

Distribution and habitats of fishes in the Mohaka River

Fisheries Environmental Report No.55



Fisheries Research Division
N.Z. Ministry of Agriculture and Fisheries

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Distribution and habitats
of fishes in the
Mohaka River

by
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N.Z. Ministry of Agriculture and Fisheries
Turangi

August
1985

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1. INTRODUCTION

The Mohaka River is widely recognised as providing an important recreational fishery. Results from a New Zealand-wide survey of anglers showed that the upper and middle reaches (between the confluence of the Oamaru and Kaipo Rivers and Willow Flat) supported a recreational trout fishery of national importance (Teirney, Unwin, Rowe, McDowall, and Graynoth 1982). In addition to the trout fishery, the river also has whitebait, kahawai, and eel fisheries. For canoeing and rafting, it has been described as one of the most frequently used rivers in the country (Egarr and Egarr 1981).

The electricity generation potential of the river has been recognised for many years (Galloway 1980) and in 1968 six dam sites were identified as being potentially feasible for power generation (Fig. 1). Exploratory work to assess this feasibility was initiated by Ministry of Works and Development (MWD) in 1980, and work has so far been concentrated on the three lower sites in the vicinities of Raupunga, Willow Flat, and the confluence of the Te Hoe and Mohaka Rivers.

Fisheries Research Division (FRD) considered it important to gain some understanding of the Mohaka fishery before any specific hydro-electric proposals were developed. Accordingly, a proposal requesting some financial support for studies on fish distribution, density, and habitats was submitted to MWD by FRD (Rowe 1982). A meeting was then convened by MWD to discuss the FRD proposal. Organisations represented at the meeting were: Ecology Division, Department of Scientific and Industrial Research; FRD, Ministry of Agriculture and Fisheries; Hawke's Bay Catchment Board; Hawke's Bay

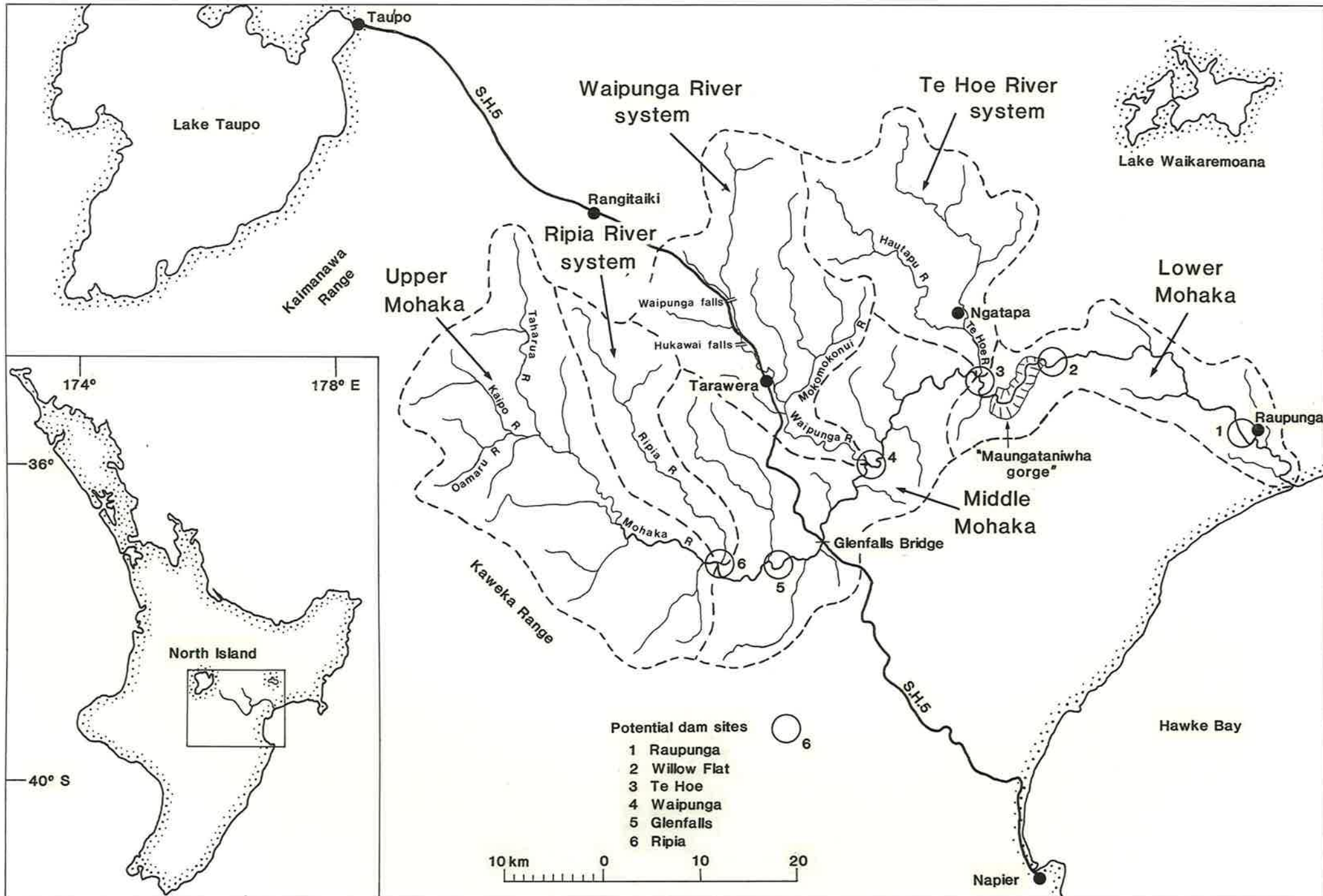


FIGURE 1. Mohaka River system.

Acclimatisation Society; Wildlife Service of the Department of Internal Affairs; New Zealand Electricity, and MWD.

It was agreed at this meeting that FRD should co-ordinate a survey of the river in February 1983 and have the results available by the end of 1983. It was estimated that by this time the feasibility of the engineering for hydro-electric development was likely to have been established. A working party was then to have been formed early in 1984 to discuss and plan any necessary field work for 1984-85.

Funds for helicopter charter and support services were subsequently made available by MWD, and field work in the Mohaka River was done from 31 January to 7 February 1983, and on 15-16 February 1983.

The basic aim of the survey was to provide a data base on fish in the Mohaka from which studies to assess hydro-electric development proposals in the river could be readily identified. To achieve this the following objectives were set:

1. Determine the species of fish present and their distribution throughout the Mohaka catchment.
2. Measure fish habitat variables.
3. Identify natural features of the river which limit fish distribution.
4. Provide a preliminary indication of some effects which hydro-electric development may have on fish.
5. Recommend additional studies required to assess possible impacts of hydro-electric development on the fish stocks, habitats, and fisheries.

2. STUDY AREA

The Mohaka River flows into Hawke Bay 50 km north of Napier. Its headwaters begin 25 km east of Lake Taupo in the north-eastern end of the Kaimanawa Range (Fig. 1).

Access to the Mohaka is limited to a small number of places, most of which are in the middle reaches, where public roads cross or run alongside the river. Access to remote areas of the catchment has been made possible in recent years by the use of aircraft and rafts.

For the purposes of this report the Mohaka River system was arbitrarily divided into upper, middle, and lower sections. The confluences of the Mohaka with the Ripia and the Te Hoe Rivers mark the boundaries for each section. The three major tributary systems, the Ripia, Waipunga, and Te Hoe, are treated separately.

2.1 Upper Section

From beech clad hills in the Kaimanawa Forest Park two small (15 km) headwater rivers, the Kaipo and Oamaru, rise and meet to form the Mohaka River. About a kilometre from its start the Mohaka is joined by a large tributary, the Taharua, and it then runs south-eastwards along the northern boundary of the Kaweka Range, picking up five other large tributaries on both banks. The last and largest of these tributaries is the Ripia River, which joins the Mohaka on its true left bank (Fig. 1).

Until it leaves the Kaweka Range, the Mohaka valley is dominated by fire-induced manuka scrub with tongues of beech forest on the upper slopes (Elder 1959) and scattered tussock and grass clearings along the valley floor (Fig. 2). The only exceptions to this are the Taharua

River, which rises at the south-west corner of the Rangitaiki Plains and flows for most of its 25-km journey through pasture land of Poronui Station, and the catchments of several tributaries in the lower Ripia, which have been modified recently for pine afforestation.

The bedrock in this headwater catchment is Mesozoic greywacke. Deposits of Taupo pumice and ash cover the bedrock in the Taharua and Oamaru catchments and for several kilometres of the Mohaka valley below these two tributaries.

2.2 Middle Section

After leaving the Kaweka Range the Mohaka turns northwards along the Mohaka fault zone, and in places the valley opens out into pasture land with scrub-filled gulleys (Fig. 3). A change in geology and landscape occurs in this section. The river's course cuts through papa (sandstones, siltstones, and mudstones of Tertiary age) and the immediate river valley is entrenched and has large sheer bluffs. The Waipunga and Te Hoe Rivers are the largest tributaries in this section.

2.3 Lower Section

Below its confluence with the Te Hoe, the Mohaka runs a turbulent 10 km east and north-east through a deeply entrenched gorge dominated by steep eroding papa bluffs above which are areas of scrub, cutover bush, and developed pasture. The gorge is referred to in this report as "Maungataniwha gorge" (Fig. 4).

After Maungataniwha gorge the river turns east again and the remainder of its course lies in a deeply entrenched valley which occasionally opens out to expose papa and shingle banks. Most of the tributaries of the lower reaches of the river enter it either through



FIGURE 3. Middle section of the Mohaka River, looking down the Mohaka valley with the confluence of the Inangatahi Stream and the Mohaka at centre.



FIGURE 4. Maungataniwha gorge looking downstream, not far below the confluence of the Te Hoe and Mohaka Rivers.

deep and narrowly entrenched gorges, or as waterfalls over papa bluffs. Above the entrenched valley of the Mohaka, developed pasture dominates the flat terraced country, and remnant podocarp stands and scrub fill most of the steeper side valleys.

The Mohaka enters the sea through a large shingle bar which changes the river's course from either running parallel to the coast or flowing directly to the ocean, the course depending on the effects of storms and tides or floods.

2.4 Ripia River System

The Ripia River's 42-km course begins among fire-induced scrub, tussock, and monoao (*Dracophyllum subulatum*) south of the Rangitaiki Plains on a tongue of pumice and ash from the adjacent volcanic plateau. The river's course winds south-east out of open pumice country into a series of Mesozoic greywacke gorges where it is joined by numerous tributaries, which flow from steep unmodified beech forest, or from tussock and manuka scrub linked with the fire-induced areas of the Mohaka Valley.

