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NEW ZEALAND FRESHWATER FISHERIES MISCELLANEOUS REPORT NO. 109

REVIEW OF FISH DISTRIBUTION IN THE WAIAU RIVER CATCHMENT, SOUTHLAND

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Servicing freshwater fisheries and aquaculture

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SUMMARY

1. At least 29 species of freshwater fish occur in the Waiau River catchment, although only 14 of these are recorded in the MAF Fisheries Freshwater Fisheries database.

2. Most of the fish species are native, there being only four exotic species comprised of salmonids and perch.

3. Many of the fish species migrate to and from the sea as a necessary part of their life cycle, including at least 14 of the native fish species.

4. Because of the prevalence of migratory species, and the fact that hydro-electric development has been extensive, fish passage is the primary issue for conservation of fish populations in the Waiau catchment.

5. The effect of the Manapouri and Te Anau lake control structures on the distribution and abundance of many of the fish species present in the Waiau catchment is largely unknown. Therefore, it is recommended that a study be undertaken to determine present distributions and abundance, to establish the merits of providing good fish passage past the lake control structures.

1. INTRODUCTION

This report is a review of freshwater fish distributions in the Waiau River catchment, Southland. It was written in response to a request made by the Waiau River Working Party, Southland Regional Council, to the Freshwater Fisheries Centre, MAF Fisheries. The report is a review of existing information, primarily from the N.Z. Freshwater Fisheries database (F.F.D.B.), MAF Fisheries publications, and Southland Fish and Game Council (S.F.G.C.) files and Annual Reports. The report also includes a section on gaps in the knowledge of fish distribution in the catchment and identifies issues pertaining to understanding the effects of hydro-electric development on fish migration.

2. NATIVE FISH DISTRIBUTIONS AND LIFE HISTORIES

Twenty-five native fish species and four exotic species have been reported from the Waiau River catchment, only 14 of which are recorded in MAF Fisheries F.F.D.B. (Tables 1 and 2). Many of the species are probably much more widespread in the catchment than the documented records suggest, and at least one other species which has not been reported is probably present (i.e., the bluegilled bully). Many of the fish, mostly native species, are sea-going at some stage in their life cycle, and this trait has particular relevance because of the extensive hydro-electric development that has taken place in the catchment.

2.1 Eel (Tuna)

Distribution

Twenty-six records of eels in the Waiau catchment exist on the F.F.D.B. (Fig. 1). The comparatively large number of records reflects the abundance and widespread distribution of these fish, especially of longfins. In addition to these records, Field-Dodgson (1981) recorded 371 longfins being trapped by Southland Acclimatisation Society (S.A.S) staff at the Manapouri lake control structure in 1978.

From their known distribution elsewhere in New Zealand, it would be expected that shortfin eels would be primarily coastal. If they could negotiate the water control structures, a few would penetrate as far inland as Manapouri and Te Anau, but in these lakes they would probably form only 1-2% of the adult eel population; for example, all 371 eels recorded at the weir by Field-Dodgson were longfins. Longfins will be ubiquitous throughout the catchment, occurring in all flowing water habitats. They will show some avoidance of swamps and muddy watercourses but will be found everywhere else, access permitting.

Life history

Both species of eel have similar life histories. Adults migrate to sea during late summer and early autumn, but the location of the spawning grounds is unknown. Larval eels arrive off the coast of New Zealand and metamorphose into "glass eels" before they ascend rivers in the spring. Soon after they enter fresh water, they begin to develop their familiar brownish

TABLE 1. Fish species in the Waiau catchment recorded on the Freshwater Fish database.

Common name	Scientific name	No. of records	Migratory?	Native?
Eel	*Anguilla spp.*	18	Y	Y
Longfinned eel	*Anguilla dieffenbachii*	7	Y	Y
Shortfinned eel	*Anguilla australis*	1	Y	Y
Galaxias	*Galaxias spp.*	5	Y/N	Y
Koaro	*Galaxias brevipinnis*	8	Y	Y
Giant kokopu	*Galaxias argenteus*	5	Y[1]	Y
Common river galaxias	*Galaxias vulgaris*	14	N	Y
Alpine galaxias	*Galaxias paucispondylus*	1	N	Y
Bully	*Gobiomorphus spp.*	12	Y/N	Y
Common bully	*Gobiomorphus cotidianus*	6	Y	Y
Upland bully	*Gobiomorphus breviceps*	6	N	Y
Common smelt	*Retropinna retropinna*	5	Y	Y
Lamprey	*Geotria australis*	2	Y	Y
Torrentfish	*Cheimarrichthys fosteri*	2	Y	Y
Trout	*Salmo spp.*[2]	1	N	N
Brown trout	*Salmo trutta*	33	N	N
Atlantic salmon	*Salmo salar*	3	Y	N
Rainbow trout	*Oncorhynchus mykiss*	13	N	N
Brook char	*Salvelinus fontinalis*	1	N	N

[1] Although sea-going, giant kokopu have been recorded only from lake populations in the Waiau catchment.
[2] Unidentified trout could be either brown or rainbow trout, the latter being of the genus *Oncorhynchus*.

TABLE 2. Fish species not recorded on the Freshwater Fish database, but probably present in the Waiau catchment.

Common name	Scientific name	Migratory?	Native?
Inanga	*Galaxias maculatus*	Y	Y
Stokell's smelt	*Stokellia anisodon*	Y	Y
Bluegilled bully	*Gobiomorphus hubbsi*	Y	Y
Redfinned bully	*Gobiomorphus huttoni*	Y	Y
Giant bully	*Gobiomorphus gobioidies*	Y	Y
Banded kokopu	*Galaxias fasciatus*	Y	Y
Black flounder	*Rhombosolea retiaria*	Y	Y
Yellowbelly flounder	*Rhombosolea leporina*	Y	Y
Yelloweyed mullet	*Aldrichetta forsteri*	Y	Y
Kahawai	*Arripis trutta*	Y	Y
Perch	*Perca fluviatilis*	N	N

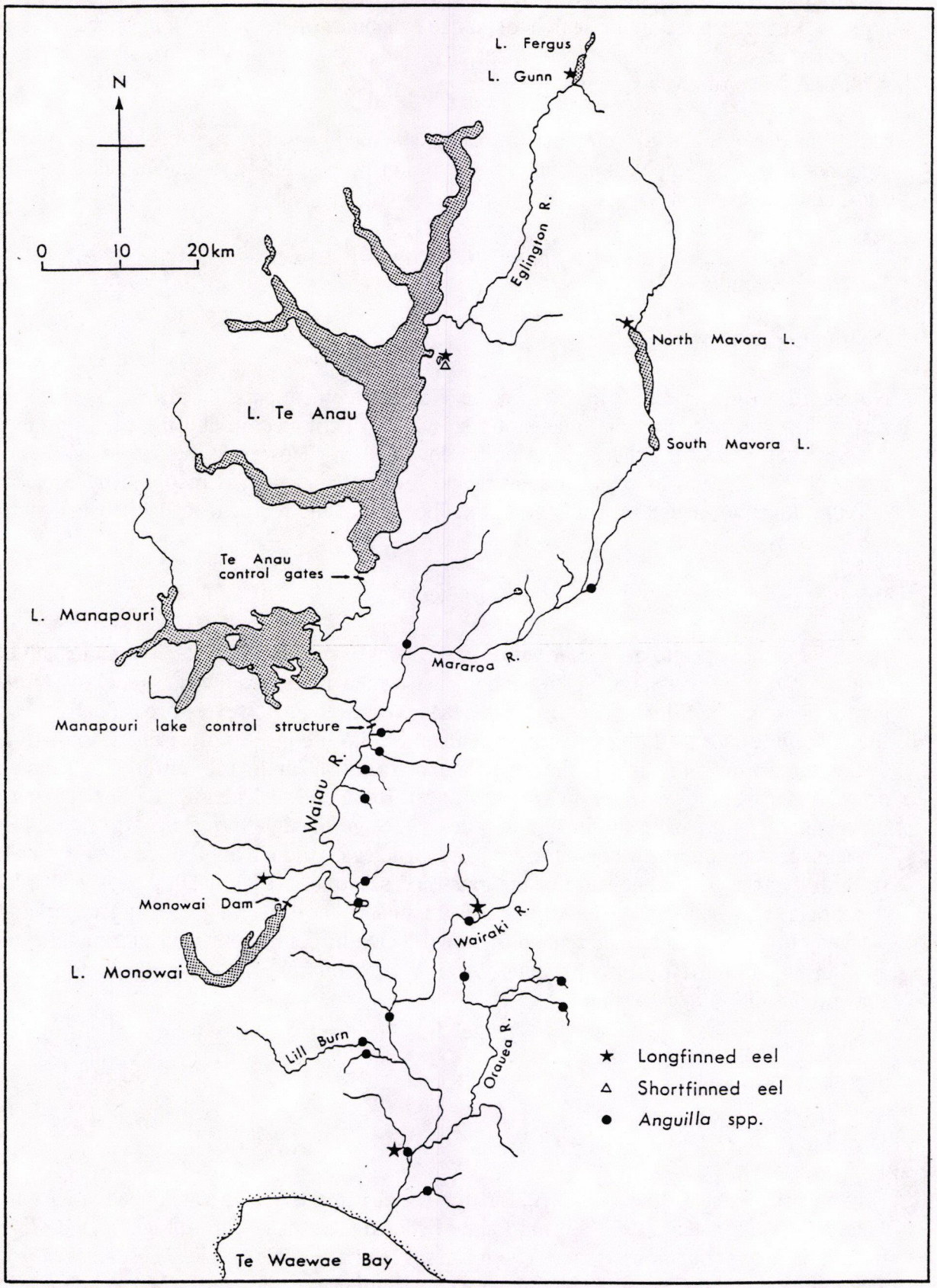


FIGURE 1. Distribution of eels in the Waiau catchment.

colouration, and at this stage are known as elvers. Each summer, large numbers of elvers migrate further upstream in search of suitable habitat. The young longfinned elvers in particular are able to climb steep waterfalls, and move through rapids, to penetrate the farthest reaches of river systems.

