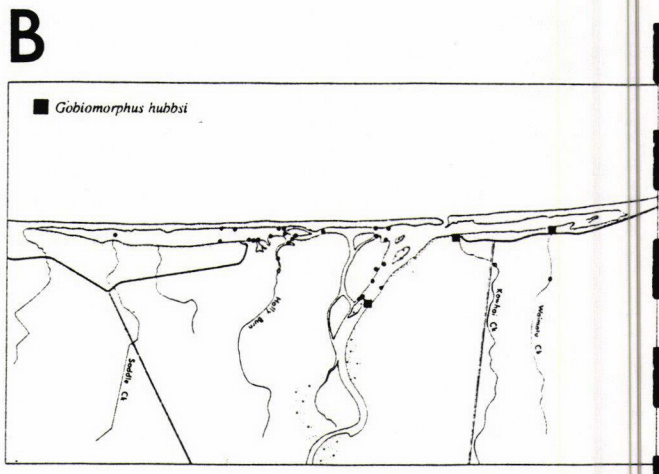
Few bluegilled bullies were found in the Waiau (Fig. 16) and there are few archival records of the species. A few (six fish) were taken from one of the two lower Waiau rapids, but none from the other after extensive search in what appeared to be suitable habitat. They were quite common in lower Waimotu Creek, though these were mostly juveniles that had recently entered the stream from the sea, they were occasional at lower Kowhai Creek, and were otherwise absent from the lower Waiau (Tuatapere and Clifden) and its tributaries, including very likely-looking water in lower Camp Creek.

7.16 Upland bully (*Gobiomorphus breviceps*)

(Occurs in the southern North Island and widely in the northern and eastern South Island.) Upland bullies are entirely freshwater dwelling fish. They occupy very diverse habitats, occurring in: small ponds and larger lakes; creeks, drains, and small streams; along the marginal shallows of larger streams and rivers; and in still or quite swiftly flowing waters. They are found from sea level to as much as 1000 m elevation.

We found surprisingly few upland bullies in the Waiau system. None was captured in the lagoons, the lower river or the tributaries that join it. This is mentioned here because this species is widespread and often abundant at low to sub-montane elevations throughout the eastern South Island (Fig. 17), and including low elevations in the Oreti Aparima, and Mataura Rivers, a little east of the Waiau in Southland. Some were taken from the Dean Burn, Excelsior Creek and Wash Creek, but the species was nowhere common. There are archival records of unidentified bullies from the upper Waiau and its tributaries, (and these are included in Figure 17 - triangles, since it is most likely that they were upland bullies). If this assumption is accepted, upland bullies are quite widespread in the Waiau, but they appear absent from many apparently suitable locations and cannot be described as abundant anywhere on the basis of existing information. James (1967) found upland bullies common in Ligor Stream but none in the Borland Burn.





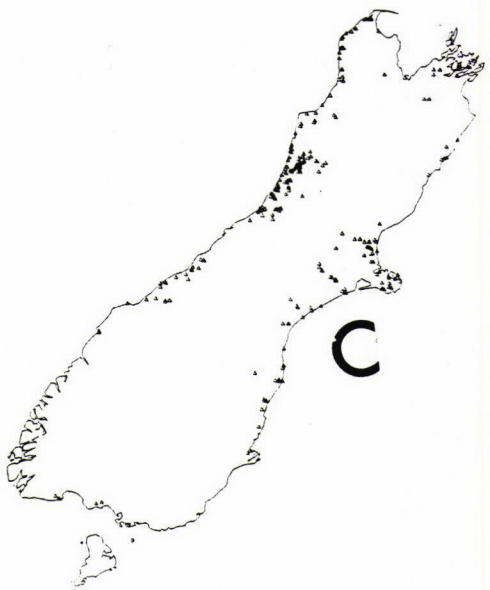
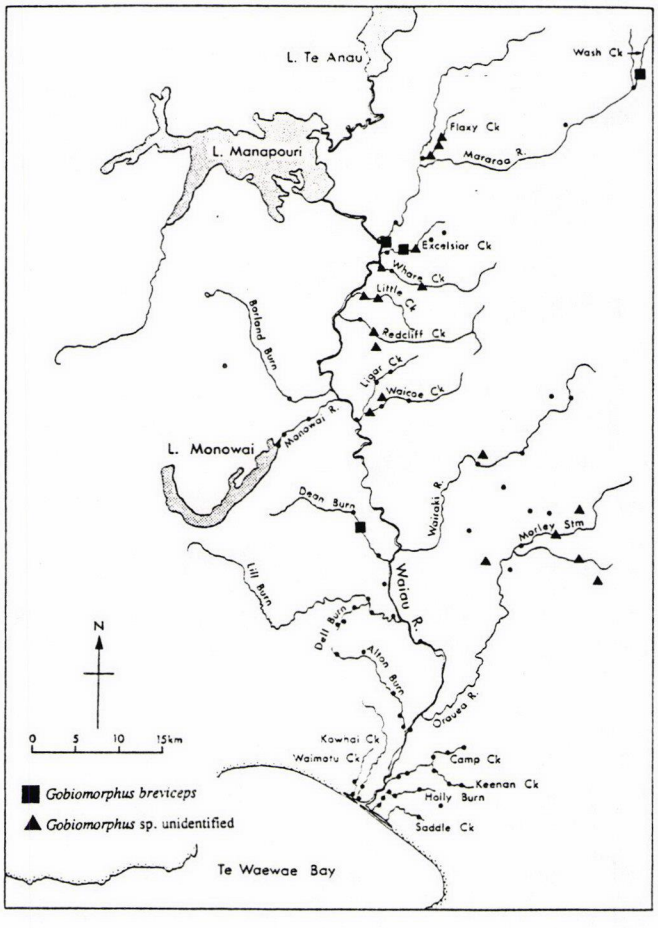


FIGURE 16. Distribution of bluegilled bully *Gobiomorphus hubbsi*: Occurrence in A: mainstem; B: estuary; C: South Island.

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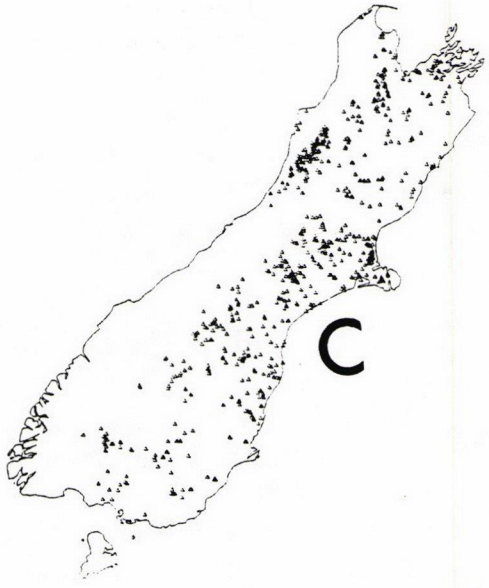


FIGURE 17. Distribution of upland bully *Gobiomorphus breviceps*: Occurrence in A: mainstem; B: estuary; C: South Island.

7.17 Black flounder (*Rhombosolea retiaria*)

(Occurs New Zealand wide.) Black flounder are truly freshwater fishes, inasmuch as they spend their juvenile through to at least early adult life in rivers and lakes. They are certainly capable of living in fresh waters for long periods, though they are believed to return to the sea to spawn, probably in winter. Small juvenile black flounders (15-20 mm long) are encountered making their way into rivers and lowland lakes from the sea during the spring. They occupy diverse habitats, varying from muddy/sandy estuaries, through low elevation lakes, to sandy pools in rivers, and even gravelly/cobbly river reaches. Inland penetration, while not as aggressive as in some migratory species, may be 50 or more km from the sea.