Several braided sections and a delta have been formed on flood plains in the lower reaches of the Ripia. Pasture has been established in the valley and on the west bank, and the steeper country on the eastern side is all in young pine forest.

2.5 Waipunga River System

The Waipunga is the Mohaka's longest tributary (about 55 km). It begins in pumice country east of the Rangitaiki Plains and flows south through Kaingaroa State Forest before turning south-east at the foot of

the Ahimanawa Range. Here, where it converges with State Highway 5 (S.H.5), the Waipunga and one of its tributaries, the Waiarua, join and cascade over an ignimbrite outcrop to form a 50-m waterfall, known as the Waipunga Falls (Fig. 5). This feature is catered for as a tourist attraction by a roadside car-park and viewing point. The valley's vegetation above this point is dominated by monoao and manuka scrub and large areas of recently developed pine forest. Large tracts of cutover podocarp forest on the higher slopes, ridges, and steeper gulleys also feature in the landscape.

Below Waipunga Falls the Waipunga enters a steep gorge and 4 km downstream of this it passes over the Hukawai Falls, which comprise several low chutes formed in ignimbrite. The Waipunga then runs alongside S.H.5 to just beyond Tarawera, where it opens out briefly and picks up on the left bank its largest tributary, the Mokokonui River (18 km). The Mokokonui's headwater tributaries all begin in unmodified mixed podocarp forest, but give way to cutover scrub and poorly developed pasture in their lower reaches.

Below Tarawera, poorly developed pasture and scrubland change to substantial areas of recently developed pine forest as the valley narrows again; after this the river turns east through a stretch of cutover mixed podocarp forest. Steep riverside bluffs of Mesozoic greywacke are a prominent feature in the lower gorge sections.

Finally, the Waipunga opens out into a mixture of scrubland and developed pasture before its confluence with the Mohaka.



FIGURE 5. Waipunga Falls. Monoao and scrubland, typical of the Waipunga's headwater valley, can be seen above and below the falls. (Only brown trout, which had been liberated, were found above these falls and the Waiarua Stream Falls (bottom left)).

2.6 Te Hoe River System

The Te Hoe River has the largest area of unmodified catchment of all the Mohaka tributaries. This river's 32-km course begins in beech forest in the southern Urewera National Park and runs south before turning south-east to flow through a long gorge dominated by many papa shingle slips. The end of this gorge is marked by a waterfall. The river emerges from the gorge to run through unmodified podocarp forest for about 6 km before it turns south again and runs through cutover forest. A large area on the eastern side above Ngatapa is being developed for pine afforestation.

At Ngatapa, developed pasture and young pine plantations dominate the west bank, and the east bank is a mixture of virgin and cutover podocarp forest and scrub. It is at Ngatapa that the Te Hoe River picks up its largest tributary, the Hautapu River.

The Hautapu River (38 km) is longer than the Te Hoe and begins near the source of the Waipunga River in pumice country, where large monoao flats have now been converted into pine forest. After it passes through an area of cutover forest the Hautapu winds south-east through a steep, eroding greywacke gorge clad in sparse podocarp forest. About 10 km through the gorge the Hautapu picks up several tributaries which drain unmodified beech and mixed podocarp forest. The river leaves the gorge at Ngatapa, and flows through an area of pasture and recently developed pine forest before it joins the Te Hoe.

From the Hautapu junction, the Te Hoe descends south through a deeply entrenched papa gorge. About a kilometre before its confluence with the Mohaka River, the Te Hoe opens out on to a large, farmed flat which ends in a wide alluvial gravel fan at its junction with the Mohaka River.

2.7 Catchment, Rainfall, and Hydrology

The Mohaka's total catchment area is 2400 km² and ranks eleventh in size in the North Island (Galloway 1980). The Waipunga catchment (464 km²) is the largest tributary catchment in the Mohaka system. The Te Hoe (364 km²) is the second largest, but has the largest area of unmodified cover of all the Mohaka catchments - about 180 km² comprising mainly mixed beech-podocarp forest.

The mean annual rainfall ranges from 2000-2600 mm in the headwaters of the catchments to 1400 mm toward the lower reaches and coastal region. A rainshadow effect caused by the Kaimanawa and Kaweka Ranges is evident in the upper reaches of the Mohaka, but precipitation is increased in the same area by annual snowfalls. In the middle and lower section droughts occur quite frequently during February and March when little or no effective rainfall occurs for up to 30 days duration.

Hydrology of the Mohaka River has been described by Arnold and Coulson (1981a, b). During times of low flow the catchment above Glenfalls contributes more than half the flow in the Mohaka River. Flows are gauged by MWD at Glenfalls and Raupunga where mean annual flows are 40 m³/s and 78 m³/s respectively. At Raupunga the Mohaka's catchment is 2370 km² which is similar in size to two other Hawke's Bay rivers, the Tukituki at Red Bridge and the Ngaruroro at Fernhill. However, the average number of annual flood peaks recorded at Raupunga is 19, whereas the Tukituki and Ngaruroro have more than 50 each (Beable and McKerchar 1982). The maximum recorded discharges in the Mohaka River were 795 m³/s at Glenfalls and 1420 m³/s at Raupunga in 1967.

Sediment loads carried by the Mohaka River have been estimated at Raupunga and Glenfalls by Adams (1979). Generally, less bedload, but

more suspended and dissolved solid movement, occurs in the Mohaka River compared with other Hawke's Bay rivers, such as the Ngaruroro and Tukituki.

Annual temperature regimes for the Mohaka River and other Hawke's Bay rivers were reported by Mosley (1982). Compared with Ngaruroro and Tukituki River temperature regimes, the Mohaka River is cooler and has a shorter duration of maximum temperatures. Further data on flows, temperature, and pH are contained in section 4.4.4.

3. METHODS

The primary objective of the survey was to determine fish distribution in the Mohaka system. To achieve this objective electric fishing sampling sites were chosen to encompass as much of the system as possible and to ensure that a range of geological, vegetation, land use, and altitudinal zones was represented. Where possible, sites were chosen above and below fish distribution barriers such as waterfalls, and in several instances where the Maori names of streams implied the presence of fish, sites were also sampled. Before the survey, FRD aerial reconnaissance and MWD ground reconnaissance identified access difficulties and in several instances sites were relocated or deleted.

During the survey, six sites proved inaccessible and two streams were dried up, so alternative sites close by were chosen to replace them. A total of 73 sites was sampled throughout the Mohaka system (Fig. 6). Sample site map references and stream names are shown in Appendix I.

In the upper, middle, and lower sections there were 17, 14, and 11 sites respectively, 34 of which were on tributaries and 8 along the

margins of the mainstem. In the Ripia, Waipunga, and Te Hoe systems, a further 7, 11, and 7 sites were located in tributaries, and 6 on mainstems. Of all the sites sampled therefore, 81% were located on fairly small tributaries within the Mohaka catchment. The many large pools and runs of the mainstem and larger tributary systems could not be sampled with electric fishing equipment. Therefore, habitat types which usually support adult trout, and shoals of smelt and whitebait, were not sampled during this survey.

At each sample site, a back-pack electric fishing machine was used to catch fish by fishing downstream to a hand-held seine net (Fig. 7). Although electric fishing was mainly qualitative, the length of stream fished was noted at each site. The area fished was calculated using the sample length multiplied by the average stream width. Where the stream was too wide to be effectively fished, the approximate width fished was used for the area calculation. A range of habitat types at each site was electric fished. Electric fishing was most effective in small streams because complete coverage of all habitat types could be achieved. In eight instances where sample sites were located in large streams or in the Mohaka's main channel the method was restricted to the margins or shallow reaches only.

At five sites in the lower reaches, collection of eels and common bullies was stopped once more than 20 individuals of each species were caught, and fishing effort then was concentrated on establishing the presence of any other species. As a result a greater area was sampled without recording further eels and bullies caught. However, the increase in area sampled was not substantial and species compositions and fish densities were considered representative of those sites.

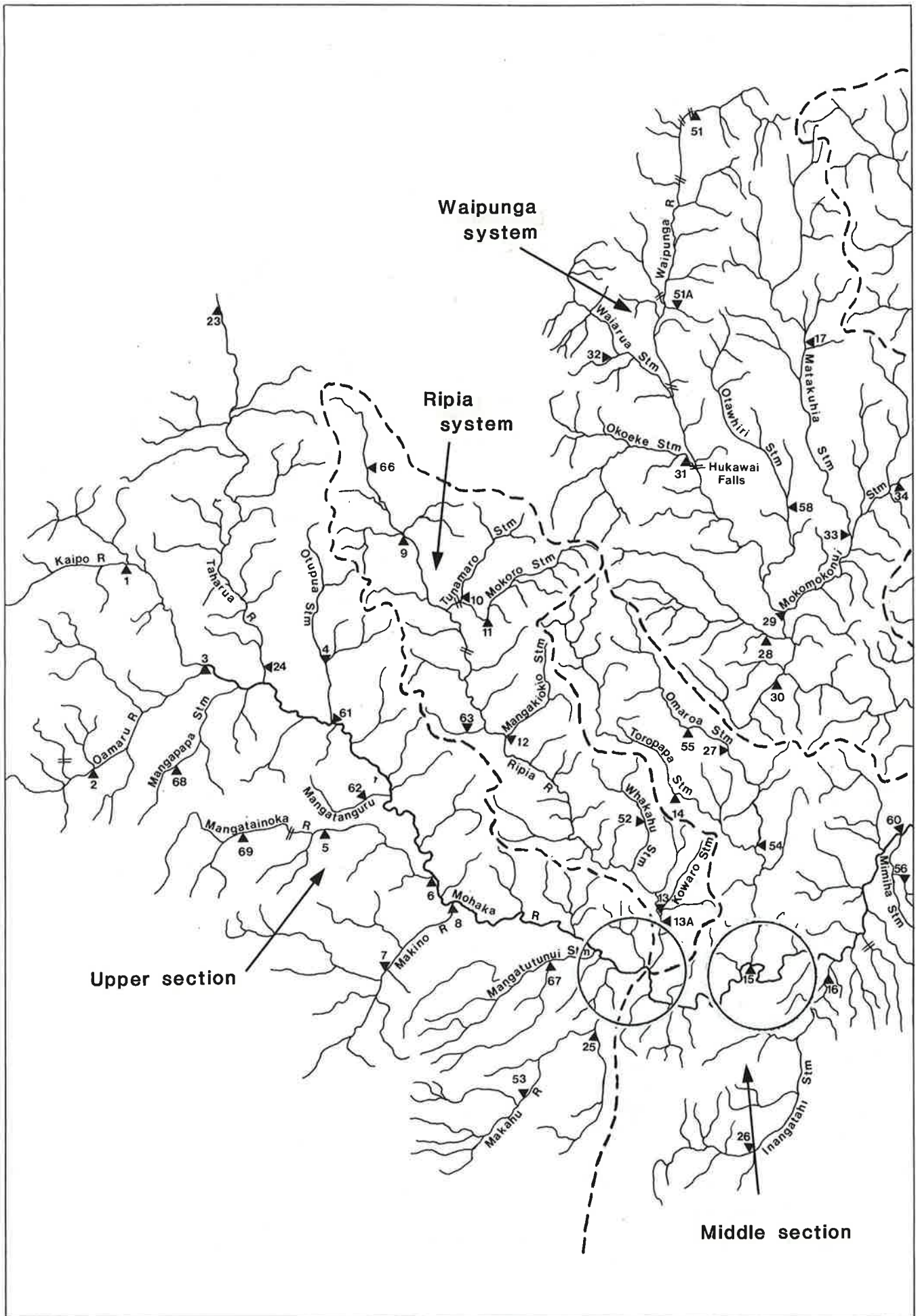


FIGURE 6. Location of sample sites.