Shortfinned eels have a preference for sluggish, muddy waters and coastal swamps and lagoons. The longfinned eel is found in all types of waters, but its dominant habitat is rivers and inland lakes.

2.2 Inanga (Inaka)

Distribution

No records of this species occurring in the Waiau catchment exist on the F.F.D.B. This is surprising, given the fact that inanga are so widely distributed around the country and that a significant whitebait fishery exists on the lower river. However, the species is recorded in the S.F.G.C. files as being present in the lower Waiau, and is recorded by McDowall (1990). Juvenile inanga probably comprise the bulk of the recreational whitebait fishery in the lower Waiau.

Life history

Juveniles of this species are the principal component of the whitebait catch in almost all New Zealand rivers. The whitebait grow into inanga, which are a shoaling fish generally of open, gently flowing, or still water in the lower reaches of rivers. However, occasionally they are found in quite swiftly flowing rivers. The inanga has a life history precisely adapted to tidal cycles. Spawning is mainly in the autumn, and adult fish (up to 150 mm in length) migrate downstream from lower river areas into estuarine/tidal areas. The migrations occur on full moon phases and enable the inanga to take advantage of high spring tides to deposit eggs amongst grasses and rushes on the river bank. The eggs, though exposed to the air, are kept from drying out by the moisture of the grass and substrate. They hatch 2 or 4 weeks later, depending on when subsequent spring tides inundate the spawning area. The larvae are washed out to sea, where they remain for about 6 months before returning, during late winter and spring, as the familiar whitebait. After a year in fresh water, most inanga mature, spawn, and die.

2.3 Giant Kokopu

Distribution

Five records exist on the F.F.D.B. for this species in the Waiau catchment, all from the Lake Monowai system (1981/82) and Lake Mistletoe (Te Anau-Milford highway) (1978/80), indicating lake populations at these two locations (Fig. 2). This species is usually sea-going. The only record that might be attributed to a sea-going population of giant kokopu is from the Lake Monowai outlet, but this record most probably was of a fish of lake origin, given the presence of a population of giant kokopu in Lake Monowai.

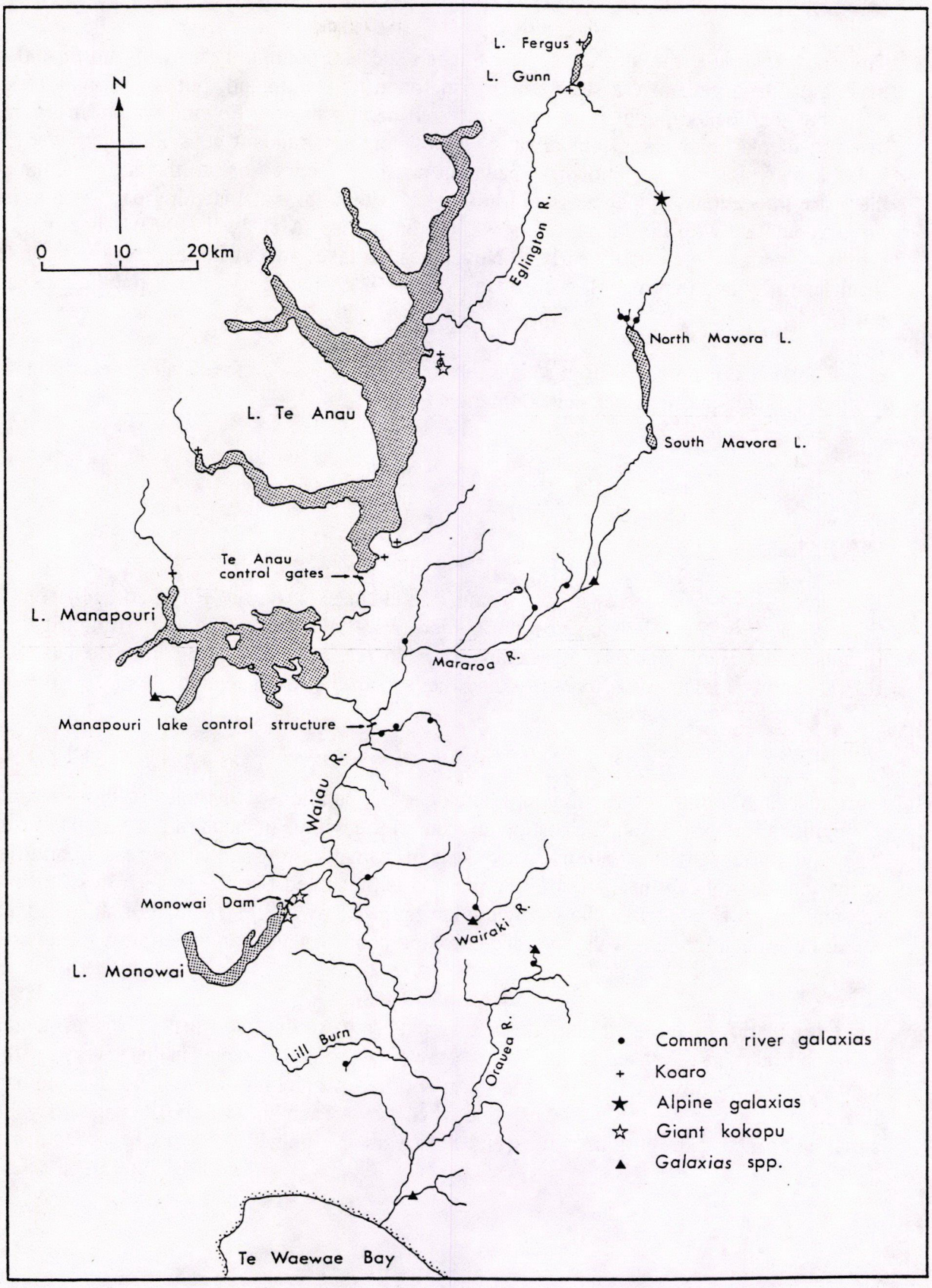


FIGURE 2. Distribution of galaxiid species in the Waiau catchment.

Life history

The giant kokopu is the largest of the whitebait species, commonly growing up to 400 mm in length. It is generally a sea-running fish found not far inland, but occasionally it also occurs as landlocked populations. Its preferred habitat is slow flowing waters in swamps, lowland creeks, and lakes, but always where there is abundant cover. Where the giant kokopu spawns is not yet known. Spawning possibly occurs close to the adult habitat, but there are indications of spawning migrations. It is thought that spawning occurs in autumn or early winter, with the larvae being washed out to sea (McDowall 1990). The whitebait return to fresh water, usually early in November. It takes two or three years for the fish to reach maturity and they may live for many years. The life history of lake populations is not known.

Giant kokopu are regarded as rare, largely because of loss of their habitat resulting from swamp drainage and pastoral development.

2.4 Koaro

Distribution

Eight records of this species in the Waiau catchment exist on the F.F.D.B., all from lake populations (Fig. 2). They have been recorded from Lake Te Anau and its tributaries, Lake Fergus, Lake Henry, and Lake Manapouri. No record of sea-going koaro exists on the F.F.D.B., but McDowall (1990) reported them from the lower Waiau.

Life history

This species has both sea-running and landlocked populations. Juveniles of the sea-running populations form the second largest component of the whitebait catch in New Zealand rivers. The adults prefer swift, tumbling, rocky streams in native forest. They breed in autumn or early winter, probably in their adult habitat. It is presumed that the larvae are swept out to sea and return as whitebait the following spring (McDowall 1990). This fish, particularly at the juvenile stage, has well developed climbing abilities and can penetrate well upstream.