Black flounder were common and widespread in the eastern Waiau lagoon (Fig. 18), including small juveniles and very large adults (to > 430 mm). They were found upstream in the mainstem as far as the first two rapids, though they were few there, and small. None was taken beyond the upper estuary in this survey. Hayes *et al.* (1992) reports a Southland Acclimatisation Society record from mid-Waiau, and this is consistent with knowledge of the species elsewhere (McDowall 1990).

7.18 Yellowbelly flounder (*Rhombosolea leporina*)

(Occurs New Zealand wide.) Yellowbelly flounder are largely marine/estuarine fish that are able to live in low salinity waters, such as the Waiau lagoon, but are not found in purely fresh waters, are not known to penetrate upstream beyond estuarine waters, and are best regarded as adaptable marine wanderers; presumably they, too, return to sea to spawn.

Yellowbelly flounders were a minority species in the Waiau lagoon, being widespread and present as both juveniles and adults (Fig. 19). Their presence as a minority flounder species in the Waiau lagoons is consistent with knowledge of their presence elsewhere in New Zealand river systems.

7.19 Yelloweyed mullet - *Aldrichetta forsteri*

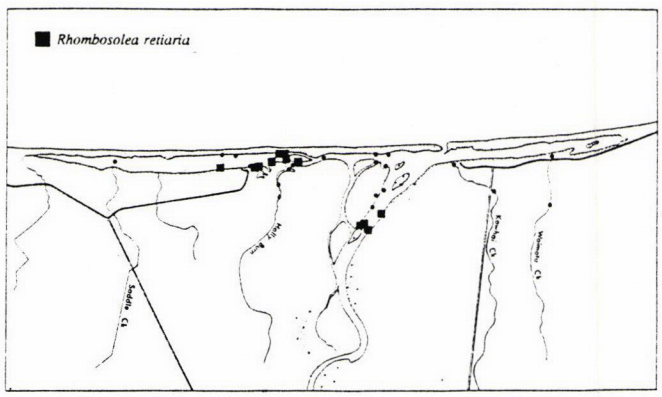
(Occurs New Zealand wide.) Yelloweyed mullet are essentially marine fish that have a high tolerance of the reduced salinities that prevail in river estuaries, where they frequently occur. They are extensively detritus feeders, and no doubt make a living feeding on bottom detritus, on algae growing on rocky and mud substrates, plus small organisms that are found in the lagoon. They probably cannot live in the low salinities of the lagoon indefinitely, and so there is likely to be constant movement of yelloweyed mullet to and from the lagoon. They often enter river estuaries on the rising tide and leave again on the falling tide, though this is unlikely to be true of the population in the eastern lagoon. Yelloweyed mullet certainly return to sea to spawn.

Gill net sets showed yelloweyed mullet to abound in the open waters of the eastern Waiau lagoon, and probably occur widely in both lagoons (Fig. 20). Most mullet taken were medium to large in size (> 150 mm), though this may have been due to the mesh sizes of the gill nets (by which means most mullet were taken). A few were taken in fyke nets, gilled in the leaders of these nets, or in seine hauls.

A

NO RECORDS FROM MAINSTEM AND TRIBUTARIES

B



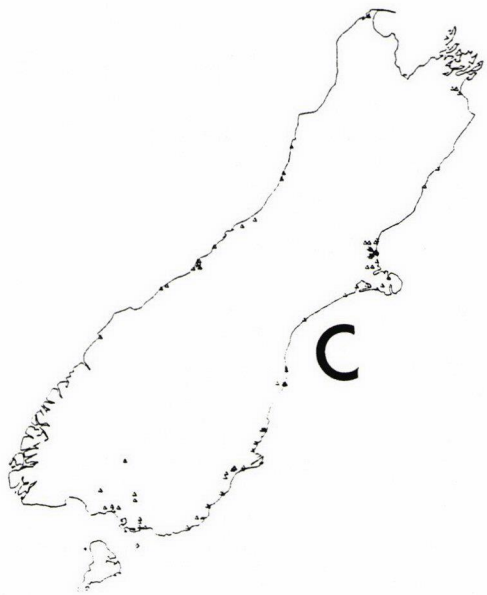


FIGURE 18. Distribution of black flounder *Rhombosolea retiaria*: Occurrence in A: mainstem; B: estuary; C: South Island.

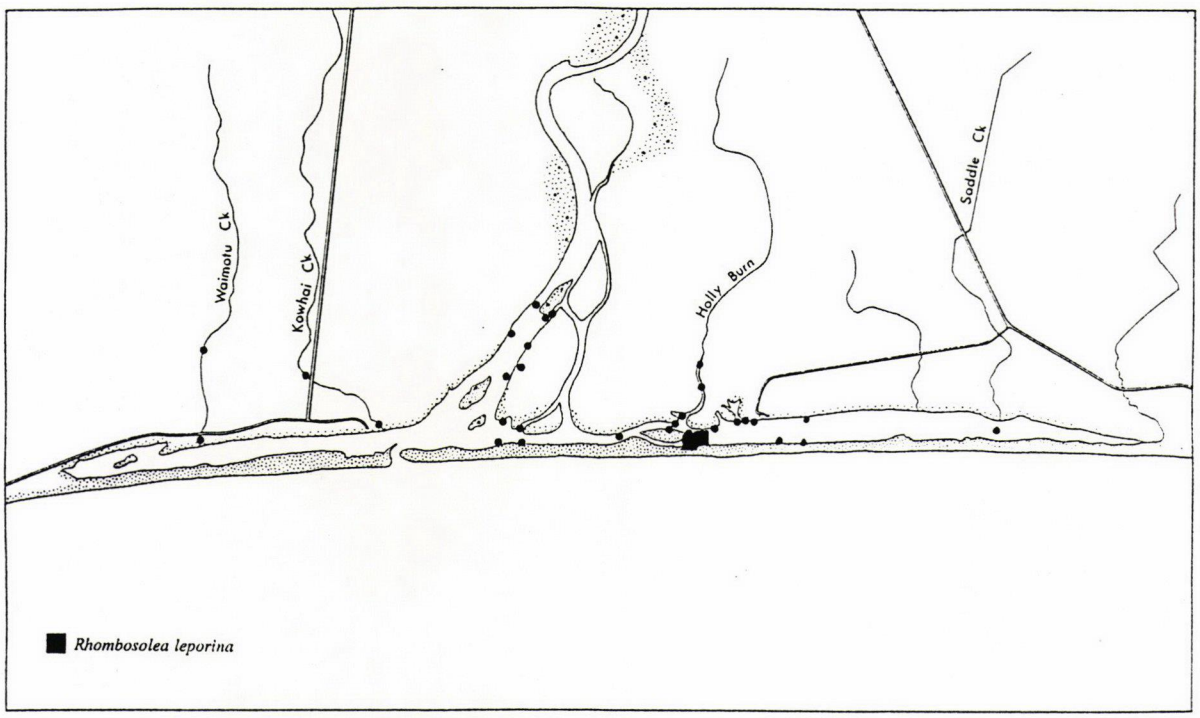


FIGURE 19. Distribution of yellowbelly flounder *Rhombosolea leporina* in the Waiau River estuary.