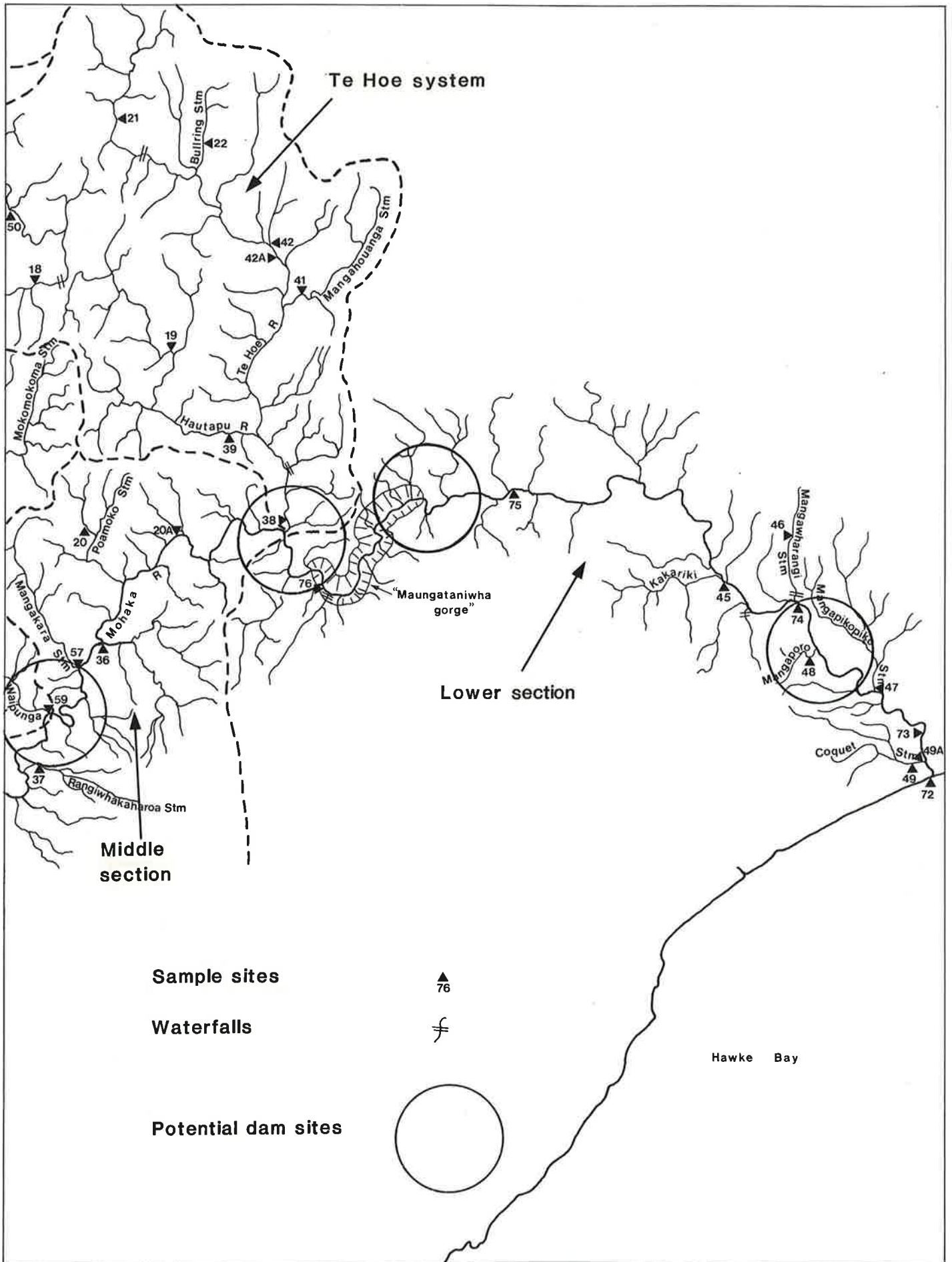


FIGURE 6 - continued.



FIGURE 7. An ideal stream for efficient back-pack electric fishing. Stunned fish were caught in the hand-held seine net. Unmodified native forest, a steep gradient, and a stream substrate dominated by boulders and rubble, made this site ideal for koaro (see section 4.5.3).

The catch at each sample site was held in a bucket containing benzocaine. Small fish (fish which fitted into a 1-l container) were fixed and stored in a solution of 10% formalin. Large fish were killed, weighed, measured, and had their stomachs preserved in 60-70% ethyl alcohol at the end of each day. All small fish were weighed and measured, and had their stomachs removed for analysis at the Turangi laboratory. Fork length was measured to the nearest millimetre and weights were measured to the nearest gram. Trout stomachs and benthic samples were sent to Ecology Division, DSIR Hastings for analysis (McLennan and MacMillan 1984).

At each electric fishing site, habitat data were collected on the form shown in Appendix II. Full habitat descriptions were not made at all sites, particularly at those which could not be properly electric fished. Not all the habitat data collected were or could be used for this report. The following descriptions of methods apply only to those sites for which data have been used. All habitat measurements were made at the time of electric fishing.

All distances and widths were measured in metres with a tape measure. Depths were measured to the nearest centimetre with a graduated rod. Water temperature was measured in degrees Celsius with a total immersion mercury thermometer. A universal (wide range) indicator was used with a Hach colour comparator to measure pH. Temperature and pH measurements were made of flowing water.

Gradient was calculated by use of the trigonometric formula:

$$\text{gradient m/100m} = 100 \text{ m} \times \tan A$$

where A = the angle of elevation measured at water level over 100 m using a Suunto clinometer.

Embody's method (Lagler 1956) was used to calculate average velocity. By use of "Simpson's Rule", the area of cross-section was calculated from depths measured at 0.2- to 1-m spacings depending on stream width. Flows (m^3/s) at each site were then calculated by multiplying the area of cross-section by average velocity.

Percentages of substrate type, cover, macrophytes, diatoms, and algae were estimated over the area electric fished. Photographs looking upstream and downstream at each sample site were taken, and most sites also were photographed from the air.

For the analysis of field data, and for descriptive purposes, the Mohaka River system was divided into six areas (Figs. 1 and 6) as follows:

1. Upper section - the Mohaka River and all its tributaries above the Ripia River confluence
2. Ripia River system - the Ripia River and all its tributaries
3. Middle section - the Mohaka River and all its tributaries from its confluence with the Ripia River to its confluence with the Te Hoe River, but excluding the Waipunga River.
4. Waipunga River system - the Waipunga River and all its tributaries
5. Te Hoe River system - the Te Hoe River and all its tributaries
6. Lower section - the Mohaka River and all its tributaries below its confluence with the Te Hoe River.

4. RESULTS

4.1 Fish Species in the Mohaka River

Table 1 shows the species of fish caught during the survey and also includes a list of those species reported as being present in the estuary area by the Hawke's Bay Acclimatisation Society.

The most widely distributed fish caught during the survey was the long-finned eel, which occurred at 71% of the sample sites (Fig. 8). Brown trout and rainbow trout were the next most widespread fish and occurred at 51% and 39% of the sites respectively. However brown and rainbow trout were not always caught at the same sites; the frequency of co-existence of both species was 62%.

Numerically, brown trout dominated the catch (Fig. 9), and collectively both species of trout accounted for 50% of the total number of fish recorded. Long-finned eels were more widespread than trout, but overall their numbers were fewer.

Common bullies and short-finned eels were fairly abundant in the total catch. However, this may have been because large numbers of juveniles were sampled from sites in the lower reaches where, at this stage in their life cycle, these fish usually concentrated. Cran's bully, blue-gilled bully, and inanga were each recorded from single sample sites.

The largest numbers of fish were generally caught at sites where stream flow was less than $0.2 \text{ m}^3/\text{s}$ and stream width was around 2.5 m. However, this may be an indication of the sampling efficiency of the

TABLE 1. Checklist of fish and crustacea in the Mohaka River.

Common name	Scientific name
Species caught during the electric fishing survey, February 1983.	
Long-finned eel*	<i>Anguilla dieffenbachii</i>
Short-finned eel*	<i>Anguilla australis</i>
Common smelt*	<i>Retropinna retropinna</i>
Koaro*	<i>Galaxias brevipinnis</i>
Inanga*	<i>Galaxias maculatus</i>
Rainbow trout†	<i>Salmo gairdnerii</i>
Brown trout*†	<i>Salmo trutta</i>
Torrentfish*	<i>Cheimarrichthys fosteri</i>
Blue-gilled bully*	<i>Gobiomorphus hubbsi</i>
Common bully*	<i>Gobiomorphus cotidianus</i>
Cran's bully	<i>Gobiomorphus basalis</i>
Crustacea	
Koura	<i>Paranephrops planifrons</i>
Shrimp*	<i>Paratya curvirostris</i>
Species reported by Hawke's Bay Acclimatisation Society as caught in the estuary area.	
Lamprey*	<i>Geotria australis</i>
Kahawai‡	<i>Arripis trutta</i>
Yelloweyed mullet‡	<i>Aldrichetta forsteri</i>
Grey mullet‡	<i>Mugil cephalus</i>
Black flounder*	<i>Rhombosolea retiaria</i>
Yellowbelly flounder‡	<i>Rhombosolea leporina</i>

* Migratory species.