Lake populations have a similar life history pattern. Adults live mostly in rivers entering lakes, but also in the lakes themselves. Spawning probably occurs in the rivers, with the larvae migrating downstream into the lakes soon after hatching. The planktivorous larvae live in the surface waters of lakes, but when they reach the whitebait stage they begin shoaling around lake margins and ascend the rivers in summer.

2.5 Banded Kokopu

Distribution

No records of this species occurring in the Waiau catchment exist on the F.F.D.B. However, the S.A.S. 1972 Annual Report mentions *Galaxias fasciatus* being found in Lake Te Anau and that "native trout" were numerous at the Te Anau hatchery spring. The term "native trout" can apply to banded kokopu, giant kokopu, or koaro. This report of the presence of banded kokopu in Lake Te Anau has not been verified, although it was reported to have been provisionally identified by R. M. McDowall in "Tuatara" Vol. 12, 1964 (S.A.S. Annual Report 1972). However, if the report is correct, the fish need not have been sea-going, as banded kokopu do form landlocked populations, as do giant kokopu and koaro.

Life history

This is yet another whitebait species, found throughout New Zealand from sea level to a great distance inland in some river systems. Mostly it occurs close to the sea and at lower elevations, usually in streams draining coastal hills. It can form landlocked populations. The fish is most often found in small, stable streams that have rocky, boulder beds and small cascades interspersed with small sandy pools. They are found in association with cover in the form of large boulders, overhanging banks, logs, and other instream debris. The presence of forest cover is usually very important, but the species may sometimes also be found in stable streams that are deeply entrenched and heavily overgrown by stream-bank vegetation.

Spawning takes place in late autumn to early winter, probably near the adult habitat, and the larvae are quickly washed out to sea. The whitebait return to fresh water in October, making their way up rivers to small tributaries and forest swamps where they grow to maturity. Like koaro, they are adept climbers, being able to negotiate vertical, wet, rocky faces of water falls.

2.6 Common River Galaxias

Distribution

Fourteen records of this species occurring in the Waiau catchment exist on the F.F.D.B. (Fig. 2). The species appears to be widely distributed in the catchment, generally in open, upper reaches of tributaries or in small streams.

Life history

This species is found almost exclusively east of the Southern Alps in the South Island, and it is entirely river resident. It is found in moderately swiftly flowing waters, usually with a gravel to boulder substrate. Adults reach 150 mm in length and are cryptic bottom dwellers. They are nocturnally active, rarely being seen during the day because they hide in the substrate. They spawn in the spring and early summer, laying their eggs in excavated

depressions beneath boulders. The fry are found in shoals in slow river margins, but when they are about 30-35 mm in length they become bottom dwelling.

2.7 Alpine Galaxias

Distribution

There is only one record for this species from the Waiau catchment in the F.F.D.B. (Fig. 2), from high in the headwaters of the Mararoa River. It is the southernmost record of this species, but is close to another known population in the headwaters of the Oreti River.

Life history

This is another river-resident galaxiid, which is found primarily in Marlborough and Canterbury on the eastern flanks of the Southern Alps. The southernmost records have been from the upper reaches of the Oreti River and the Mararoa River. The alpine galaxias occurs only in swift, cold, often snow-fed, subalpine and alpine rivers and streams with gravelly/boulder beds. The fish are found in the moderately deep, broken water of the rapids. Although the spawning sites are unknown, spawning apparently occurs in spring near the adult habitat, as larvae are found in the same locations as the adults, but around the river margins.

2.8 Smelt

Distribution

There are two species of smelt - the common smelt and Stokell's smelt. Five records of common smelt in the Waiau catchment exist on the F.F.D.B. (Fig. 3). They have been recorded from the Waiau River mouth, and, although not on the F.F.D.B., they also have been recorded from the Manapouri lake control structure (S.A.S. Annual Report 1972). The Manapouri lake control structure probably restricts further upstream movement of the sea-going population. However, this species also readily forms lake populations, and these account for most of the records from the Waiau. They have been recorded from Lake Monowai (1974), Lake Te Anau (1940), Lake Henry outlet (1980), and Lake Thomas (1966). They also have been reported in Lake Manapouri (Department of Internal Affairs, unpublished Investigation Report for the Manapouri Power Scheme (late 1960s)).

Stokell's smelt also have been reported from the Waiau mouth, although they are not on the F.F.D.B. These reports were made by McDowall (1979), referring to samples of Stokell's smelt from the Waiau mouth collected by Stokell himself, but recent observations on the distribution of the species cast some doubt on this old record (McDowall 1990). However, S.A.S. files record this species from the Waiau mouth in early 1984, based on an "almost positive" identification by I. A. Mathieson. If these reports are in fact correct, they represent the southernmost record of the species and are outside its generally accepted range.

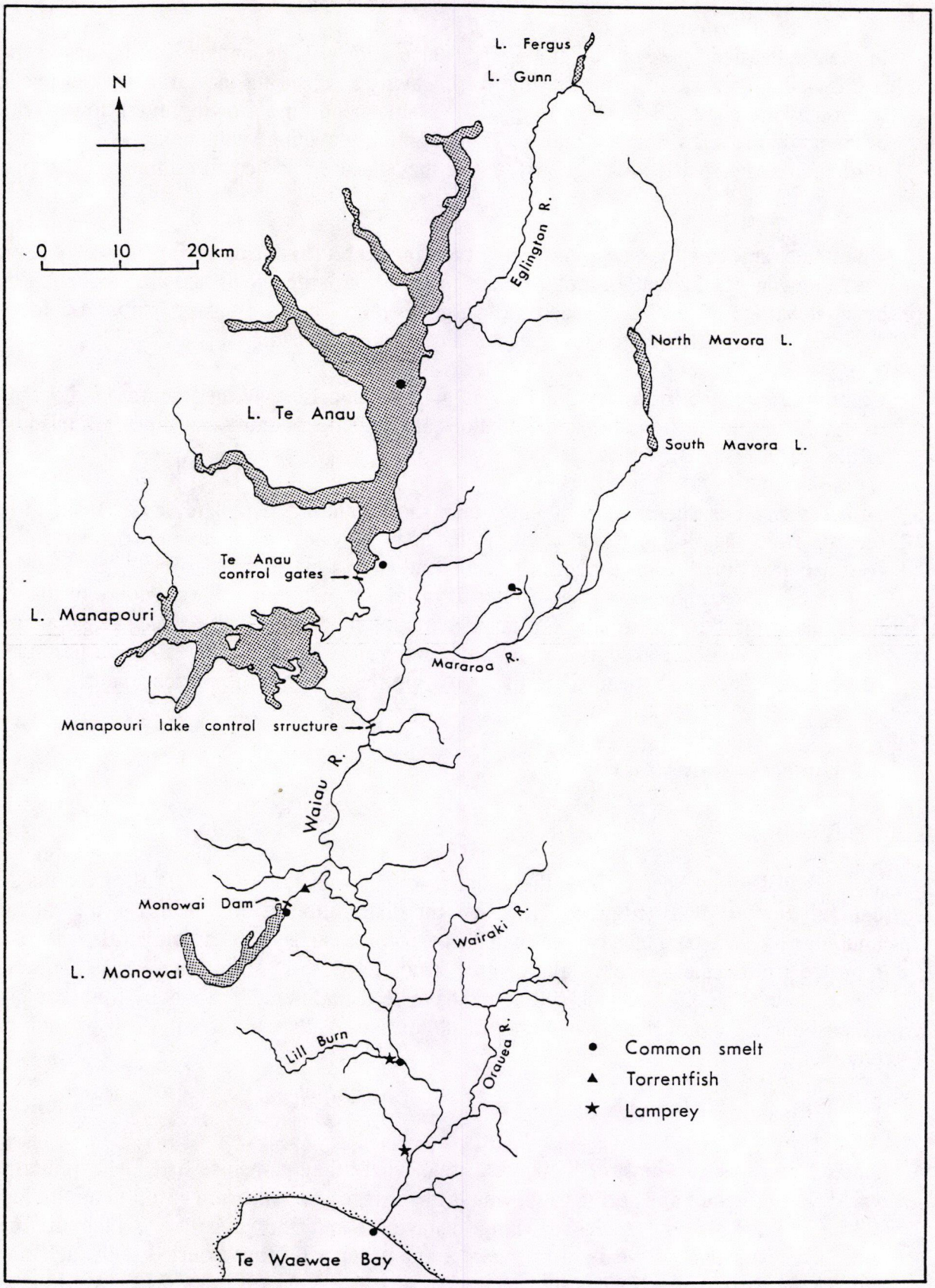


FIGURE 3. Distribution of smelt, torrentfish, and lamprey in the Waiau catchment.