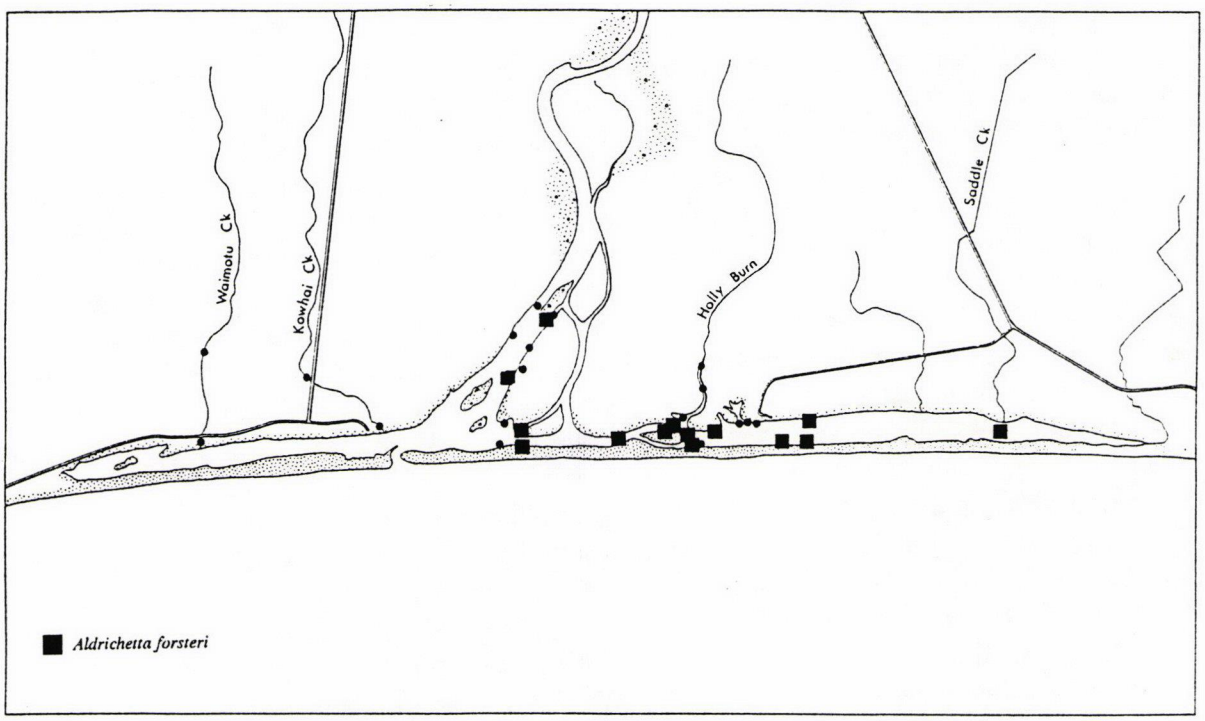


FIGURE 20. Distribution of yelloweyed mullet, *Aldrichetta forsteri* in the Waiau River estuary.

7.20 Koura (*Paranephrops zealandicus*)

(Occurs in South Island east of the Southern Alps.) Mostly, koura (freshwater crayfish) are found in small, little-modified, entrenched streams, often in forest, where they spend their whole lives with no known migrations.

Koura are widespread and intermittent in the Waiau (Fig. 21), occurring mostly in the smaller stable tributaries, often in forest, and at lower elevations. They were nowhere common.

8.0 SPECIES COMPOSITION OF THE WAIAU RIVER WHITEBAIT RUNS

There has been no published analysis of the composition of the Waiau River whitebait runs in spite of both extensive and intensive work in other areas (McDowall 1965; McDowall and Eldon 1980, Rowe *et al.* 1992). Our field programme was timed to ensure that those migratory fish that tend to enter the river during the spring had arrived in the river prior to our sampling. As a result we were too late to determine the composition of the whitebait runs in the river (which was not a specified part of the programme); furthermore it was our expectation that sampling in the tributaries would provide post-whitebait juveniles of the species involved, and thus reveal the composition of the runs. This expectation was not fulfilled, and very few post-migratory whitebait, or sub-adults and adults, of four of the five potential whitebait species were encountered during widespread sampling of the lower Waiau and its tributaries. When this was realised, we obtained two frozen samples of whitebait taken from the river on unknown date, and identified these as far as is possible from frozen material (which is difficult owing to crushing and distortion of body shape through freezing, defrosting and then preservation). These two samples contained a total of 1580 whitebait, of which most (1,386 = 87.7%) were inanga whitebait, with a significant number also of koaro (120 = 7.6%), and also some of either banded or giant kokopu (74 = 4.7%). As these are the first reported analyses of Waiau whitebait, it is unfortunate that the condition of the fish prevented further identification to species. While the proportions of non-inanga whitebait in the samples may seem low, on a national comparison their frequency ranks quite high. In most river systems, especially where catchments have been extensively deforested and converted to pasture, inanga whitebait make up far the greatest proportion of the catch, typically more than 95% (McDowall 1965). These results confirm the prediction of Hayes *et al.* (1992) that the bulk of the recreational whitebait catch at the Waiau River mouth would be inanga.

9.0 MIGRATION, DIADROMY AND RIVER MOUTH OPENING

As is noted earlier, and as is typical of most of New Zealand's freshwater fishes, most fish species in the Waiau are diadromous (McDowall 1988). This means that they regularly move to and from the sea at regular phases of their life cycles. The life stage at which these migrations take place vary by species - they may emigrate to sea as tiny larvae, small juveniles or large adults, and may return to fresh water as small juveniles or mature adults. Migrations may take place at most times of the year, but predominate in spring and autumn, and are least in winter. Fishes found in the Waiau in this category include: lamprey, short-