† Introduced species.

‡ Estuarine species.

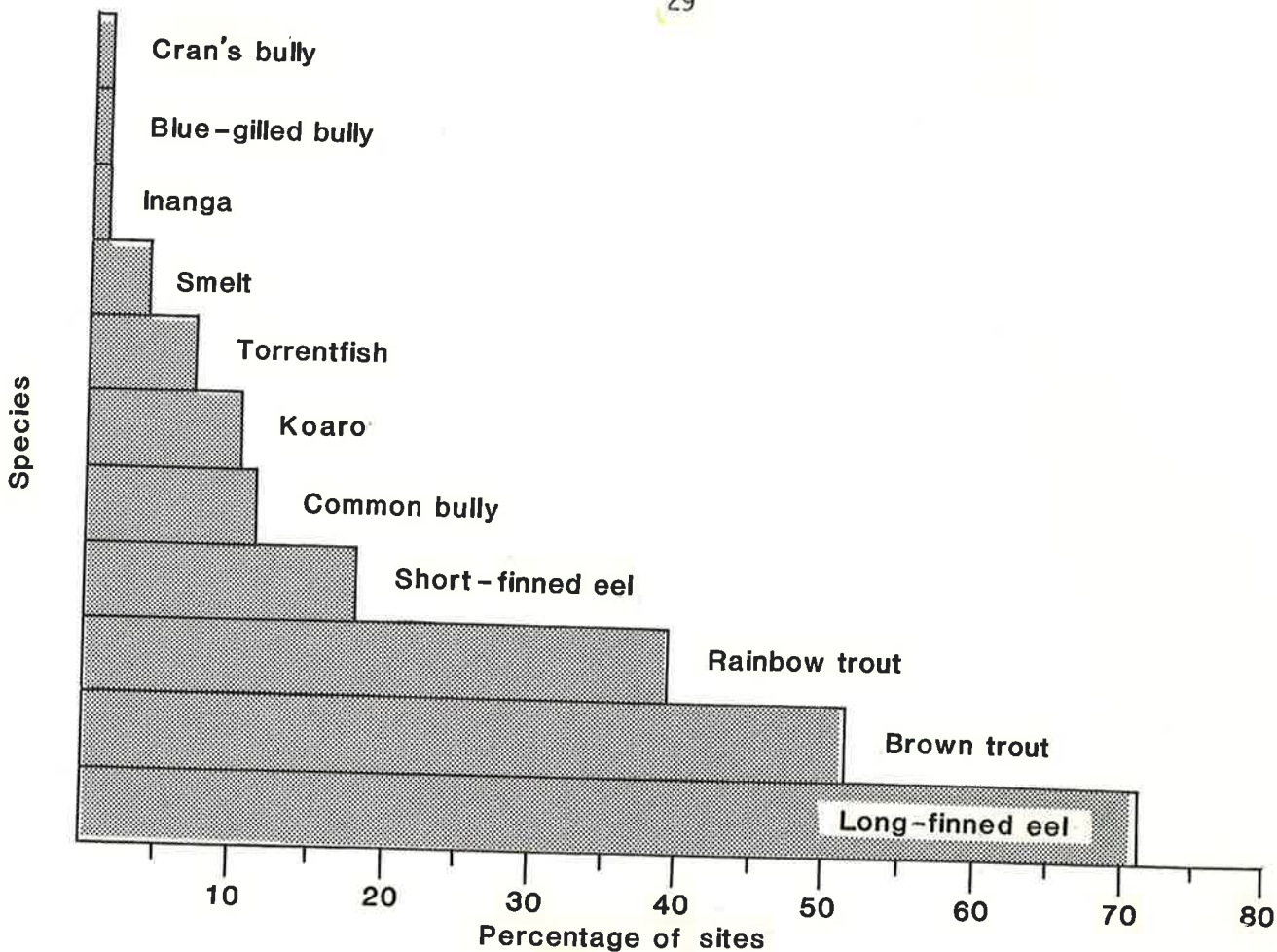


FIGURE 8. Frequency of occurrence of fish species in the Mohaka catchment, 1983.

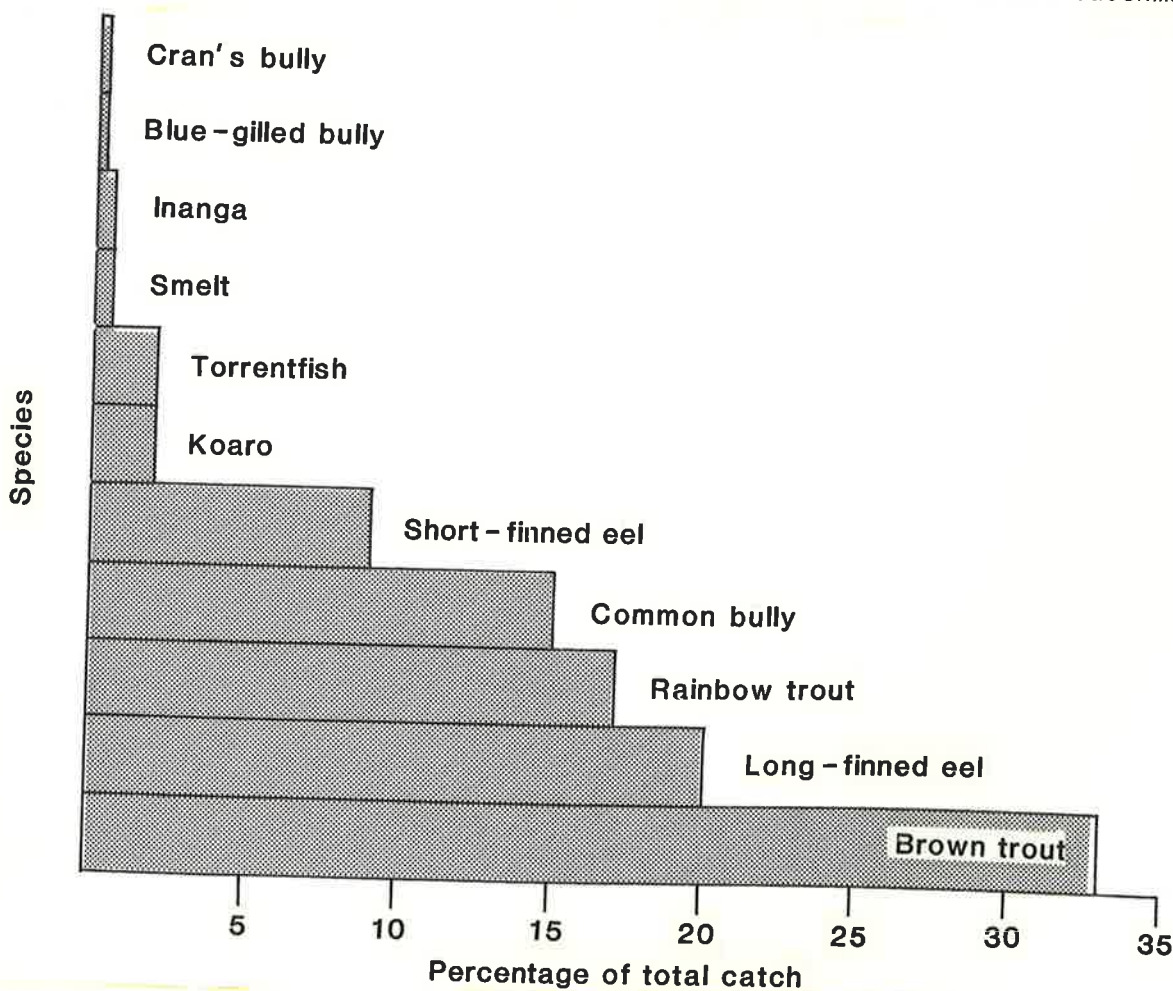


FIGURE 9. Percentage composition of fish species caught in the Mohaka catchment, 1983.

electric fishing machine in a stream of this size, rather than an indication of an optimum size of stream for these fish.

4.2 Upstream Migration of Fish

Figures 10 and 11 show densities of the more common migratory fish species recorded at increasing distances upstream. The six potential dam sites identified by MWD (Galloway 1980) are also marked in Figures 10 and 11 to show their differing potential effects on the distribution of the various fish species.

Densities of short-finned eels declined above the Maungataniwha gorge, the upstream end of which is near in the proposed Te Hoe dam site, whereas densities of long-finned eels appeared to increase above this point (Fig. 10). With the exception of two blue-gilled bullies, koaro was the only migratory fish species which was not caught below Maungataniwha gorge. Figure 11 shows that the highest density of koaro was found about 20 km above the gorge, but density declined upstream of this. The highest density of torrentfish occurred immediately below Maungataniwha gorge, but none was found above the gorge. High densities of common bullies occurred in the first 25 km of the river and only a single specimen was recorded beyond this, but it was above Maungataniwha gorge.