Life history

In the South Island, sea-run common smelt (also known as cucumber fish, because of their strong odour) migrate from the sea into fresh water during spring and early summer to spawn when they are about 80-100 mm long. Some may spend time growing in the lower reaches of rivers before spawning in summer. Although the spawning site is unknown, it is thought to be in or near estuaries (or lagoons), where the eggs are released and sink into the substrate (McDowall 1990).

Upon hatching, smelt larvae are swept out to sea and return during spring and early summer the following year, about 12 months later. They form large shoals and are frequently taken by whitebaiters in the lower reaches of large rivers. They are also an important food for "sea-run" brown trout in the lower reaches of South Island rivers.

Common smelt also form lake populations, which can arise by either natural landlocking or from human introductions. Lake populations are much less common in the South Island than in the North Island.

Stokell's smelt is smaller (70-90 mm) than the common smelt, and, apart from the two records from the Waiau (Southland), which may be doubtful, their known distribution is confined to Canterbury. Stokell's smelt spend little time in fresh water, being the most marine of the retropinnids. They do not form lake populations and are generally found not far inland from the sea, usually not far above tidal waters. The life cycle is similar to that of common smelt, except that they migrate into fresh water generally at an earlier stage of development and must spend some time growing there before they reach maturity.

2.9 Lamprey (Kanakana)

Distribution

Two records of this species from the Waiau catchment exist on the F.F.D.B., from the Alton and Lill Burns (1965) (Fig. 3). However, the distribution of this species in the catchment undoubtedly will be much wider than these records suggest. Lampreys also have been reported from the Manapouri lake control structure (S.A.S. Annual Report 1972), and the Monowai weir (Field-Dodgson 1981), and have been traditionally caught by Maori at a stone dike about eight miles up the west branch of the Waikarua Stream (S. Cormack pers. comm.).

Life history

Adult lamprey spend most of their life at sea, where they parasitise fish. They enter fresh water during winter and spring to spawn. At this stage, they measure 450-500 mm in length. Little is known about their spawning behaviour, but the juveniles (which are called ammocoetes) spend 3-4 years in fresh water and are usually found buried in the substrate in silty backwaters.

2.10 Torrentfish

Distribution

Two records of this species in the Waiau catchment exist on the F.F.D.B. (Fig. 3). These are from the Monowai River (1981) and the Lill Burn (1972). Torrentfish also have been trapped at the Mararoa fish pass (S. Mitchell pers. comm.; S.F.G.C. files).

Life history

This is also a sea-going species, mainly found near the coast but also found well inland. It penetrates upstream in some river systems that flow to the sea via lakes. It occurs mostly in waters with gravel/boulder substrate, commonly large rivers with broad open beds, but also small streams. It is not dependent on forest cover. The fish are found in the swiftest, tumbling, broken, white water of the rapids, where they live in the spaces amongst the boulders and cobbles.

Torrentfish are highly migratory at most stages of their life history, spending much of their lives moving upstream and downstream over long distances. Larval life is spent at sea, and the juveniles (25-35 mm) move from there into river estuaries during spring and autumn. After a few weeks, the young fish move further upstream to adult habitats and they keep moving upstream as they grow. Females predominate upstream and probably migrate downstream to spawn, while the males are found mainly in the lower reaches of rivers. The location and nature of the spawning areas are unknown.

2.11 Common Bully

Distribution

Six records of common bully in the Waiau catchment exist on the F.F.D.B. (Fig. 4), all from the Mararoa and Te Anau catchments. The species is probably widespread in the Waiau catchment. Huge numbers have been reported from the Waiau River mouth (S.F.G.C. files). There are an additional 12 records in the F.F.D.B. for *Gobiomorphus* sp. in the Waiau. Most of these are from the middle and lower catchment, below the Manapouri lake control structure, and were probably either common or upland bullies.

Life history

This is the most widespread bully in New Zealand, and, because it is the least secretive of the bullies, it is also the most widely seen. The species forms both sea-going and lake-dwelling populations. In rivers, the common bully normally hides among gravel and cobbles along the margins, but in lakes it is frequently seen in large numbers along open shorelines. In rivers, spawning occurs during spring and summer, with the eggs being laid on rocks and logs. The larvae are swept down to the sea where they grow to 15-20 mm before returning later in spring and summer. In lakes, the larvae are planktonic, but when they are about 10 mm long they become bottom dwelling and move to inshore shallows. Larger adults, up to 80 mm, tend to occur in deeper water.

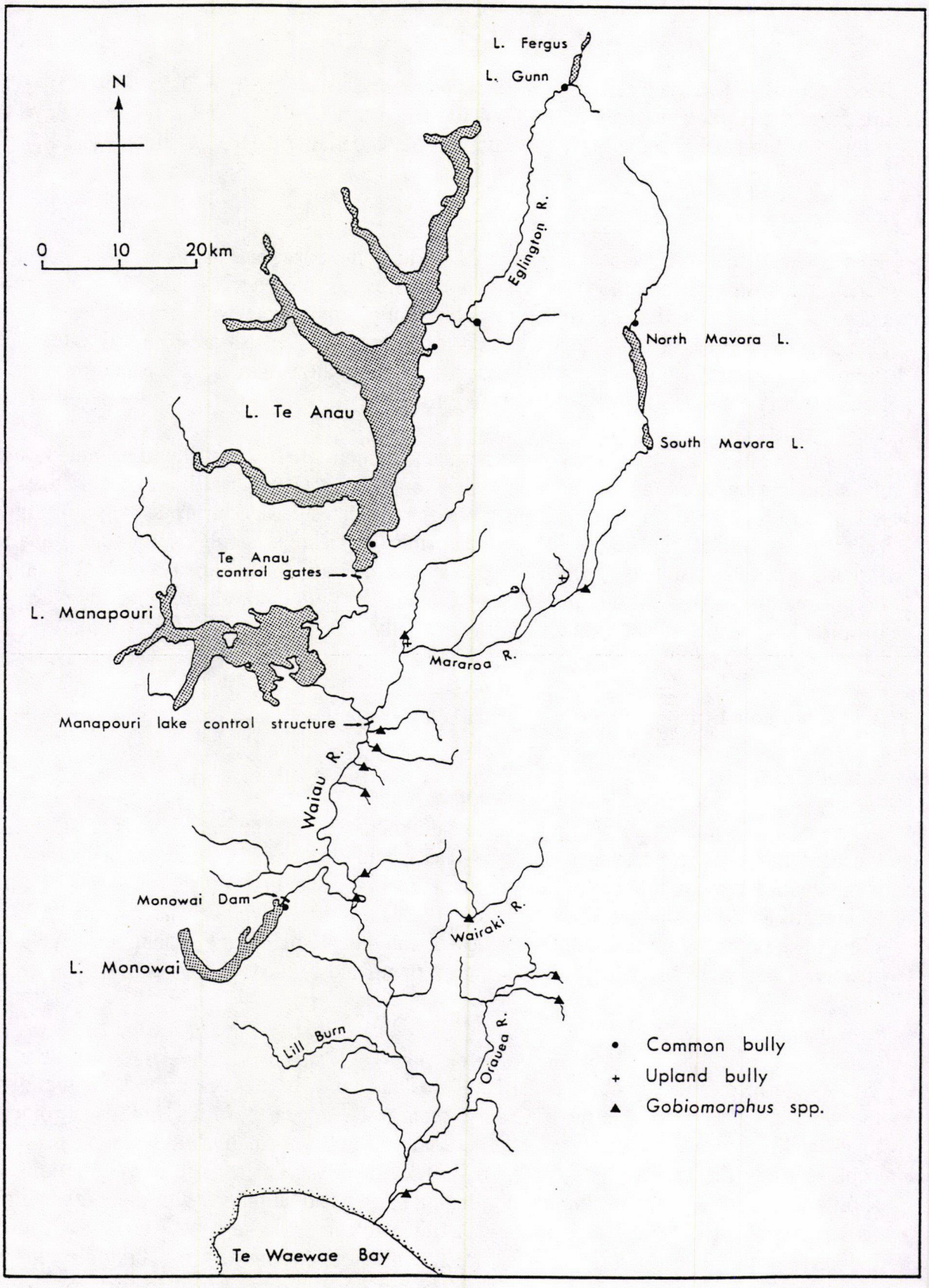


FIGURE 4. Distribution of bully species in the Waiau catchment.

2.12 Upland Bully

Distribution

Two records of this species in the Waiau catchment exist on the F.F.D.B., both from the middle to lower Mararoa catchment (Fig. 4). The species no doubt is more widespread than these records suggest, especially in the upper Waiau. Some of the 12 records for *Gobiomorphus* sp. mentioned in Section 2.11 may have been unidentified upland bullies.