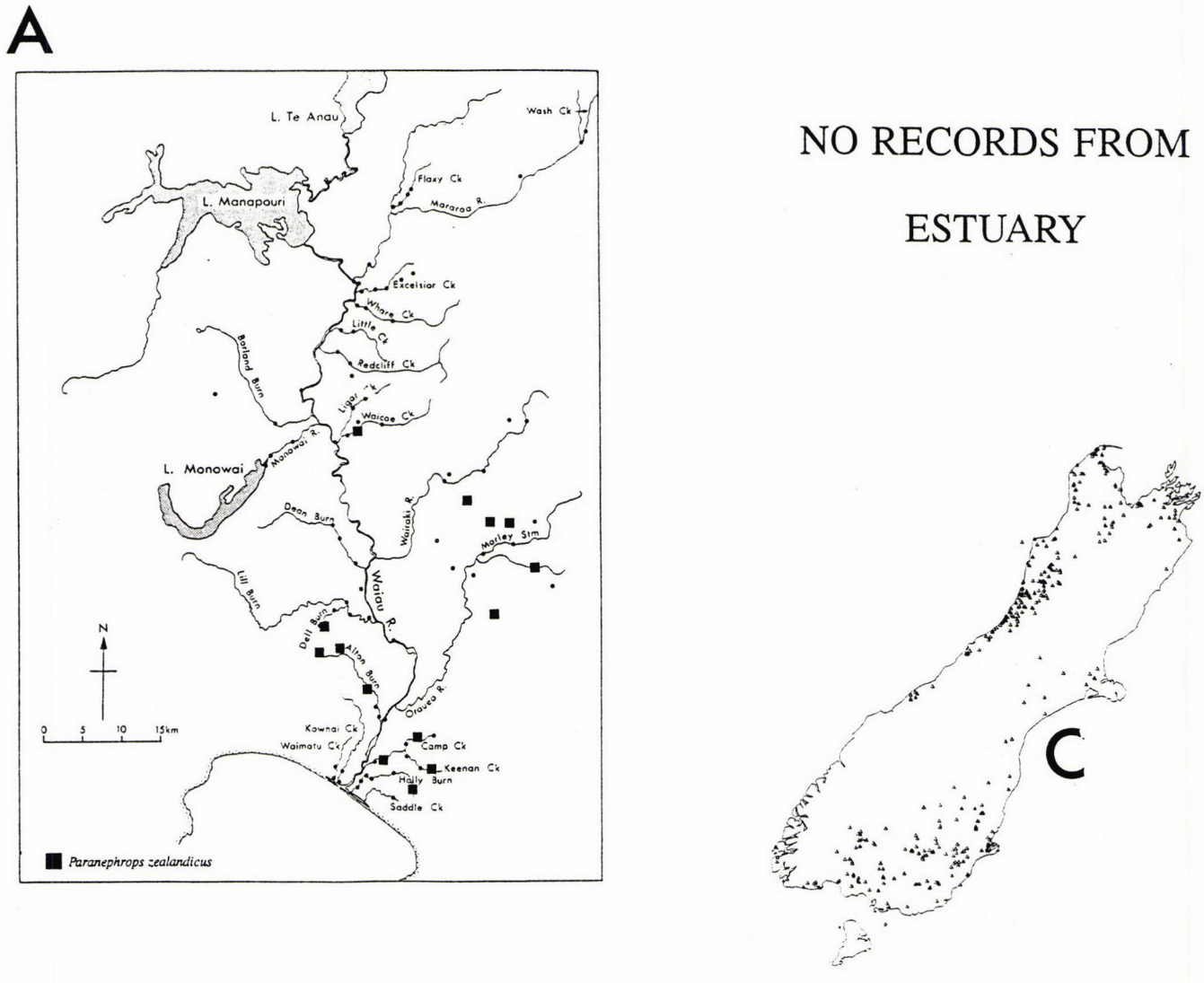


FIGURE 21. Distribution of koura, *Paranephrops zealandicus*: Occurrence in A: mainstem; B: estuary; C: South Island.

and longfinned eels, common smelt, inanga, koura, torrentfish, redfinned, bluegilled, and common bullies, and black flounder (Table 1). In addition, there are some fish that are better described as marine wanderers that move freely in and out of river estuaries, at often variable seasons and life stages, and which include estuaries as part of the aquatic resource they exploit for habitat, food and so on. These include yelloweyed mullet and yellowbelly flounder (Table 1).

Particularly for species that need to make these movements, i.e. those listed above as diadromous, maintenance of an open mouth is critically important.

10.0 SYNTHESIS

As must be evident from the preceding account of the Waiau River fish fauna, it is not a rich assemblage. There are three distinctive features of the fauna:

1 It is somewhat impoverished, with several species absent that might have been expected there;

2 Inland penetration of the river by the mostly diadromous species is very limited, so that the fauna soon becomes very sparse;

3 The abundance of many species present in the river is low.

In theory it is possible that these features of the fauna constitute a temporary situation, perhaps caused by recent major flooding, drought, or other such periodic and/or random catastrophe, but archival data on the river and data on fish distributions and abundance elsewhere in Southland, give no grounds for making such an assumption. I therefore assume that the state of the fauna is either historic (i.e. the fauna may always have been as it is), or is a product of the general state of the river at present (i.e. it could have changed as a result of land development and deforestation of its catchment and/or as a result of the impoundment of the Waiau by the Mararoa Weir and the diversion of the waters of the upper river). There are no empirical data that permit the clear identification of the reasons why the fauna of the river is as it is; however, it is possible to consider hypothetical scenarios, and make comparisons between the fauna of the Waiau, those of other rivers in Southland, and those of rivers more widely in New Zealand, and to draw some conclusions that may explain the state of the fauna and which could be tested by additional work. Detailed examination of other rivers in Southland as a basis for comparison with findings in the Waiau River was explicitly excluded from the study brief.

10.1 Species apparently lacking from the Waiau fauna

Four species that might have been expected to be present in the Waiau (on the basis of their known general distributions), but were not recorded, are giant kokopu (apart from a landlocked stock in Lakes Monowai and Mistletoe), shortjawed kokopu, banded kokopu and giant bully.

Giant kokopu are presently known only from landlocked populations in the Waiau, and we cannot account for not finding sea migratory stocks in the system, especially as the species occurs quite widely elsewhere in Southland (Fig. 9). Though shortjawed kokopu are reported from the rivers that drain southern Fiordland to the west of the Waiau (Fig. 11), they are not known from any of the pastoral rivers of Southland, such as the Oreti, Aparima and Mataura. Absence of the fish from the Waiau is consistent with this pattern, though it might yet be found in some of the more remote but lower elevation, still-forested streams that drain into the Waiau from the Longwood Range (Holly Burn, Camp Creek) or the Waitutu Forest (Alton Burn, Waimotu Creek, or even Lill Burn). Absence of this fish from the system could be attributed to habitat deterioration resulting from deforestation, but it is sparse and intermittently distributed elsewhere in New Zealand, and may always have been absent from the Waiau.

Banded kokopu are known elsewhere in some of the more intensively developed river systems of eastern Southland (Fig. 10) as well as in those of southern Fiordland to the west of the Waiau, and there seems no obvious reason for them to be lacking from the Waiau. Furthermore, whitebait taken at the Waiau River mouth appear to include banded kokopu. It is possible that suitable habitats for banded kokopu have not been located and searched in the Waiau, or that no suitable habitats for their rearing, growth and reproduction remain as a result of the extensive deforestation of the catchment. If the latter is true, banded kokopu whitebait entering the Waiau have no future.

Giant bully are intermittent and patchy in their general New Zealand distribution, and are found only in the lower elevation/estuarine reaches of rivers, including rivers that have been extensively modified by human land use practices. They also occur in other, pastoral rivers of Southland (Fig. 22), and may be present, undetected, somewhere in the lower Waiau or may truly be absent from the river.

Impacts of the Mararoa Weir and flow diversion cannot be implicated in the absence of any of these species from the Waiau.

10.2 Distribution, abundance and inland penetration by diadromous species

Most of the Waiau fish fauna is diadromous, i.e. a regular phase of the life cycles of these species is spent in the sea (Tables 1 and 2; McDowall 1988). This means that there are migrations of various life stages of these species in and out of river mouths, and that the invasive stage moves up stream to find suitable habitats in which to feed, grow, rear and/or spawn. It is important to recognise that in these species there are dual, reciprocal migrations - **both** from the sea and up stream into rivers, **and** down stream through rivers and into the sea. Thus issues of migratory behaviour by species, river mouth and channel conditions, and access up and down stream are of high importance to diadromous species finding appropriate habitats and completing their life cycles. There are no explicit data on what controls inland penetration by New Zealand's (and the Waiau's) freshwater fish species, but it appears that there is a series of factors:

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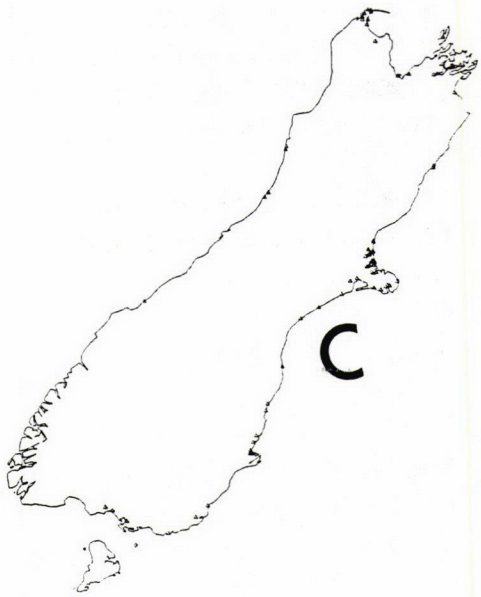


FIGURE 22. Distribution of giant bully, *Gobiomorphus gobioides:* Occurrence in A: mainstem; B: estuary; C: South Island.

- Distance alone may be critical for some species which never migrate far from tidal influences, in spite of the apparent lack of hindrances to upstream migration e.g., inanga, common bully;

- Others may move well inland, but be impeded by moderately swift flows and/or extensive rapids, e.g. common smelt;

- Yet others may move upstream through these conditions but be stopped by vertical falls or long cascades e.g. bluegilled bully and torrentfish;

- And yet others can climb very high falls (tens of metres high) and appear to be stopped by virtually nothing but the most extreme conditions e.g. koaro, longfinned eel.