In Table 1, brown trout have been described as migratory fish because there is evidence that sea-run populations occur in New Zealand (McDowall 1978, Davis, Eldon, Glova, and Sagar 1983). In the Mohaka there is no evidence to show that trout migrate between the river and sea, but Hawke's Bay Acclimatisation Society have successfully operated traps to collect ova from both species of trout in several tributaries

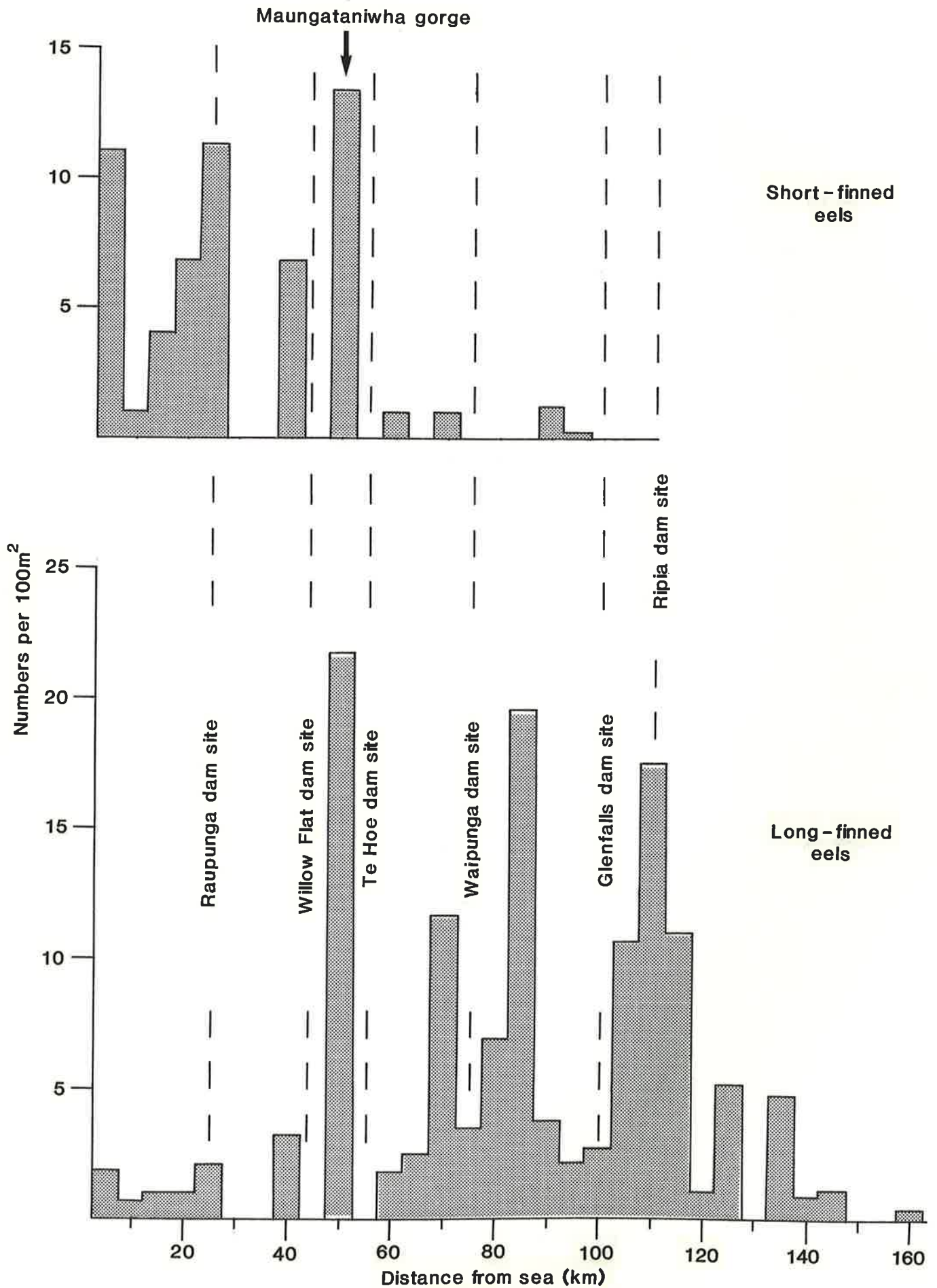


FIGURE 10. Density of eels in the Mohaka system.

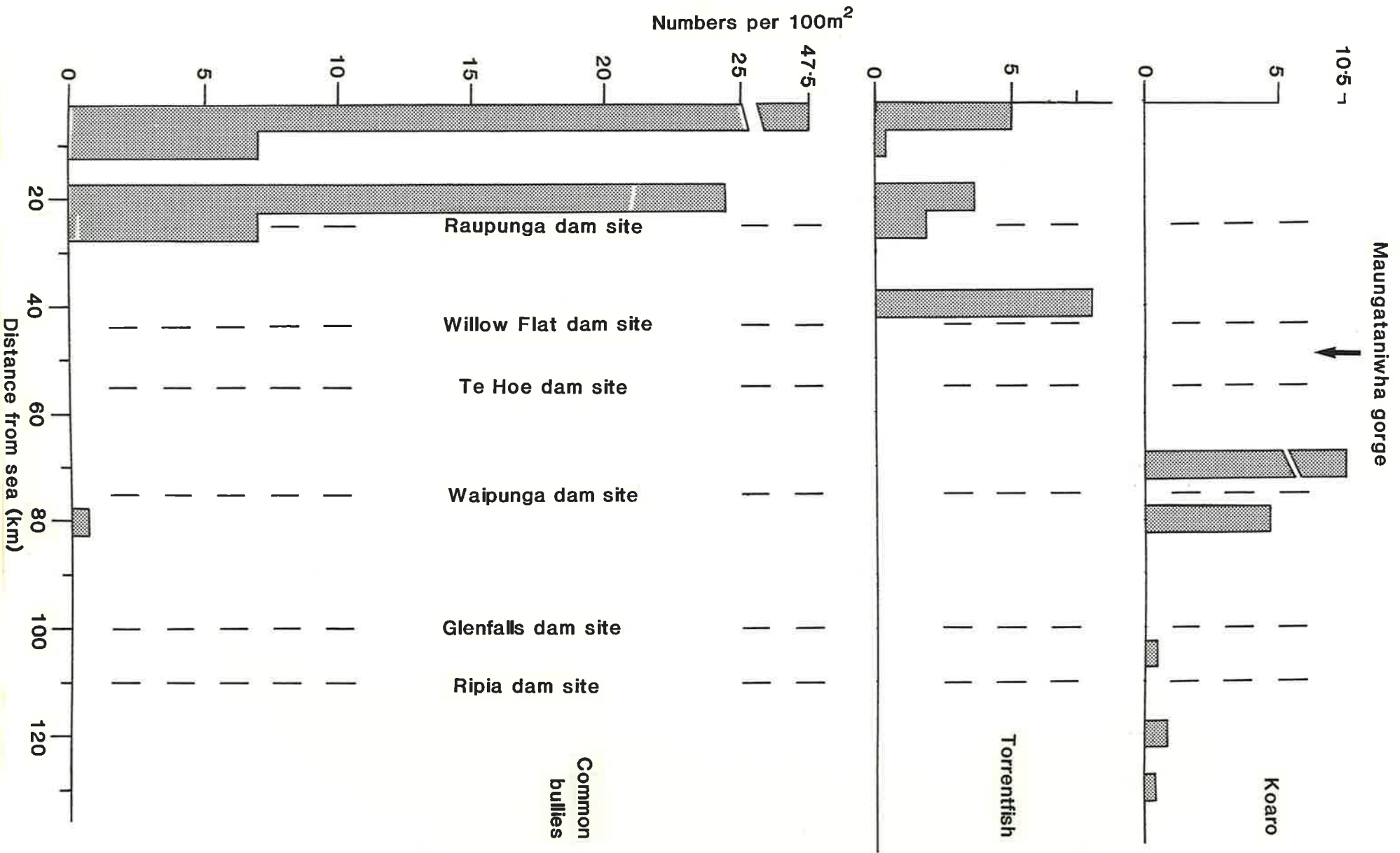


FIGURE 11. Density of some migratory fish in the Mohaka system.

of the Mohaka's middle section. This indicates that trout undertake spawning migrations within the Mohaka, but the extent of their movements is unknown.

4.3 Fish Densities

The average density of each fish species in each section is shown in Table 2. In all but the middle and lower sections, brown trout occurred in higher densities than any other fish. In the Waipunga River brown trout densities were greatest above Waipunga Falls (44 fish/100 m²), where they were the only fish species recorded.

Rainbow trout occurred in their highest densities in the middle section and in Waipunga River. The combined densities of both trout species were the same in the upper and middle sections, but changed from predominantly brown trout in the upper section to predominantly

TABLE 2. Average densities of fish per 100 m² in various areas of the Mohaka River system.

Species	Total fish caught	Location					
		Upper Ripia	Middle Waipunga	Te Hoe	Lower		
Long-finned eel	221	1.0	2.3	4.1	2.4	1.8	3.9
Brown trout	361	7.1	6.8	3.2	12.0	6.0	0.6
Rainbow trout	191	1.1	3.4	5.0	4.8	3.6	0
Short-finned eel	105	0	0	1.0	0.7	0.9	6.0
Common bully	160	0	0	0	0.6	0	12.3
Koaro	25	0.5	0	8.2	0.4	2.3	0
Torrentfish	20	0	0	0	0	0	3.7
Smelt*	5						
Inanga*	6						
Blue-gilled bully*	2						
Cran's bully*	2						

* Insufficient numbers caught to calculate densities.

rainbow trout in the middle section. The highest densities of both trout species combined were found in the Ripia and Waipunga systems.

Koaro were recorded in their highest densities in the middle section and occurred there in greater densities than any other fish species. However, koaro density in the middle section is based on a single sample site and may not have been typical for other streams in the middle section.

Long-finned eel densities were highest in the middle section. Similar densities occurred for long-finned eels in the lower section, but these were made up by high numbers of elvers at one site whereas those caught in the middle section represented a much broader range of sizes and sites (see section 4.5.1).

Short-finned eels occurred in high densities in the lower section only, as did common bullies. The densities of common bullies in the lower section were even higher than shown in Table 2, but because most were small many escaped through the mesh in our nets or were unaffected by the electric fishing machine. Nevertheless, common bullies occurred in the highest densities of any fish species in the Mohaka River.

4.4 River Characteristics and Fish Distribution

Physical characteristics measured and described at electric fishing sites, and other physical characteristics of the river which may affect fish distribution, are summarised below.

4.4.1 Profile and Gradient

The main channel of the Mohaka River has an even and gentle gradient for most of its course other than in the two gorge sections.

Maungataniwha gorge is about 45 km from the sea and extends for about 10 km to just below the confluence of the Mohaka and Te Hoe Rivers; the second and smaller gorge is 125 km from the sea and runs for about 7 km to just below the Mohaka and Makino confluence (Fig. 12).

There are no waterfalls in either of these two gorges, but the severity of the long and continuous series of very turbulent rapids, particularly in Maungataniwha gorge, is likely to be a barrier to some migratory fish (see Figs. 10 and 11). There are significant waterfalls in the middle reaches of the Mangatainoka, the upper reaches of the Waipunga, and the upper reaches of the Te Hoe. These and other waterfalls are shown in Figure 6. Many of the smaller Mohaka tributaries have gradients which exceed 20m/100m at times, and these often enter the mainstem as waterfalls.

Most gradients measured at sample sites were around 2m/100m (Table 3). However these measurements may be biased towards low gradients, because sample sites were chosen where helicopter access was possible, and these sometimes coincided with the only, or one of the few, clear and flat areas along a tributary's entire course. The highest mean gradient and the steepest gradient measured were in tributaries of the middle section of the Mohaka, and the lowest gradients were at sites in the Mohaka's lower section.