Life history

This is probably the most common and widespread bully in the South Island. Its common name is misleading, because it frequents both upland and lowland waters. It is a river-resident species which lives in a variety of habitats. Although mainly a species of gently flowing rivers, it also occurs in swift streams and upland lakes. It is bottom dwelling, and seeks the cover of rocks and weed. Spawning occurs in spring and summer on rocks or logs. The larvae hatch in three to five weeks and, in rivers, shoal in the margins of pools, whereas in lakes they become planktonic.

2.13 Bluegilled Bully

Distribution

This species has not been recorded from the Waiau River, but it is likely to occur there as the river is within the species' distributional range. It is most likely to occur in the lower river.

Life history

This is a sea-going species, the adults of which are often found in association with torrentfish. It is found throughout New Zealand, usually in the middle to lower reaches of swift, gravelly streams and rivers. The fish inhabit the loose aggregations of rocks and boulders of the rapids.

Spawning is probably comparable with that of other species of bullies, and apparently occurs in spring and autumn; the larvae subsequently are washed out to sea. After about six months at sea, the juveniles (15-20 mm) migrate into rivers in large numbers during spring and autumn. The young penetrate upstream as they grow, the females more so because they are more abundant upstream than males.

2.14 Redfinned Bully

Distribution

Although not recorded from the Waiau catchment on the F.F.D.B., this species has been recorded from the lower Waiau by McDowall (1990) and the S.F.G.C. The S.F.G.C. also

have reported redfinned bully from the middle and upper catchment, but as this species is commonly coastal there is some doubt about this observation.

Life history

This is another sea-going species, with a life cycle similar to that of the other sea-going bully species. It is a widespread and common, but mostly coastal, species. It inhabits fast, bouldery streams, and is usually found where the substrate consists of large rocks and boulders, particularly at the heads of rapids. Spawning occurs from July, probably until November, the eggs being laid on rocks and logs. Upon hatching, the larvae go to sea. From November onwards, the juveniles make their way back to fresh water and, over the next few months, gradually move upstream to their rocky stream, adult habitats (McDowall 1990).

2.15 Other Species

Distribution

Giant bully, black and yellow belly flounders, yelloweyed mullet, and kahawai have not been recorded from the Waiau catchment on the F.F.D.B., but they have been recorded from the lower river by the S.F.G.C., and black flounder also have been recorded from the middle reaches of the river. With the exception of the giant bully and black flounder, which are true freshwater/estuarine species, these fish are largely marine but inhabit estuarine areas to feed.

Life histories

The giant bully is yet another sea-going bully species. It is the largest of the bullies, commonly growing to 150 mm or more in length. It is a widespread, coastal species, seldom being found more than 1-2 km inland. Little is known about its biology. It occurs primarily in the lower reaches of rivers and streams, in and just above the influence of the tide. Spawning has not been studied, but it is likely to occur in estuaries and to be comparable with that of redfinned and common bullies, with the larvae also being marine (McDowall 1990).

The black flounder is found all around the New Zealand coastline. It occurs commonly at sea, in estuaries and harbours, and upstream in rivers for many kilometres (McDowall 1990). Its biology is unstudied. The fish are found mostly in quiet, sandy-bottomed pools and backwaters, but occasionally in gravelly rivers. They are also common in lowland and coastal lakes. Their eggs are either laid in rivers and the larvae washed to sea, or, more likely, the adults themselves migrate to the sea to spawn (McDowall 1990).

3. INTRODUCED FISH DISTRIBUTIONS AND LIFE HISTORIES

3.1 Trout

3.1.1 Distribution

Brown and rainbow trout are widespread in the Waiau catchment (Fig. 5). Rainbows are more numerous in the upper tributaries of the Waiau, but are virtually absent in the lower tributaries. However, rainbows often are caught in the tidal and lower reaches of the main river (Graynoth and Skrzynski 1974). Brown trout predominate in the Waiau River below the Manapouri lake control structure. There are some "sea-run" brown trout caught by anglers in the tidal reaches, mainly during January to April (S.A.S. Annual Report 1973). It is not clear whether these are true sea-run fish, or simply fish that spend some part of their lives feeding in the tidal reaches. The extent to which these fish migrate up and down the river is also unclear.

Rainbow trout in the Mararoa catchment become progressively less abundant toward the headwaters. Since installation of the Manapouri lake control structure in 1975, observations made by S.F.G.C. staff suggest that there has been an increase in the proportion of rainbow trout in the Mararoa River, and that these fish appear to be penetrating progressively further upstream. Within a year following installation of the control structure, there was reported to have been a marked reduction in the number of large brown trout in the Mararoa River, but this was followed by a marked increase in the number of rainbows both in the river and in the Mavora Lakes (S. Sutherland S.F.G.C. pers. comm.).

Some information on trout species composition and distribution in the Mararoa River was gathered from drift dives made by the S.F.G.C. between 1976 and 1985. In February 1976, rainbow trout made up 15% of the species composition from the main road to the confluence with the Waiau. A comparison of the drift dive counts between 1976/78 and 1985 suggested that brown trout numbers had changed little, but that rainbow trout had increased (S.F.G.C. files).

Comparison of angler catches in the Mavora catchment between 1947/52 (Allen and Cunningham 1957) and 1978/79 (S.A.S. creel census, S.F.G.C. files) showed that the proportion of rainbows in the anglers' catch had remained similar (19% and 18%) over that time.

Early trapping records from the lower Mararoa, one mile up from the Waiau confluence, demonstrated that, historically, there were large migrations of brown trout from the lower Waiau up into the Mararoa and its tributaries. For example, during the period 1927-1929, about 900 fish were trapped each season (S.A.S. Annual Report 1972).

Studies of tagged fish moving through the Mararoa fish pass by the S.F.G.C. in 1978 suggested that brown trout did not move upstream through the pass, but that rainbows did (S.F.G.C. files, S.A.S. Annual Report 1979, Field-Dodgson 1981). Currently, the pass is blocked with gravel which precludes any fish passage.

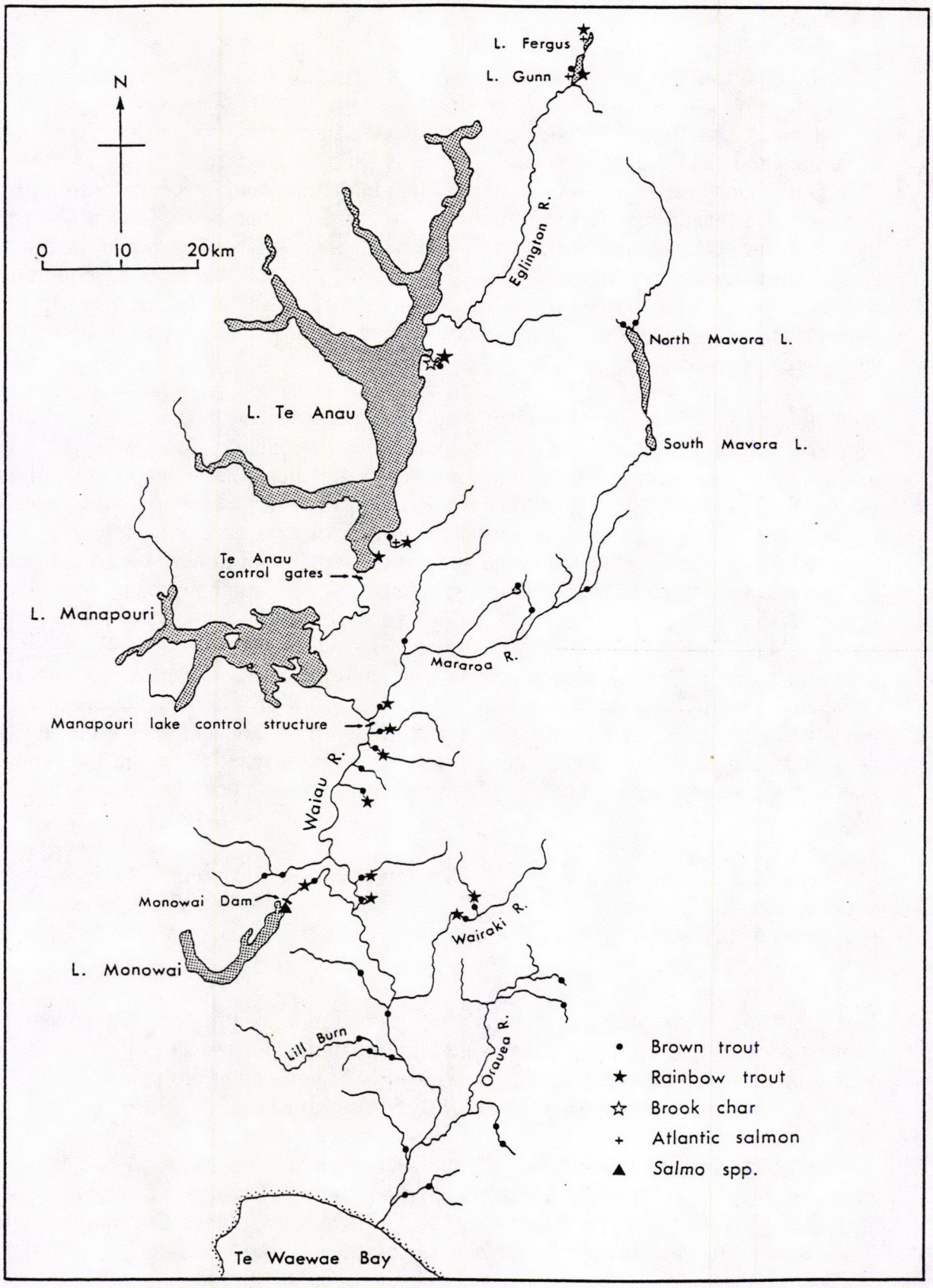


FIGURE 5. Distribution of salmonids in the Waiau catchment.