The occurrence of diadromous fish species in the Waiau needs to be interpreted in the context of their typical migratory behaviours. Interpretation of the factors that control inland penetration is difficult - lack of inland penetration may be caused by the lack of ability or drive to migrate, or it may be caused by the absence of suitable habitats at inland locations. Shortfinned eels, for instance, are typically found close to the coast and at low elevations. While this might appear to be because they are weak migrants, it seems instead to be due, as much as anything, to the paucity of suitable shortfin habitats in inland locations. Clearly, if there are suitable habitats at inland locations, shortfins appear as capable of reaching them as longfins (and this is well demonstrated in the Waiau, where shortfins are present in Lake Mistletoe, east of Lake Te Anau, about 150 km from the sea, but otherwise have been recorded in the Waiau only from the lower river and estuary - Fig. 5). Lampreys also penetrate long distances, as may torrentfish. Black flounder may be found substantial distances inland, 50 km or more from the sea. Bluegilled and redfinned bullies and torrentfish are lively migrants that are stopped by severe flows or moderate falls but still turn up well inland where conditions allow. Even common smelt, which are generally thought of as low elevation, coastal fish, may move long distances inland in rivers which have extensive slow moving lower reaches, such as the Waikato, Wanganui and Manawatu. Inanga and common bullies are typically found no more than a few kilometres inland (the latter species except where it is landlocked in an inland lake and this is a common occurrence).

For the freshwater fish fauna of the Waiau (as in any river), the question of inland penetration obviously has direct implications for how widely distributed species are, and therefore for the species richness of the various zones of the river; furthermore abundance is in part a function of how many fish are able to penetrate inland to occupy suitable habitats. The way various species penetrate the Waiau is summarised and the implications of these distribution patterns are discussed below:

10.2.1 Lamprey

Lampreys reach both the Mararoa Weir and the Monowai Dam, though in what numbers is not known. They are adept at climbing steep surfaces, and can probably negotiate the Mararoa Weir if there is a wet surface, as they do the Arnold Dam on the Arnold River, on the West Coast (Tweed 1987).

10.2.2 Eels

Clearly, longfinned eels are well able to move up the entire Waiau (Fig. 4). They reach the Mararoa Weir (88 km up stream) in quite large numbers. Their evident abundance at the Weir and also in Excelsior Creek is enigmatic. Though eels are obviously capable of making their way up through the river system, why they are not staying in the mainstem habitats, given that they are reaching them and passing on upstream through them, is unclear. It is possible that accumulations of longfins below the weir and in Excelsior Creek simply reflects the hindrance to migration caused by the Mararoa Weir. Though eels are very skilled climbers, they can do so only to a size of about 120 mm (Jellyman 1977); when larger than that, they are too heavy for surface tension on wetted surfaces to support their weight and they can no longer climb vertical faces unless these are very rough. It is likely that, by the time some eels reach the Mararoa Weir, they are too large to climb and are prevented from moving further upstream. In addition, if there are long periods when there is no wetted surface on the concrete face of the weir, climbing will also be prevented. For these reasons, eels may accumulate below the weir. However, they do move up stream past the Mararoa Weir, as there are records of longfinned eels from Lakes Gunn and Fergus, at the head of the Eglinton Valley and from the Mararoa River above the Mavora Lakes.

Shortfins were sparsely present in the estuary and not recorded in our sampling further upstream (Fig. 5).

10.2.3 Whitebait species

Like other rivers in Southland, the Waiau has a modest though significant whitebait fishery (McDowall 1993); consisting of inanga (primarily), koaro, and at least one of the three kokopu species (see section 8). Though the fishery is popular, it is hard to conceive that the runs are so intensively fished that recruitment of fish is virtually annihilated - considerable escapement and entry to the lower river by the young of inanga, koaro, and kokopu seems likely. Suitable habitats for the juveniles and adults of koaro and banded and shortjawed kokopu are small, stable, clear-flowing, forested, bouldery streams. A few adult koaro were taken from only two forested sites and occasional post-whitebait juveniles from rapids in the lower river (mainstem and lower Camp Creek). No banded or shortjawed kokopu were encountered, anywhere. Why other forested streams, such as the upper Alton Burn, upper Keenan Creek, and upper Holly Burn, contained neither koaro, nor banded and shortjawed kokopu, is unknown. Since koaro and some kokopu species are clearly moving into the Waiau (based on analysis of the whitebait catch), either they are not finding suitable habitats in the river, or sampling has yet to discover where these habitats are. Both may, in part, be true.

10.2.4 Bullies and torrentfish

Several non-whitebait diadromous fish occur in the Waiau in small numbers. Bluegilled, redfinned and common bullies and torrentfish leave the sea as tiny juveniles (< 20 mm long) to pursue their freshwater life stage. There are very occasional records of torrentfish in the mid to lower river, but the species was very sparse at all these locations, it was not found at all in the mainstem at Tuatapere, and it was even rare in the two rapids in the upper estuary. There were redfinned bullies in a few lower mainstem sites and tributaries but they

were always rare. Bluegilled bullies were present but rare at the second river riffle and were moderately common in Waimotu and Kowhai Creeks but nowhere else (and had not, previously, been recorded from the Waiau). Common bullies were occasional as far upstream as Clifden, occurred in modest abundance at Tuatapere, and were abundant only in the first and second river riffles. (Giant bullies have not been recorded from the Waiau apart from a SF&GC record cited by Hayes *et al.* (1992) that I have not been able to corroborate.)

From their very low abundance in the riffles and runs of the lower river and its tributaries (such as Kowhai and Waimotu Creeks - where they could be expected to abound), it seems likely that none of these species is entering the river in large numbers. There were large areas of apparently suitable gravel/cobble riffle and run habitat in the two lower riffles in the Waiau mainstem and in tributaries such as Camp Creek, and these species were very rare or absent there.

10.2.5 Other species

Common smelt and black flounder occur in the Waiau estuary and lower river in numbers and with distributions not inconsistent with those found elsewhere. Black flounder could be expected further up the river than the first two rapids (Fig. 18), but were not found there; however, they are difficult to catch, occupy unusual riverine habitats, and our sampling may have missed them.

10.3 Occurrence and distribution of non-diadromous species

Three main species of non-diadromous species of fish, plus koura occur in the lower Waiau (alpine galaxias are known only above the Mavora Lakes, and so are not germane to this report). Round head and flathead river galaxias are widespread throughout the catchment (Fig. 12) and abundant in many localities. Flathead galaxias were found occasionally in the mainstem. The frequent abundance of these fish, almost anywhere there were bouldery/cobble substrates and swift flows, is a distinct contrast with the distributions and abundance of most other fish species in the system, except longfinned eels, which were perhaps more widespread though not generally as common at each location.

Upland bully were much less widespread, though they occurred mostly in the upper tributaries of the catchment (Fig. 17); they were never abundant anywhere that we encountered them.

Thus, apart from longfinned eels and lampreys, virtually no diadromous species penetrates and occupies the river upstream beyond about Clifden. Many species are restricted to the lower river and tributaries, mostly being very sparse even there, with a few penetrating further upstream though never in more than small numbers. While amongst the non-diadromous species roundhead and flathead galaxias were widespread and often abundant (Fig. 12), upland bullies were quite widespread but never abundant in the mid and upper Waiau tributaries (Fig. 17) and koura were similarly quite widespread but locally uncommon in the mid and lower tributaries (Fig. 21); neither was prevalent in the mainstem.

For diadromous species there is no reason why there should be a general explanation for the general pattern of limited penetration and low abundance, though this possibility is not ruled out. It is possible that either:

- The fish **are not** finding their way to the mouth of the Waiau River in large numbers because of conditions at sea; or:

- They **are** finding their way to and into the river but on moving upstream, they are not finding suitable habitats in which to feed, grow and mature?