Table 4 shows that koaro, trout, and long-finned eels, which were found in their highest densities above Maungataniwha gorge, were all from sites with similar gradient ranges. However, there were distinct

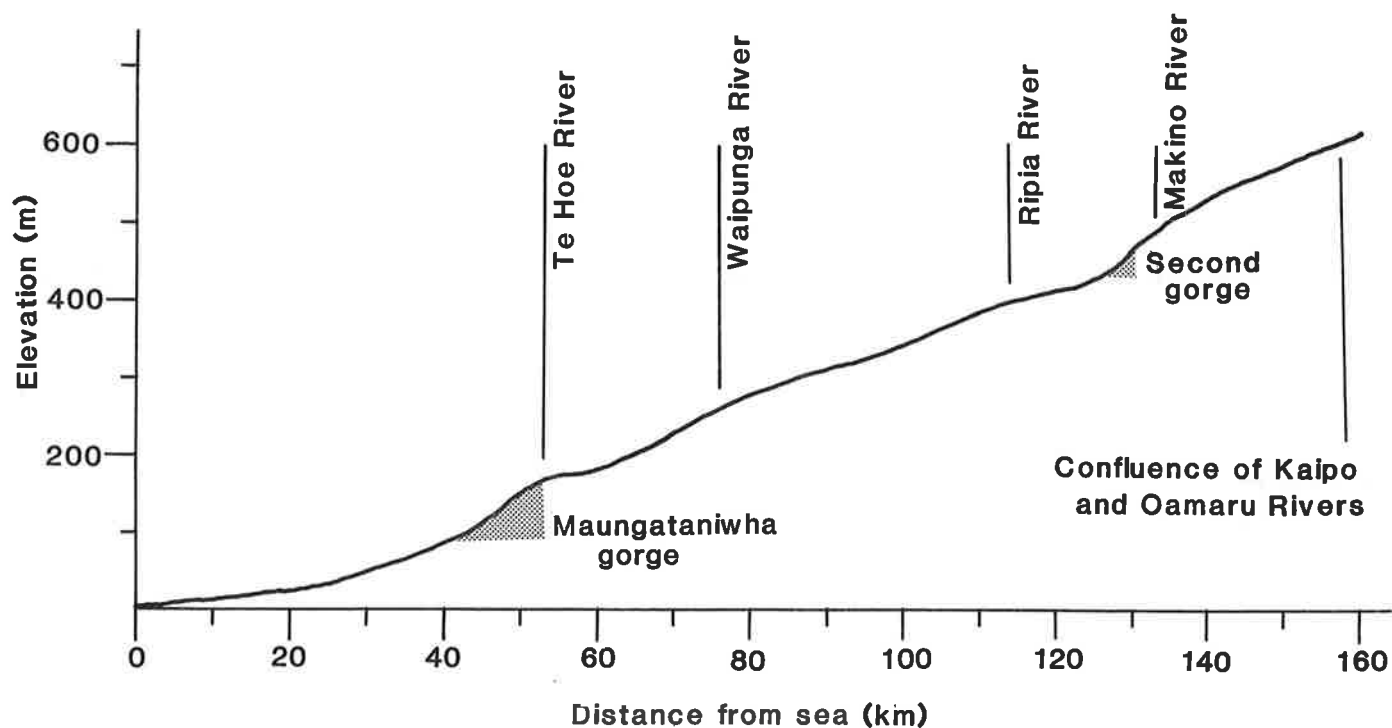


FIGURE 12. Bed profile of the Mohaka River. (Derived from NZMS 1:63 360 topographical map series).

TABLE 3. Mean gradient (m/100m) and gradient range at sample sites from six areas of the Mohaka system.

	Number of sites	Mean	Range	
			Minimum	Maximum
Upper section	15	2.29	0.35	6.98
Ripia	8	2.28	0.43	4.36
Middle section	13	3.93	0.87	21.63
Waipunga	12	1.63	0.17	3.49
Te Hoe	9	1.99	0.87	4.37
Lower section	5	1.08	0.35	2.10

differences in the mean gradient at sites where koaro, trout, and long-finned eels occurred; koaro was found at sites with the steepest mean gradient, then brown trout, rainbow trout, and long-finned eels were found at progressively less steep sites.

Fish species found predominantly below Maungataniwha gorge (Table 4) were from sites with much lower mean gradients than those from sites above the gorge (Table 3). However, at least 13 sites above the gorge had gradients within the ranges shown for the four species listed at the bottom of Table 4. Only 1 common bully (less than 1% of the total catch of common bullies), and 13 short-finned eels (12% of the total catch of short-finned eels) were found at sites above Maungataniwha gorge.

TABLE 4. Sample site gradients (m/100m) for various fish species in the Mohaka River.

Fish species	Number of sites	Mean	Gradient	
			Minimum	Range Maximum
Found predominantly or only above Maungataniwha gorge				
Koaro	7	3.07	0.87	6.99
Brown trout	35	2.17	0.35	6.98
Rainbow trout	28	2.12	0.58	6.99
Long-finned eel	44	1.92	0.35	6.99
Found predominantly or only below Maungataniwha gorge				
Torrentfish	2	1.31	0.87	1.75
Short-finned eel	7	1.28	0.35	2.10
Common bully	4	1.18	0.35	1.75
Smelt	3	0.99	0.35	1.75

4.4.2 Substrate

A river's substrate components are generally dictated by the geological formation, gradient, and catchment cover the river or stream flows through. For example, a high silt and sand composition can be expected in the substrate when a stream flows through flat pumice country with sparse catchment vegetation, whereas bedrock, boulder, and rubble substrates without siltation are more commonly associated with steep gradients and a stable catchment and geology.

Table 5 summarises the substrate components measured at sample sites from six areas in the Mohaka system. Sites with gradients more than 2m/100m, in almost all instances had greywacke substrates composed of 60% or more bedrock or boulders and rubble. Bedrock substrates were a common feature in the papa country of the lower section of the Mohaka and at several sites in this area it was recorded as 100% of the substrate. Bedrock was also the main component in the substrate at several sites in the Mohaka's upper section where the river has cut through the pumice mantle and into the greywacke underneath.

TABLE 5. Mean percentage of substrate components from six areas of the Mohaka system.

Area	Silt 0.06mm	Sand <2mm	Gravel <64mm	Rubble <256mm	Boulder >256mm	Bedrock
Upper section	3	11	31	23	22	10
Ripia	4	21	27	21	26	1
Middle section	11	12	24	29	20	4
Waipunga	2	25	26	41	6	0
Te Hoe	2	10	34	35	17	2
Lower section	8	9	18	16	9	40

Most tributaries of the Mohaka's upper section had high percentages of gravel in their substrate, and the remainder of the substrate in these upper section areas was dominated by rubble and boulder combinations. The highest mean percentage of gravel in the substrate was found in the Te Hoe, where rubble and boulder combinations also dominated the remainder of the substrate.

Larger quantities of sand were found at Ripia and Waipunga sites than elsewhere in the system. This may have resulted from pumice country in the headwaters of both rivers. However, the percentage of silt in the substrate at sites in the Ripia and Waipunga was low even though large areas of both catchments had recently been developed for afforestation. There were large quantities of silt in the Mohaka's middle and lower sections because of the softer bedrock and more modified catchment of these sections.

Overall, sample sites had larger percentages of gravel and rubble (rarely less than 10%) than any other substrate component. Sand and silt were a common component of the substrate, but in most instances occurred in low percentages.

Table 6 shows the mean percentages of substrate components found at sites where each fish species occurred. Each sample site usually contained a variety of substrate combinations and some species were only caught from one particular combination, which sometimes represented only a small fraction of the total sample site area. Unfortunately such details could not be taken into account in a survey of this kind. The figures in Table 6 are therefore presented as a possible indication of general, rather than specific, substrate preferences for each fish species.

TABLE 6. Substrates associated with fish occurrence in the Mohaka River. (Values shown are means of percentages of substrate types at all sites at which each species occurred.)

Fish species	Silt	Sand	Gravel	Rubble	Boulder	Bedrock
Long-finned eel	4	12	27	31	20	6
Short-finned eel	7	7	23	23	10	30
Brown trout	3	14	27	29	19	8
Rainbow trout	2	10	31	36	20	1
Koaro	3	9	27	28	32	1
Torrentfish	-	2	5	20	23	50
Common bully	8	13	16	25	13	25
Smelt	10	11	17	13	15	34
Inanga*	30	30	40	-	-	-
Blue-gilled bully*	10	10	30	20	20	10
Cran's bully*	-	-	-	-	-	100

* Recorded at one site only.

4.4.3 Hydrology

Flows recorded at the permanent recorder stations at Raupunga (15 m³/s) and Glenfalls (7 m³/s) on the Mohaka River during the fish survey were some of the lowest flows so far recorded. The effect of these low flows on the pattern of fish distribution could have been quite severe. Several of the pre-chosen sample sites were completely dry and had to be excluded, and others which were sampled were obviously well below normal water levels because of the drought conditions. These conditions could have had one of two effects on fish normally inhabiting these sites: fish numbers could have been lower in samples collected from areas where fish had emigrated or perished because of the low flows, or sample sites could have contained abnormal congregations of fish because of the low flows. These effects were not apparent in the field, but further surveys to enable a comparison of fish densities at these sites under a range of flow conditions may show differences.

An indication of the size and flow of the streams sampled in six areas of the Mohaka is given in Table 7. The large range of flows and wetted widths in the upper section shows the variability in tributary size and flow found in the Mohaka's headwater catchment. The same also applies to the headwaters of the Waipunga and Te Hoe Rivers. Conversely, tributaries in the lower section were small in size and flow. Because of this, the habitat and abundance of some fish species in streams of the lower section are likely to be limited. The mainstem of the Mohaka River is not included in the figures shown in Table 7, but its size and flow in the lower section are likely to afford fish more suitable habitat than its tributaries in the same section.

4.4.4 Temperature and pH

Temperature and pH readings were made at all but two of the sample sites and are summarised in Table 8. Although a similar range of temperatures was sampled in each of the six areas, Table 8 shows a trend for temperatures to increase in a downstream direction. In the upper section, Waipunga, and Te Hoe, where most samples were taken from streams in or flowing from a bush catchment, mean temperatures were cooler than those from streams in other areas.

Mean temperatures of streams in the middle and lower sections of the Mohaka during the survey were consistent with normal temperatures recorded for February in the mainstem, at MWD recorder stations at Glenfalls and Raupunga respectively (Fig. 13), despite the drought conditions and low flows at the time.