Information on trout in the upper Waiau catchment, including Lakes Te Anau and Manapouri, is not up-to-date, and is confined to angler catch records from Lake Te Anau over the period 1947-1967. At that time, the angler catch in Lake Te Anau was composed of 23% brown trout, 63% rainbow trout, and 13% Atlantic salmon (Graynoth 1971). In the upper Waiau over the same period it was 6% brown trout, 83% rainbow trout, and 11% Atlantic salmon.

3.1.2 Spawning Areas

Only three tributaries of the lower Waiau below the Manapouri lake control structure provide good quality trout spawning waters. These are the Wairaki River, and Redcliff and Whare Creeks. Since completion of the Manapouri control structure, Whare and Redcliff Creeks provide the only spawning waters of any consequence above the Waiau-Borland confluence. Below there, the Wairaki River is the most valuable spawning water (I.A. Mathieson S.F.G.C. files). Some brown trout spawning also takes place in the mainstem, the Orawia, and other tributaries of the lower Waiau.

Above the Manapouri lake control structure, the Mararoa and Whitestone Rivers provide extensive spawning for both brown and rainbow trout. A major spawning run takes place in the Mararoa River and up into the Whitestone (S.A.S. Annual Report 1972). Spawning occurs throughout most of the mainstem of the Mararoa, including that part between South and North Mavora Lakes and above the latter. The major spawning areas in the Whitestone catchment are the lower 3.3 km of the river and the reach between Te Anau highway and Moat Creek.

Before the Te Anau control structure was installed in 1974, the upper Waiau River between Lakes Te Anau and Manapouri was used for spawning by trout and Atlantic salmon. It was thought that the trout came mainly from Lake Manapouri. Trout still spawn in this part of the river, but the altered rates and seasonal patterns of flow that result from operation of the control gates have, at times, seriously affected trout spawning beds in the river. In one season (prior to 1981), an estimated 80% of redds in the river were lost because of low winter flows (E.J. Gibbs unpublished data). This situation persists to the present (S.F.G.C. 1991 newsletter).

3.1.3 Life Histories

Brown trout form the basis of very important river and stream fisheries in the entire South Island and in the central and southern North Island. They are widespread in the South Island and in North Island rivers south of a line between northern Taranaki and southern Hawkes Bay.

The species exhibits a variety of life history strategies in New Zealand, including river residence, lake-dwelling, and sea-going, or mixtures of the three. Spawning usually occurs in late autumn to early winter, and there is often an upstream migration to the spawning grounds. Brown trout in lakes usually migrate up into tributaries to spawn, and those in rivers may or may not migrate, depending on where suitable spawning areas are located.

During spawning, the fish deposit their eggs in nests (redds) that they dig in the gravel of the river bed. These areas usually have moderate flow and the gravel must be permeable (relatively free of silt) for the eggs and larvae to survive. Adults move back downstream after spawning, although some may remain near the spawning areas if adequate adult habitat is present. Fry emerge from the gravels in early winter and spring and grow over the first summer near the spawning areas. In the autumn, significant downstream migrations of juveniles may occur, but the extent and timing of these and other movements throughout the life cycle are variable.

Rainbow trout also provide extremely important recreational fisheries, particularly in the lakes of the central North Island and in many lakes along the eastern flanks of the Southern Alps. They are less widespread than brown trout, and significant populations usually occur in association with lake systems. This species is more migratory than brown trout. Spawning usually occurs in late winter and spring, in a similar fashion to that of brown trout. Adults gradually move back downstream after spawning. Upon emergence from the gravels in late spring, a large proportion of the fry may undergo an extensive downstream migration, usually into the parent lake. The rest of the fry rear in the spawning areas and most migrate downstream in the autumn and following spring.

3.2 Atlantic Salmon

Distribution

The Waiau catchment is the only location in New Zealand where Atlantic salmon have been established successfully. This resulted from a concerted acclimatisation programme by the N.Z. Marine Department during the period 1908 to 1911. Prior to this success, other attempts to establish the species in New Zealand had failed, despite 23 separate importations of ova (Gibbs 1981). By the 1930s, the species was considered well established in Lakes Manapouri and Te Anau, and in the Waiau, Upukerora, and Eglinton Rivers (Pearce 1928, Southland Anglers Club 1929, Hefford 1930, Hobbs c. 1950, N.Z. Marine Department Annual Report 1923-24). The fish were somewhat unusual in that they adopted a wholly freshwater existence and migrated from the lakes to the tributary rivers to spawn (Regan 1927, Calderwood 1927, Hefford 1927a, Parrott 1932, Stokell 1934, 1955, 1959). This is not to say that Atlantic salmon were confined to the lake system. They were occasionally caught in the lower Waiau down to the river mouth (Gibbs 1981) and in nearby rivers (McDowall 1990). Also, there is evidence to suggest that spawning was not confined entirely to the upper Waiau lake system. Apparently, some Atlantic salmon used to migrate out of the Waiau River into the Mararoa River, presumably to spawn. During 1927-1929, 30-40 Atlantic salmon per season were recorded from a fish trap located in the lower Mararoa River, one mile above the Waiau confluence (S.A.S. Annual Report 1972).

The Waiau Atlantic salmon stock built up during the 1920s and early 1930s, reaching a peak of 1000 to 1200 angler-caught fish by 1929 - 1930 (Gibbs 1981). However, in the late 1950s it declined, possibly as a consequence of the expansion of the rainbow trout population, which was introduced to Lake Te Anau in the mid 1920s (McDowall 1990). By the 1970s, Atlantic salmon were virtually extinct in the Waiau system. Between 1947 and 1967, Atlantic salmon accounted for 12% of the total catch (1500 per annum) by anglers in Lake

Te Anau and the Waiau River (Graynoth 1971), although Graynoth stated that few salmon had been caught in recent years. The only recent comparable records are for 1972 to 1982, which show that salmon accounted for only 1% of the catch in these two waters (Wildlife Service unpublished data, Gibbs 1981).

By 1980, the outlets of Lakes Gunn and Fergus were the only areas where Atlantic salmon spawning was known to still occur. To save the species, an artificial spawning and rearing operation was conducted by the Wildlife Service in the 1970s and 1980s, with a genetically limited brood stock. Releases were made in Lakes Gunn and Fergus and, more recently, in the Upukerora River and Home Creek, tributaries of Lakes Te Anau and Manapouri, respectively. Despite these efforts, Atlantic salmon remain rare in the upper Waiau and very rare in the lower Waiau.

Life history

Atlantic salmon are one of the classically "great" freshwater game fishes of the world. They are renowned amongst anglers as the most aggressive fighters of the salmonids. Although they attracted a lot of attention in the early days of acclimatisation into New Zealand, they have drawn little interest recently from anglers, primarily because of their rarity.

The life history of the species is similar to that of migratory brown trout. In the Waiau - Lake Te Anau system, the adults migrate from the lakes up into the tributaries, or to the upper Waiau River between Lakes Te Anau and Manapouri, to spawn during early winter. Spawning is similar to other salmonids. Some adults survive spawning (unlike Pacific salmonids which all die following spawning), and return to the adult habitat. The juveniles, or parr, rear in the spawning tributaries for one to three years before migrating downstream to the parent lakes in which they grow to maturity.

3.3 Brook Char

Distribution

This species is recorded in the F.F.D.B. only from Lake Mistletoe on the Milford-Te Anau highway. However, McDowall (1990) also reported it as being recently released into nearby Lake Henry.

Life history

In New Zealand, brook char are found quite widely, although they are little known in the Waiau. They occur in isolated locations in the central North Island but are more widespread in the South Island, particularly in inland Canterbury, Otago, and Southland river systems. They occur in several small lakes, but more commonly in small, narrow, upland streams. In New Zealand they do not usually co-exist with other salmonids and they often form stunted populations. Spawning of brook char has not been described in New Zealand, but in the species' native range in North America it takes place in autumn and winter, when the adults deposit their eggs in nests (redds) in fine to moderately coarse gravels, in moderately

swift water in rivers, or in spring-fed, gravel areas on lake beds. The fry emerge in early spring. The New Zealand populations appear to exhibit limited movements.