In either case, the problem is to determine why!

10.4 Impediments to migration

Apart from the possibility of river mouth closure which would prevent migratory fish from entering the river (and there seems little indication that this is anything more than occasional and brief), there are no obvious major impediments to upstream migrations of fish in the Waiau between the sea and the Mararoa Weir - no falls, nor even any particularly vigorous torrents or rapids; gradient in the river is not great (Fig. 23) and flows, at least as far upstream as the Monowai confluence (well beyond the general distributions of most diadromous species) provide a substantial river. These common species make their way long distances up comparable rivers in other parts of New Zealand. The only significant factor that might hinder upstream movement of some species into the distant reaches of the system is distance (ca. 97 km to Mararoa Weir). However, this does not explain the lack of fish in the lower river, and many diadromous species migrate greater distances upstream than this, elsewhere in New Zealand.

10.5 Habitat suitability and occurrence of species elsewhere in Southland rivers

The widespread distributions and often considerable abundance of roundhead and flathead galaxias throughout the tributaries of the Waiau suggest that there is nothing fundamentally "uninhabitable" about these waters. There are, for instance, no data to suggest that these species are particularly tolerant of degraded habitat conditions that are intolerable to other species - certainly not by comparison with such adaptable species as eels, common and upland bullies, and inanga. Since the flows of the Waiau mainstem are nothing more than an accumulation of the flows of the tributaries in which roundhead and flathead galaxias abound, and the geological formations in which the mainstem runs are similar to those of the tributaries, the abundance of roundhead and flathead river galaxias points to no obvious habitat peculiarities hindering fish occupying the mainstem. On the contrary, however, the virtual absence of small eels in the mainstem at the first and second riffles, at Tuatapere, at Clifden, and at Blackmount, could be interpreted as indicating that the mainstem is unsuitable habitat for a highly adaptable species. This general absence of eels in the lower mainstem, while being more abundant further upstream just below the Mararoa Weir and in Excelsior Creek, is therefore confusing and inexplicable. Why do small eels not occupy the numerous cobbly/gravel riffles of the lower river, as they do elsewhere in New Zealand?

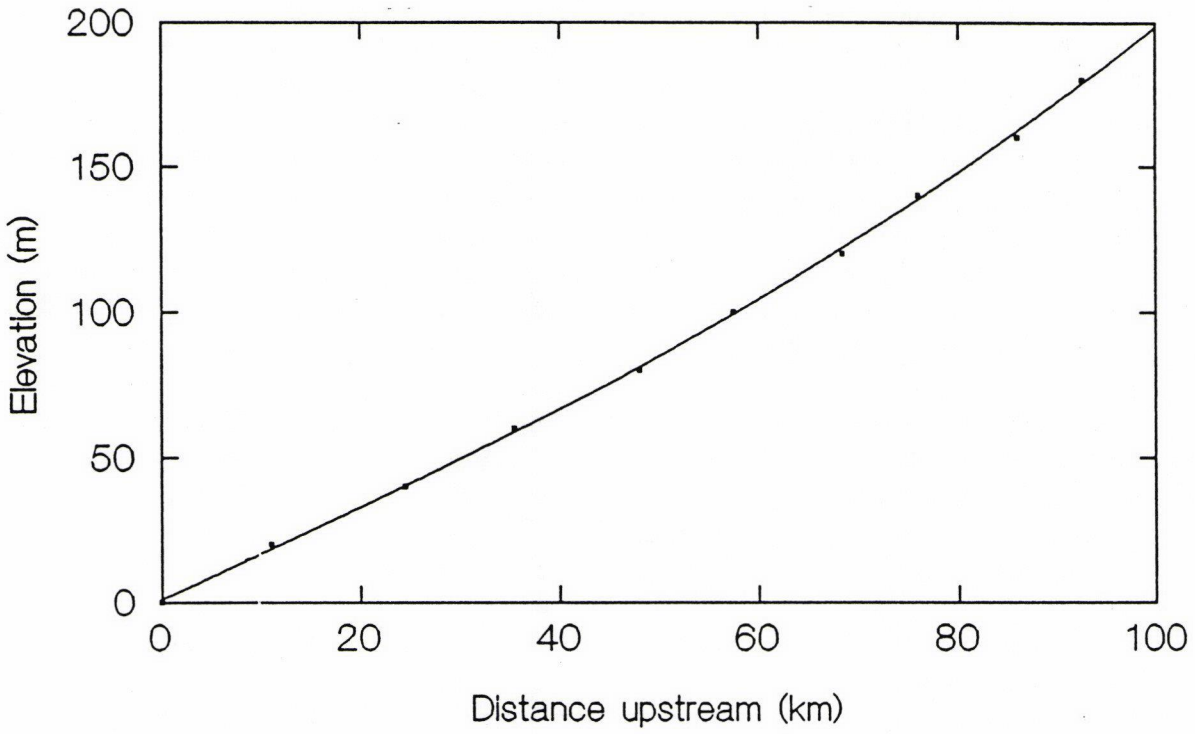


FIGURE 23. Gradient in the Waiau River from mouth upstream to Mararoa Weir.

This pattern of abundance seems unlikely to be due to excessive fluctuations in the Waiau induced by diversion of water to the power station at normal flows but diversion of flood flows into the Waiau from the Mararoa. Riffle habitats in the mainstem seemed relatively stable, whereas riffle habitats in rivers of Canterbury such as the Waimakariri and Rakaia, which have less stable and more mobile gravels, and flood just as severely as the Waiau, carry substantial populations of small eels (as well as numerous torrentfish and bluegilled bullies) (Davis *et al.* 1983).

The sparseness and limited distribution of shortfins in the Waiau, as elsewhere in Southland, is consistent with their usually occurring in coastal locations, and a general decline in their distribution and abundance in southern New Zealand (Fig. 5).

The New Zealand Freshwater Fish Database (NZFFD - McDowall and Richardson 1983) has records for banded kokopu from few of the rivers of the Southland Plain, i.e. in the area from the Mataura to the Waiau Rivers, inclusive (and none of these records is in the Waiau - Fig. 10). There are no records in these rivers for shortjawed kokopu (Fig. 11), and few for koaro (Fig. 8). Thus the sparseness of koaro, banded and shortjawed kokopu, in the Waiau is consistent with data for other rivers of the pastorally-developed Southland Plains, where these species occur only rarely (though the Waiau probably has more low-elevation forested tributaries than other rivers such as the Oreti, Aparima and Mataura, and might provide conditions more favourable for these species). All these species occur in the rivers of Fiordland (where heavy forest cover remains) that drain into Foveaux Strait, west of the Waiau (Figs. 8, 10, and 11)

Giant kokopu are somewhat more widespread and common in Southland, with a notable population in Lake George (McDowall 1990). The apparent absence of this species from the lower Waiau, where it might have been expected, may be due to inadequate sampling coverage of all habitat types; but, certainly, the pastoral development of the tributary valleys of the lower Waiau will have obliterated much suitable habitat.

Torrentfish and several of the diadromous bullies (redfinned, bluegilled, and giant) have also rarely been recorded from other rivers of the Southland Plains (Figs. 13, 15, 16 and 22). There are no obvious, macro-habitat characteristics of these river systems, the Waiau included, that generally distinguishes them from rivers elsewhere in the South Island, and which might indicate why the faunas are so impoverished. Thus, distributions of fish in the Waiau are not inconsistent with what is known of these species elsewhere in pastoral Southland.