All sample sites with a pH of 7.0 or less (acidic) were in streams which flow from bush catchments, and were also in the Taupo pumice and

TABLE 7. Summary of flows and wetted widths of streams at sample sites from six areas of the Mohaka system. (n = number of sites.)

	n	Flow (m^3/s)			n	Wetted width (m)		
		Mean	Minimum	Maximum		Mean	Minimum	Maximum
Upper section	16	0.565	0.024	2.568	17	6.9	2.2	15.0
Ripia	8	0.118	0.013	0.316	8	3.3	1.8	5.6
Middle section	10	0.216	0.032	0.771	13	4.7	1.0	13.7
Waipunga	11	0.497	0.011	1.561	12	7.4	1.2	27.7
Te Hoe	7	0.156	0.053	0.276	8	8.6	3.2	32.0
Lower section	4	0.061	0.006	0.172	5	3.7	1.2	6.3

TABLE 8. Summary of temperature and pH readings from sample sites from six different areas of the Mohaka system. (n = number of sites.)

	n	Temperature ($^{\circ}C$)			n	pH		
		Mean	Range Minimum	Maximum		Mean	Range Minimum	Maximum
Upper section	17	13.5	9.1	22.0	17	7.4	6.4	8.2
Ripia	9	16.5	10.5	22.0	9	7.3	6.8	7.9
Middle section	14	16.7	11.3	25.0	14	8.2	7.0	9.0
Waipunga	12	14.2	10.0	20.5	12	7.7	6.8	9.0
Te Hoe	10	14.5	11.0	17.8	10	7.7	7.0	8.0
Lower section	10	19.3	14.0	25.5	9	8.6	7.8	9.0

ash zone which covers the top of the Mohaka's catchment from the Oamaru River north-east across to the Hautapu River. The remainder (and majority) of sites were in alkaline waters which had a maximum pH of 9.0. All but one of the sample sites with a pH of 9.0 were in the middle and lower sections of the Mohaka, below its confluence with the Waipunga. Such high pH values are likely to be attributable to erodable limestone outcrops which the Mohaka River cuts through in its middle and lower sections.

Although pH and temperature readings were taken at different times of the day, they indicate the tolerances which various fish species in the Mohaka system may have for pH and temperature. Table 9 lists the range of temperature and pH for sites where various fish species were found. Fish found at sites with the broadest range of both temperature and pH were long-finned eels, brown trout, and rainbow trout.

4.5 Ecology of Fish Species in the Mohaka River

Table 1 (section 4.1) lists the fish species and overall catch composition found in the Mohaka River system during the 1983 survey. Densities of some of the more common species are also given. The following section deals with each fish species individually and outlines important aspects of its ecology in the Mohaka River. Introductory notes on biology and life history are from McDowall (1978).

4.5.1 Long-finned eel (*Anguilla dieffenbachii*)

This fish is an indigenous species found throughout New Zealand, from estuarine habitats to as far upstream as physical barriers such as waterfalls allow. In many instances even waterfalls are no barrier.

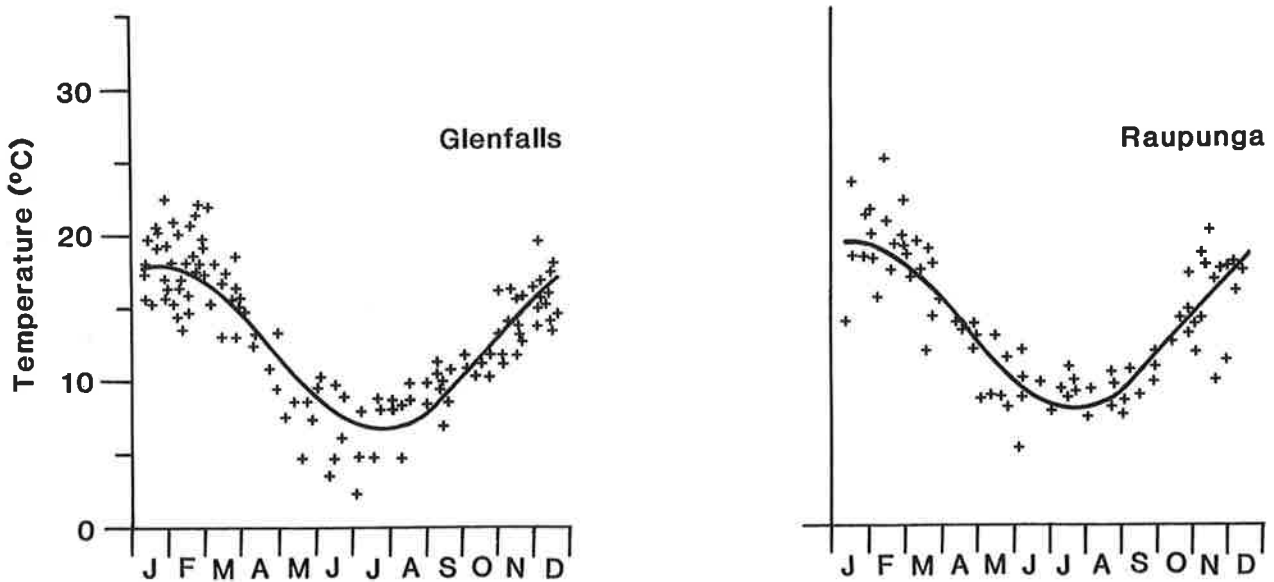


FIGURE 13. Mean daily temperature measurements and best-fit sine curves from MWD recorder stations at Glenfalls and Raupunga on the Mohaka River (from Mosley 1982).

TABLE 9. Range of temperature and pH for sites where various fish species were collected in the Mohaka River. Sample site readings were made only once and therefore daily temperature and pH ranges would be greater than those indicated by the survey figures. (n = number of sites.)

Fish species	n	Temperature (°C)		n	pH	
		Minimum	Maximum		Minimum	Maximum
Long-finned eel	49	10.5	25.0	48	6.4	9.0
Short-finned eel	13	14.7	25.5	12	7.6	9.0
Brown trout	36	9.1	22.0	36	6.4	9.0
Rainbow trout	28	10.8	22.0	28	7.0	9.0
Koaro	7	11.0	17.0	7	7.0	7.9
Torrentfish	2	16.1	22.4	2	8.0	9.0
Common bully	4	16.1	25.5	4	7.9	9.0
Smelt	3	16.1	17.5	3	7.9	9.0
Inanga*		16.1			7.9	
Blue-gilled bully*		14.7			7.6	
Crans' bully*		16.1			9.0	

* Recorded at one site only

Long-finned eelers are able to make their way over or around steep waterfalls provided there are damp rocks to enable them to adhere and climb. Adult eels migrate to sea to breed in late summer and autumn. The young return to fresh water during spring and by summer begin migrating upstream.

In the Mohaka system long-finned eels are the more widespread of the two eel species (Fig. 14), and waterfalls limit their distribution in only the upper reaches of the Waipunga and Te Hoe. Waterfalls on many of the smaller tributaries may stop long-finned eel migration, but at one site a single long-finned eel was found in a small tributary of the lower Mohaka above a steep waterfall (about 20 m high). The greatest distance from the sea that longfins were found in the Mohaka was 160 km, in the Taharua River. The distribution of long-finned eels throughout the Mohaka suggests that distance from the sea does not limit their distribution.

The highest densities of long-finned eels were from tributaries of the middle section (see Table 2). As has already been shown (see Fig. 10) most long-finned eels were found from Maungataniwha gorge upstream. However, in the upper section densities of long-finned eels above the second gorge (see Fig. 12), decreased to 0.5 eels per 100 m², which was similar to densities of longfins in the Ripia. Therefore, some feature of this second gorge may limit the number of long-finned eels migrating into the headwaters.

Physical characteristics of the middle section show that, relative to other areas, there are a large number of small streams, alkaline water, steep gradients, and coarse substrates. Long-finned eels were found in streams with temperatures and pH from the whole range of values

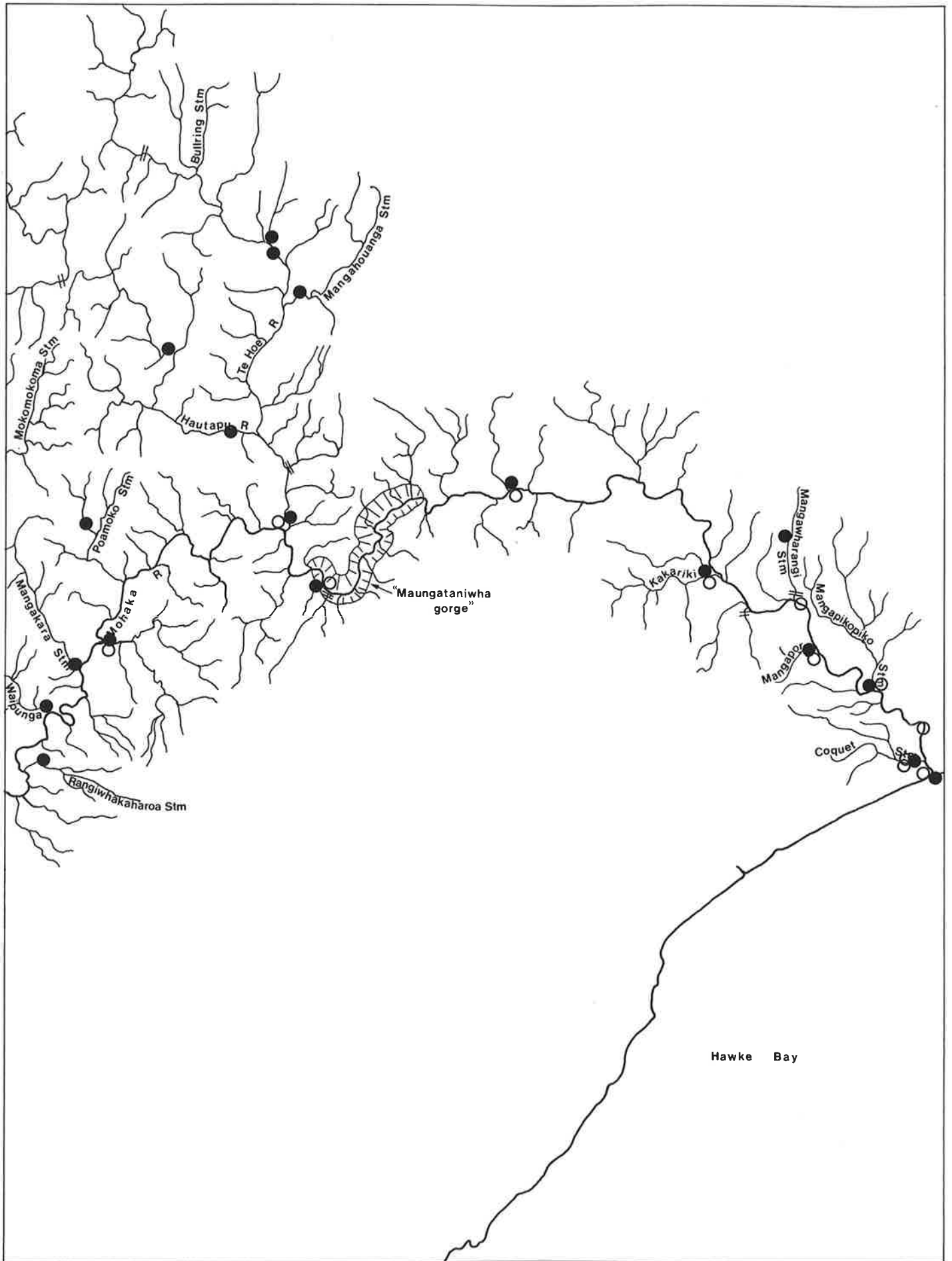


FIGURE 14 - continued.