3.4 Perch

Distribution

Perch are not recorded from the Waiau on the F.F.D.B., but have been reported from the river by Graynoth and Skrzynski (1974) and by the S.F.G.C. They probably are confined to the lower river, where they are likely to be uncommon and not highly regarded by anglers.

Life history

Perch are widespread in New Zealand but generally are present in localised populations. It is a fish of still and gently flowing waters (e.g., lakes, ponds, and sluggish rivers), especially where there is prolific weed growth. They are a wholly freshwater species, at no stage entering saline water. Spawning occurs in spring and takes place in weedy margins in the vicinity of the adult habitat.

Although perch is a highly regarded game fish in its native Europe and North America, generally it is not so in New Zealand, particularly in the south where abundant trout stocks hold the anglers' attention.

4. FISHERIES

4.1 Traditional Fisheries

Eels and whitebait were and are fished for by Maori, but no details on the fishery have been obtained.

Inanga possibly were fished for at the adult stage by Maori, but no details have been obtained except that inanga, along with lamprey, eels, native and brown trout are now available in much reduced quantities (S. Cormack pers. comm.).

Lamprey were and are fished for on their upstream spawning migrations by Maori, but little information on the fishery has been obtained. Lamprey were caught at a stone dike about eight miles up the west branch of the Waikarua Stream (S. Cormack pers. comm.).

Flounder are fished for by Maori, but no historical details on the fishery have been obtained, except for a record of recent fishing, for which it is unclear whether those fishing were Maori. *("Flounders have been set netted for some years in the lagoon for the last few years until this summer when in a period of dry weather the flow was reduced to such an extent that the bed of the river became stagnant and caused the nets to smell of rotten sediment"* (S. Cormack pers. comm.).)

Kahawai and yelloweyed mullet probably were and are taken by Maori, but no details on such fisheries have been obtained.

4.2 Recreational Fisheries

4.2.1 Trout

Brown and rainbow trout together provide a significant recreational fishery throughout most of the Waiau catchment. Brown trout dominate the fishery in the lower catchment, with rainbow trout becoming more important further upstream. "Sea-run" brown trout provide a summer fishery at the Waiau mouth.

The Waiau trout fishery is regionally important (Teirney *et al.* 1984, Riddell 1985). The angling experience is reinforced by the beauty of the river and its surroundings. Rainbow trout provide an added attraction on the Waiau, as it is the only major Southland river with a population of this species.

Riddell (1985) calculated a mean catch rate of 0.24 fish per hour for the river, and a mean angling day of 5.5 hours. Teirney *et al.* (1984) estimated that the Waiau River supported 15% of the Southland angling effort, placing it fourth in the angler usage stakes after the Mataura, Oreti, and Aparima Rivers. Teirney *et al.*'s estimate of total angler visits to the river (12 000 per season) was 2.3 times greater than that estimated by Riddell (5256 per season). Both studies found spin and live bait to be the most popular methods, with fly fishing increasing in popularity towards the headwaters. They differed on the stretches of the river fished most frequently. Teirney *et al.* (1984) found the middle reaches to be most popular, whereas Riddell (1985) found that the lower reaches were most popular.

Teirney *et al.* (1984) summarised anglers' comments, which included negative attitudes toward the effect of hydro-electric development on the river, specifically the reduction in flow, the algae problem in summer, the river being unfishable because of high water turbidity when the Mararoa weir gates are open, and the fact that the natural beauty of the river has been spoilt.

4.2.2 Atlantic Salmon

These fish are now rare in the Waiau catchment and therefore do not support a recreational fishery in their own right. Very occasionally they are caught by trout anglers, who prize the fish because of their rarity.

4.2.3 Whitebait

Whitebait support a recreational fishery in the lower Waiau River (Kelly 1988). On average, 50-60 whitebaiters per day fish the river during the whitebait season.

4.2.4 Other Species

Other species that are fished for recreationally in the lower Waiau River include yelloweyed mullet, kahawai, flounder, and eels.

4.3 Commercial Fisheries

4.3.1 Whitebait

Although there is no official commercial fishery for whitebait on the Waiau, no doubt whitebait is sold by some recreational whitebaiters to supplement their income. No information is available on such sales.

4.3.2 Eels

There are at least 29 commercial eel fishing permits issued to Southland residents, but only a few of these fishers would operate on the Waiau River. The Southland region returns about 10% of the New Zealand catch of eels, and, of this, 90% are longfins (MAF Fisheries files). In the Waiau, most commercial eel fishing would be carried out on the lower river.

The only other information on commercial fishing is an observation by S. Cormack that *"about 20 years ago a Takata Fenua Maori commercially fished the Waiau lagoon".*

5. FISH PASSAGE

A feature of the fish fauna in the Waiau River, and in fact of New Zealand freshwater fish in general, is the prevalence of migration, particularly to and from the sea. In this regard, the hydro-electric developments in the Waiau catchment will have had, and will continue to have, an impact on fish distribution. The following section has been provided by D.J. Jellyman (MAF Fisheries, Christchurch) and highlights the need for consideration of passage for eels in the Waiau catchment. Eels probably have the highest value of all the migratory native fish species in the Waiau, because of their traditional, recreational, commercial, and conservation values.

5.1 Elver Access

The Waiau catchment has been extensively modified by hydro-electric developments (i.e., Monowai (6 MW, commissioned 1925), Manapouri (590 MW, commissioned 1969/71), Manapouri lake control structure (1975), and Te Anau control gates (1974)). In the past, it is likely that the Monowai power station caused some mortality to those elvers that arrived at the station's tailrace, as there is no possibility of access to the Monowai River from that point. When there was some flow down the old Monowai River channel (spilling from the power station header pond), elvers could enter this and proceed upstream to the control gates at the lake outlet. From here, they may have been able to leave the river and climb around the gates to enter the lake, although there are no records of this happening. However,

intermittent high flows also attracted eels and other fish into the old river channel where many perished once high flows stopped (S.A.S. Annual Report 1988). Installation of the new fish pass (May 1989) should have rectified this problem and facilitated access of elvers to the control gates at the lake outlet, but there remains the uncertainty of whether elvers can then negotiate this structure and enter the lake itself.

Of greater concern is the obstruction to migration posed by both the Manapouri lake control structure and the Te Anau control gates. Since it became operational in April 1978, the Mararoa fish pass has proved to be unsatisfactory for the passage of trout, despite several modifications. How effective it has been for the passage of elvers is uncertain. It is known that in earlier years, elvers entered the trap in large numbers (e.g., Electricorp has provided photographs taken through the viewing "portholes" of the pass in January 1983, showing the interior packed with elvers). However, discussions with Stuart Sutherland of S.F.G.C. have raised doubts whether these elvers could actually negotiate the pass itself, owing to the high interior differences in water level. Sutherland considered it likely that the only time that elvers could negotiate the pass would have been when the weir gates were open, thus producing a higher downstream water level, which in turn would have decreased the differences in level within the pass. Elver passage also would have been possible on those few occasions when flows overtopped the weir itself, at which time elvers could have climbed over the weir. (N.B. Ian Jowett, MAF Fisheries, considers Sutherland's view to be incorrect, and maintains that neither level differences nor velocities within the pass would restrict elver passage.)

A visit to the control structure in mid November 1991 found the fish pass completely choked with gravel and the water supply to it turned off. Making the pass operational again would require removing gravel from inside it, as well as from the area immediately downstream of the weir. A better option for elver passage would be the construction of a channel to the base of the weir and installation of an elver pass over the weir crest adjacent to the gates.

For those elvers which manage to get past the weir, there is likely to be a problem of orientation. During their summer upstream migration, elvers show a strong inclination to orientate into a current, and will avoid swimming downstream. However, upstream of the Manapouri lake control structure, the flow of the Waiau River is normally in the direction of Lake Manapouri (unless the control structure is spilling excess water, or spilling discoloured water from flooding in the Mararoa River). Elvers arriving above the weir during non-spilling periods would tend to continue their migration by swimming up the Mararoa River, rather than swimming downstream into Lake Manapouri.

That some elvers do negotiate the Manapouri lake control structure is evidenced by information obtained from Bill Jarvie (S.F.G.C., Te Anau), that he has seen elvers on one occasion attempting to bypass the Te Anau control gates by wriggling up the true left bank above the gates. This also raises questions about the amount of time that elvers are able to negotiate the gates. When the gates are fully open, elver passage is possible, but for much of the time water velocities under the gates would prevent elver access.