The sparseness of the faunas in some of the lower Waiau tributaries possibly can, at least in part, be attributed to a combination of the geology of their catchments and pastoral development. The substrates in the Holly Burn, and at least some parts of Camp, Kowhai, and Waimotu Creeks appear to be derived from soft sandstones. These produce sands that are light and often coarse, and which move freely along the stream bed when flows are even slightly elevated. There is also often a sparseness of coarser gravels and cobbles in these streams, partly because they become smothered by the shifting sand substrates. Most native fish are cryptic, and hide, especially during the day, within the crevices formed by piles of rocks and gravels. Such habitats are limited in these sandstone creeks, which therefore provide only limited good native fish habitat. However, the same species are often also lacking in those sections of these streams where there is apparently good substrate and habitat.

I therefore hypothesise, at least for those species in which the juvenile emigrants from the sea are quite small, that oceanic conditions at sea off the Southland coast are limiting recruitment of juveniles into Southland rivers. The Southland current sweeps from the west, eastwards through Foveaux Strait, and possibly hinders these small fish from reaching the mouths of the rivers there in large numbers.

An alternative hypothesis could be that these fish are sparse because temperatures are too low, towards the southern limits of their ranges in Southland, but this seems unlikely, since most of them occur on Stewart Island and at substantial, and thus cooler, elevations elsewhere in the South Island.

A further, alternative, explanation for the low diversity and low abundance of fish species in the Waiau may be that water quality conditions in the Waiau fail to attract these small fish from the sea, and though able to reach and enter the river mouth, they are choosing not to do so. The waters of the Waiau are distinctly peaty and tannin-stained (brown), but this is not an unusual characteristic of New Zealand rivers in which these same species abound.

If the explanation is accepted that the lack of diversity/abundance of species in the river is due to oceanographic conditions in Foveaux Strait, several inconsistencies need to be explained.

Firstly, the question of how the whitebait juveniles of inanga and other species, and also common smelt, find their way into the river in abundance needs to be addressed. They are much larger than juvenile torrentfish and bullies (mostly >45 mm long), are likely to be stronger swimmers, and may thus be better equipped to find river mouths in the oceanographic environment that occurs in Foveaux Strait.

Secondly, an explanation of the considerable abundance in the lower river of common bullies (which have small juveniles <20 mm long) is also required; possibly, the point made earlier (see section 7.13) that common bullies may have a highly flexible life history in which the larval and juvenile stages are sometimes completed in fresh water (as commonly occurs in landlocked populations), provides stock for recruitment into the lower Waiau. The eastern lagoon would provide a suitable sanctuary for this recruitment, with its considerable isolation from the river's mainstem and its likely low water turnover.

Thirdly, given that upland bullies occur in very diverse habitats, from ponds and lakes to swift bouldery streams, and from sea level to elevations up to 1000 m in Otago rivers, their general sparseness in the Waiau is also inexplicable. Furthermore, there are no obvious habitat reasons why roundhead and flathead galaxias should be widespread and abundant while other species are not, especially why upland bullies, which often share streams with these galaxias species in many South Island waterways, are absent from many Waiau tributary streams.

What ever the correct explanations for these various inconsistencies, our observations strongly suggest that, whether or not large numbers of any, or all, of these species are reaching the Waiau River mouth and are making their way into the estuary, they do not seem to be populating the lower cobble/gravel riffles of the river mainstem, nor the river's lower tributaries. There are not as many species, or individuals of these species, in the modified river as would be expected in a river of similar size and characteristics in most other parts of New Zealand. However, the pattern in the Waiau appears not much different from other

Southland rivers. Furthermore, the patterns apply equally to tributaries unaffected by modified flows as to the mainstem. Thus there is no reason to attribute these features of distribution and abundance of native fish in the Waiau to the effects of the Mararoa Weir.

Taken as a whole the fish fauna of the Waiau River is enigmatic and full of contradictions that are likely to be explained only after intensive analysis of fine-scale habitat tolerances of the species, habitat characteristics of the waterways and the behaviour of the marine stages of migratory species.

10.6 Varying faunas of the estuarine tributaries

There was a distinct absence of fish in some tributaries, such as Holly Burn, but abundance in others such as Waimotu and Kowhai. Reasons for this are not explicitly obvious. Waimotu and Kowhai Streams provided pool-riffle sequences, and coarse cobble substrates with extensive within-substrate cover for fish, and it was from this habitat that the higher diversity of fishes in these streams was mostly taken - particularly bluegilled bullies, some redfinned bullies and occasional torrentfish. By contrast, the lower Holly Burn had a bed of mud grading upstream into loose, low-density, sandstone sands that formed a loose substrate and offered little or no within substrate cover; it had few or no native fish at all sites.

In addition to these differences, Waimotu and Kowhai Creeks drain into the western lagoon, not far from the river mainstem, and quite close to the river mouth, whereas the Holly Burn drains into the eastern lagoon which is several kilometres from the river mouth, and connected to it by a long reach of lagoon plus the eastern channel. This isolation of the Holly Burn from the river mouth might have contributed significantly to its apparent absence of diadromous fish. However, high habitat diversity of a type suited to cryptic substrate-living fish like bluegilled and redfinned bullies and torrentfish undoubtedly attracted these species to Waimotu and Kowhai Creeks. Camp Creek enters the Waiau mainstem about 4 km upstream from the estuary, and has plentiful rapid water, coarse cobble substrate. But it lacks most fish species, similar to the Holly Burn; again, the implication is that native fish do not seem to be penetrating the estuary and lower river or its tributaries.

10.7 The state of the Waiau estuary

With a general lack of human population adjacent to the Waiau lagoon and lower mainstem, human impacts on the estuary are relatively slight. Frequently New Zealand's river estuaries become sites of rubbish tips - dumping grounds for old car bodies and truckloads of old concrete rubble, and they are recipients of effluent discharges from farms, centres of human population, or industry, etc. The Waiau has been spared nearly all of this wanton damage. There are virtually no roads alongside the lower river, nor any significant concentrations of human populations/settlements, few industries of any sort, and few of the sorts of farming activities that generate the greatest effluent volumes (dairy sheds, piggeries, etc.). Farming on riparian lands is relatively low intensity. With two major exceptions the estuary remains in a tidy and unpolluted condition.

The exceptions are that:

1 The riparian estuarine areas are now devoid of forest and much of the nearby land has been developed for pastoral farming, though even this development is not as intensive as in some locations, so that there are still some quite extensive areas of rushes and flax.

2 There has probably been extensive destruction of low elevation, swampy fish habitat owing to the loss of what were once most probably extensive tracts of lowland rimu podocarp forest, and kahikatea/flax swamp forest. This loss has likely degraded habitats once available for some fish species. This applies especially to channels around the estuary itself, as well as to low gradient, heavily overgrown, and entrenched, tributaries of the lower Waiau, such as Camp, and Kowhai Creeks and the Holly Burn, which would once probably have supported such whitebait species as giant kokopu and inanga, with banded kokopu occupying the small, tumbling streams that drain off the valley terraces into the estuary or its tributaries.

10.8 Proposals for the enhancement of estuarine habitats and mitigation of damaging impacts

ECNZ has purchased some land adjoining the Waiau estuary and the lower tributaries. One of its expressed goals for managing these properties is to contribute to enhancement of fish habitats associated with the land, and it has sought advice on these points. Given the apparent low diversity and sparseness of the faunas of these waters, and the apparent lack of penetration by most migratory fish beyond the estuary, their potential for enhancement of estuarine habitats is not easily determined. In addition, because these low elevation/estuarine waters receive inputs from streams that drain higher elevation catchments in independent farm ownership, anything that is done to enhance the low elevation stream sections and the estuary itself will always be subject to degradation resulting from silt-laden or polluted inflows from upstream, i.e. anything done in the lower reaches, to stabilise substrates, establish ponding, and so on, will always be under threat unless attention is given also to protecting the higher reaches. Given these limitations some actions can be taken to preserve or restore aquatic values that are likely to benefit the fish populations. These need to be seen as long-term objectives (decades, or longer).