5.2 Significance of Closed Areas to Maintenance of Eel Stocks

Eels form an important commercial fishery in New Zealand, with 1000+ tonnes caught annually. MAF Fisheries is currently reviewing management of the fishery. As eels spawn only once, at the end of their lives, the most practical way of maintaining the sustainability of the resource is to ensure that there are sufficient reserve areas set aside where no commercial fishing is allowed. Hence the preservation of stocks within National Parks and various reserves becomes particularly important. A review of the commercial eel fishery (Jellyman in prep.) has shown that 30% of New Zealand's lake habitat regarded as suitable for eels is within National Parks. Of this 72 770 ha, 66 860 ha is within the South Island, 80% being within the Waiau catchment (Lakes Monowai, Manapouri, and Te Anau). As the discussion in Section 5.1 indicates, there are real uncertainties about the continued recruitment of elvers into these lakes. This should not be seen merely as a local problem, as there are implications here for the continued well-being of the national commercial eel fishery.

6. GAPS IN FISHERIES KNOWLEDGE

1. How significant is the traditional Maori and commercial eel fishery?

2. How significant is the traditional Maori lamprey fishery, and are there fishing sites other than the stone dike in the west branch of the Waikarau Stream?

3. What is the location and extent of inanga spawning areas and the effect on them of the artificial flow regime in the lower Waiau?

4. What is the effect of the artificial flow regime on trout habitat and angling downstream from the Manapouri lake control structure and in the Waiau River between Lakes Manapouri and Te Anau?

5. What are the effects of river mouth blockages on feeding and spawning movements of "sea-run" brown trout, on migrations of native fish species, and on angling in the lower Waiau?

6. What has been the effect of the Manapouri lake control structure on trout populations in the Waiau catchment?

7. Are migrations between the Waiau and Mararoa River important in maintaining trout stocks in the two rivers?

8. Can the fish pass on the Manapouri lake control structure be made operational again, and can it be operated to allow the upstream and downstream passage of brown and rainbow trout, eels, and other migratory species of native fish?

9. How would the artificial flow regime between the Manapouri lake control structure and Lake Manapouri affect the migrations of eels and other sea-going native fish that might be able to negotiate the Mararoa fish pass?

10. What is the benefit of, and is it possible to install, a fish pass for eels on the Te Anau control gates?

11. Are sea-going koaro present in the Waiau whitebait run, and if so how extensive is their distribution and can their upstream passage over the hydro weirs be facilitated?

12. Is there a significant population of torrentfish in the Waiau, what is their distribution, and can their upstream and downstream passage past the Manapouri lake control structure be facilitated?

7. RECOMMENDATIONS

This review of the distribution of fish in the Waiau catchment has highlighted the fact that very little is known of the distribution of native fish and even less about their abundance. It also has highlighted concerns about fish passage past the Manapouri and Te Anau control structures.

It is recommended that a study of the effects of the control structures on the distribution and abundance both of native and introduced fish species be undertaken, and that the merits of establishing good fish passage past these structures be investigated. The studies should comprise:

(i) surveys of fish distribution and abundance throughout the Waiau catchment, using techniques for quantitatively sampling large rivers which have been developed for the native fish extension of the "100 rivers" survey;

(ii) a comparison of the present fish distribution with what is known of the pre-hydro development distribution, to establish the effects of the control structures on fish distribution and abundance;

(iii) an analysis of the distribution and abundance of fish species which are likely to develop with good fish passage facilities at the control structures, and a comparison with the present situation;

(iv) an assessment of the relative values (cultural, recreational, and commercial) of the fisheries which have been affected by hydro-electric development in the catchment. In particular, the Maori fisheries for eel and lamprey, the commercial eel fishery, the recreational fisheries for whitebait and trout, and the conservation values of rare and endangered species should be considered.

8. ANNOTATED BIBLIOGRAPHY

Allen, K., and Cunningham, B.T. 1957. New Zealand angling 1947-1952; results of the diary scheme. *N.Z. Marine Department, Fisheries Bulletin No. 12.* 153 p.

Comparison of angler catch statistics throughout New Zealand including the Waiau catchment.

Calderwood, W.L. 1927. Atlantic salmon in New Zealand: The salmon of Lake Te Anau. *Salmon and Trout Magazine 48:* 241-252.

Cited by Gibbs (1981).

Field-Dodgson, M. 1981. Mararoa fish pass. *Freshwater Catch No. 12:* 18-20.

Presentation of results of a trapping study by the Southland Acclimatisation Society of fish using the Mararoa fish pass in 1978.

Gibbs, E.J. 1981. A review of Atlantic salmon in New Zealand, with notes on current status and management. pp. 55-64. *In:* Hopkins, C.L. (comp.), Proceedings of the salmon symposium. *N.Z. Ministry of Agriculture and Fisheries, Fisheries Research Division Occasional Publication No. 30.*

History of Atlantic salmon introduction and management mainly in the Waiau catchment.

Graynoth, E. 1971. Southern Lakes angling statistics 1947-1968. *N.Z. Marine Department, Fisheries Technical Report No. 64.* 20 p.

Summarised angler catch statistics for the Southern Lakes district between 1947 and 1968, with some specific information about the catch in Lake Te Anau.

Graynoth, E.,and Skrzynski, W. 1974. The Southland trout fishery. *N.Z. Ministry of Agriculture and Fisheries, Fisheries Technical Report No. 99.* 24 p.

Angler catch statistics for Southland between 1947 and 1968 including the lower Waiau and Mararoa catchments.

Hefford, A.E. 1930. Annual Report for 1929-30. N.Z. Marine Department 12-27.

Cited in Gibbs (1981).

Hobbs, D.F. c.1950. Atlantic salmon in the upper Waiau system, history of salmon fishing. Unpublished and undated report on file, Department of Internal Affairs, Queenstown.

Cited in Gibbs (1981).

Jellyman, D.J. In prep. A review of the fishery for freshwater eels in New Zealand. *N.Z. Freshwater Fisheries Report.*

Kelly, G.R. 1988. An inventory of whitebaiting rivers in the South Island. *N.Z. Freshwater Fisheries Report No. 101.* 65 p.

List of whitebaiting rivers in the South Island and the status of each in terms of their commercial or recreational importance.

McDowall, R.M. 1979. Fishes of the family Retropinnidae (Pisces: Salmoniformes): a taxonomic revision and synopsis. *Journal of the Royal Society of New Zealand 9(1):* 85-121.

Includes mention of samples of Stokell's smelt collected by Stokell from the Waiau River mouth (cited in McDowall (1990).

McDowall, R.M. 1990. "New Zealand Freshwater Fishes: A Natural History and Guide." Heinemann Reed, MAF Publishing Group, Wellington. 533 p.

Basic text for information on the distribution and life history of New Zealand freshwater fishes.

Parrott, A.W. 1932. Age and growth of the Te Anau salmon. Some new data on Atlantic salmon growth in New Zealand. *Salmon and Trout Magazine 66:* 86-94.

Cited in Gibbs (1981).

Pearce, T.D. 1928. Southland as a fishing resort. pp. 26-31. *In*: Stock, A.H. (Comp.), "History of the Southland Acclimatisation Society, New Zealand." Southland News, Invercargill.

Cited in Gibbs (1981).

Regan, C. 1927. Atlantic salmon in New Zealand. Tasmanian and New Zealand salmon at the Natural History Museum. *Salmon and Trout Magazine 48:* 234-239.

Cited in Gibbs (1981).

Riddell, J.M. 1989. A survey of recreation on the Waiau River, Southland 1982-1985. Southland Acclimatisation Society. 66 p.

Includes information on the recreational whitebait and trout fisheries, their location and importance.

Stokell, G. 1934. New light on New Zealand salmon. A comparison of Te Anau fish with Atlantic and quinnat salmon from Lake Coleridge. *Salmon and Trout Magazine 76:* 260-276.

Includes information on Atlantic salmon in Lake Te Anau.

Stokell, G. 1955. "Fresh Water Fishes of New Zealand." Simpson and Williams, Christchurch. 145 p.

Textbook on the life histories of New Zealand freshwater fishes.

Stokell, G. 1959. The structural characters of Te Anau salmon. *Transactions of the Royal Society of New Zealand 87:* 255-263.

Description of physical structure of Atlantic salmon.

Southland Anglers Club. 1929. "Trout and Salmon Fishing in Southland, New Zealand." Southland Anglers Club, Invercargill. 128 p.

Cited in Gibbs (1981).

Teirney, L.D., Unwin, M.J., and Richardson, J. 1984. The relative value of Southland rivers to New Zealand anglers. *N.Z. Ministry of Agriculture and Fisheries, Fisheries Environmental Report No. 50.* 90 p.

Comparison of the use made by anglers of Southland rivers, (including the lower Waiau and Mararoa catchments) with a ranking of values perceived by anglers and the relative recreational status of each river with respect to rivers throughout the country.