10.8.1 Establishment of inanga spawning grounds

A separate commission from WRWP is for identification of inanga spawning grounds in the Waiau estuary; the importance of this for maintaining the whitebait fishery cannot be overemphasised. However, it has to be recognised that the benefits from successful enhancement of such spawning grounds in the Waiau may not accrue to the Waiau whitebait fishery, i.e. there can be no assurance that whitebait larvae that hatch from spawn deposited in the Waiau return to the Waiau as whitebait, and there is a high likelihood that they don't. However, the benefit to the whitebait fishery, as a whole, is no less real.

Furthermore, knowledge of precisely what conditions and vegetation types are best suited to supporting successful inanga spawning is limited, and some past efforts at enhancing spawning grounds, such as the exclusion of stock to promote growth of lush estuary-bank vegetation, has resulted in inanga deserting such areas and spawning elsewhere (C.P.

Mitchell, pers. comm.). Thus technology for ensuring successful enhancement of inanga spawning grounds is not well developed and effective enhancement cannot be assured.

10.8.2 Restoration of riparian vegetation

At present much of the riparian vegetation around the Waiau estuary consist of exotic grasses and trees (especially willows), though there are also indigenous rushes and flaxes in some areas. Attempts to restore natural, indigenous vegetation, and particularly the replacement of willows by flax and such podocarps as kahikatea would seem to have long term benefits. In addition, cessation of drain clearing would allow the area to return to a more swamp-like configuration, with water lying across the land, ponds and pools developing. These actions, together, would lead eventually to the restoration of low-lying swampy country, surrounded and protected by flax/kahikatea plant communities, with extensive still or slow-flowing pools, overhung by root buttresses, and connected by meandering, slow-flowing streams. Some ponding could be encouraged by construction of low weirs that result in water backing up over presently low-lying pastured land; however, care would be needed to ensure that insertion of weirs did not create barriers to the upstream migration of diadromous species, which constitute the majority of the likely fauna. Attention would need to be given to ensuring that overflows from ponded areas provided for upstream passage of the weaker migrants, such as giant kokopu, inanga and common smelt. This whole area of activity is essentially untried in New Zealand, especially with regard to restoration of the ancestral flax/podocarp swamp vegetation that possibly once prevailed around many New Zealand lowland streams and estuaries.

10.9 Flows needed in the upper Waiau (above Monowai) for native fish habitat

One of the priority issues for the WRWP regarding the future of the Waiau River and its fish fauna is to determine flows needed to sustain diverse and rich fish assemblages in the mainstem, especially the area most severely affected by flow diversion to the Manapouri power station, i.e. the region between the Mararoa Weir and the Waiau confluence with the Monowai River. Jowett (1993) prepared for the WRWP an assessment of the minimum flow requirements to provide good instream habitat for trout in this section of the Waiau. In his report, he concluded that a "residual flow in excess of $10m^3/s$ would enhance adult brown trout and food producing habitat considerably", and that with provision of "flows in excess of $15m^3/s$ the sum of trout and food producing habitat [would exceed] any of the rivers surveyed previously [Jowett 1990, 1992] indicating that the Waiau River, between the Mararoa Weir and the Borland Burn is a potentially excellent trout river". He suggested that "consideration be given to maintaining a minimum flow in excess of $10m^3/s$ in the Waiau below the Mararoa Weir".

On the basis of his surveys of habitat characteristics of native fish (not undertaken in the Waiau), Jowett (1993) also suggested that habitats suitable for native fish would exist at practically any flow, although maximum amounts would probably occur at lower flows than $10m^3/s$. He reached this conclusion on the basis that his surveys showed that native fishes such as upland bullies, common river galaxias, longfinned eels and common bullies were most abundant in depths less than 15 cm (6 inches), were reasonably abundant at depths of

15-25 cm (6-10 inches), and largely lacking at greater depths. These data, thus show that these species are most common in shallow waters along the edges of rivers and streams and are lacking from the central, deeper waters. These edge waters become available in New Zealand's flat cross-profiled, gravelly/cobble rivers at quite low flows (i.e. flows sufficient to provide about 25 cm water depth). As flows in these rivers rise, the shallow-water edge-habitat zone, that Jowett's data suggest that native fish occupy, moves laterally across the gravel but unless there is a significant change in the profile of the river bed, the area of habitat does not usually change much with increased flows. However, if increasing flows lead to increased subdivision and braiding of river channels, this conclusion does not hold, as each of the braids formed will provide shallow, edge habitat, and thereby increase habitat available to native fish with increasing flows. Increased braiding is likely to be a minor result of increasing flows in the Waiau River below Mararoa, and therefore is likely to contribute little to change in the area of native fish habitat available should flows increase.

One of the goals of the WRWP in commissioning studies of the native fish populations of the Waiau River, was to obtain data from the river to determine the applicability of the results of habitat surveys for native fish obtained by Jowett in other river systems. A reach at Blackmount (previously surveyed by Jowett for habitat availability for brown trout) was initially chosen for this study. The intention was to carry out quantitative stratified sampling of fish abundance at several depths in replicated riffles and runs, using the depth criteria previously used by Jowett (1993), i.e. to determine species present, fish numbers, and biomass in strata at depths of 0-15 cm, 15-25 cm and > 25 cm. We searched the river at Blackmount and found the river there virtually barren of native fish, in spite of the availability of extensive, coarse, cobble/gravel riffle and run habitat - after extensive searching in several riffles and runs, total catch amounted to one flathead galaxias and two small longfinned eels. Given the type of habitat available and the distance upstream from the sea (55 km), we expected to find that, at least, longfinned eels, bluegilled, redfinned, and upland bullies, and torrentfish abounded there. The highly impoverished nature of the fauna precluded carrying out the planned replicate studies of changes in the abundance of native fish with water depth. We therefore assumed that the largely diadromous fish species, expected, there were not penetrating this far upstream and transferred to the mainstem at Clifden (27 km upstream). There much the same situation was encountered. Again, after extensive search, total catch amounted to no longfins, one flathead galaxias, five common bullies, one redfinned bully, no upland bullies and eight torrentfish - again inadequate fauna to determine changes in the abundance of species with depth. In the mainstem at Tuatapere, the same process was followed, and there common bullies were common, longfinned eels occasional, and no other native fish were found. Even the mainstem at the first two riffles contained few species and all of these, apart from common bullies, were in very low numbers (occasional lamprey, koaro, bluegilled and redfinned bullies, torrentfish and black flounder).

These samplings thus clearly indicated that the non-diadromous fauna of the river was virtually absent from the mainstem, and further, that the diadromous fauna of the river was largely not penetrating the river and certainly was not occupying the mainstem. This effectively prevented carrying out the planned replicate sampling for distribution of native fish by depth.

The apparent virtual absence of native fish from the river meant that the question of water depths required to maintain native fish stocks in the mainstem has little relevance to flow management in the river and especially little relevance to flow volumes and water depths in

the upper reaches of the river, immediately below the Mararoa weir, where flows are least. Given the very sparse nature of the fauna encountered, there can be no doubt that Jowett's (1993) assertion that "suitable habitat for [common river galaxias, longfinned eel, upland and common bully] will be available at practically any flow" is correct, and can be extended to include torrentfish and bluegilled and redfinned bullies.

Reasons for the very impoverished nature of the native fish fauna of the Waiau mainstem (and tributaries) are discussed elsewhere (see section 10.2), but it is reiterated here that there is no reason to consider that the impoverished state of the fauna has anything to do with flow diversions and fluctuations caused by the Mararoa Weir. The native fish populations encountered in the river are far below what would appear to be the carrying capacity of the existing, largely dewatered, upper reaches of the river. Furthermore, the fauna of the river is highly impoverished much further downstream, where there are very substantial flows on extensive areas of gravel/cobble riffle run habitat.

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