measured during the survey. The greatest numbers were found in temperatures from 12°C to 20°C (mean 15.9°C) (Fig. 15). Figure 16 suggests that alkaline waters are likely to be preferred, because more than 90% of long-finned eels were recorded at sites with a pH greater than 7.

A preference by long-finned eels for substrate with a high percentage of coarse material and a low percentage of fine material is indicated in Table 6. This was also apparent during the sampling when it was noticed that longfins up to 60-70 cm were commonly fished from among coarse substrate, whereas eels of greater length were usually found in log and stick jams or underneath banks.

Length frequency distributions of long-finned eels above the lower section (Fig. 17) are similar, but the difference in mean lengths between the upper, middle, and lower sections (Fig. 18) indicates that lengths increase with distance upstream (an exception was one 64-mm long-finned eel found 109 km from the sea in Omaroa Stream). Large long-finned eels (greater than 60 cm) were found 140 km from the sea as often as they were found 70 km from the sea.

4.5.2 Short-finned eels (*Anguilla australis*)

The biology and life history of the short-finned eel is similar to that of the long-finned eel. Like the longfin they have the ability as juveniles to migrate great distances inland. Distribution of the two species overlaps, but shortfins prefer a more sluggish habitat than longfins and are consequently associated more with lakes and swamps or the lower regions of river systems.

In the Mohaka, shortfins were found in largest numbers in the lower section, no further than 50 km upstream, and most were below

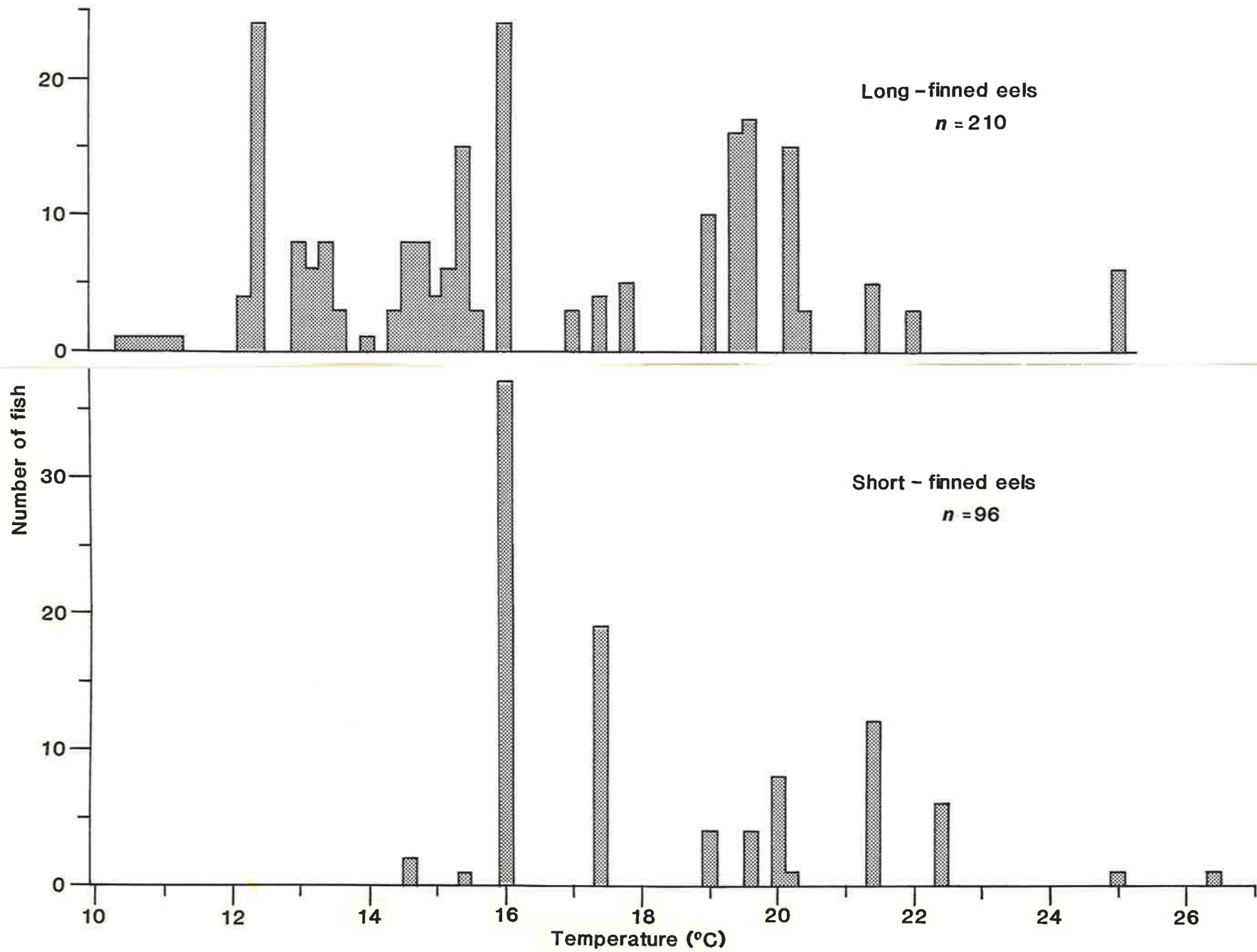


FIGURE 15. Frequency of occurrence of eels at different temperatures in the Mohaka River system.

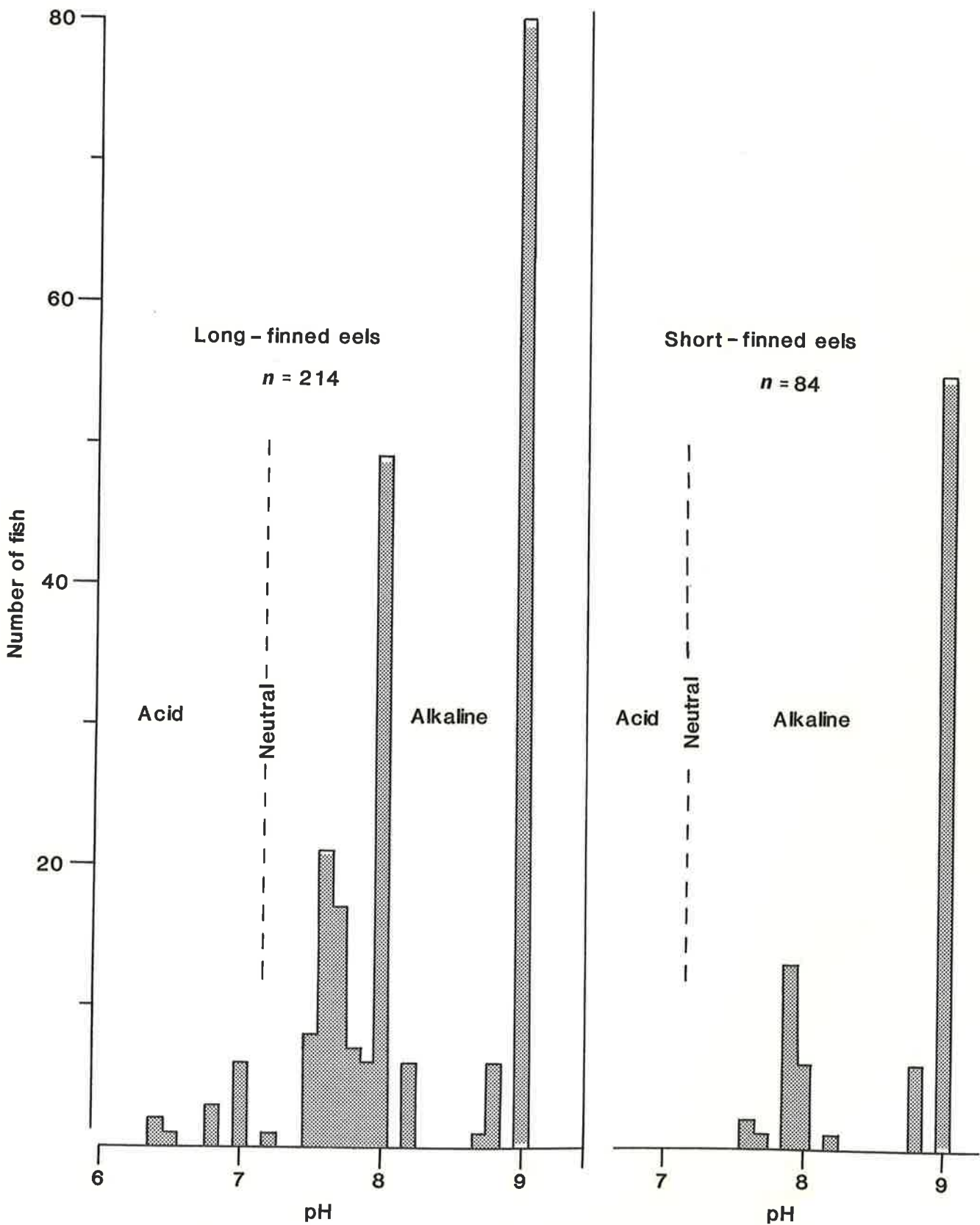


FIGURE 16. Frequency of occurrence of eels at various pH readings in the Mohaka River system.

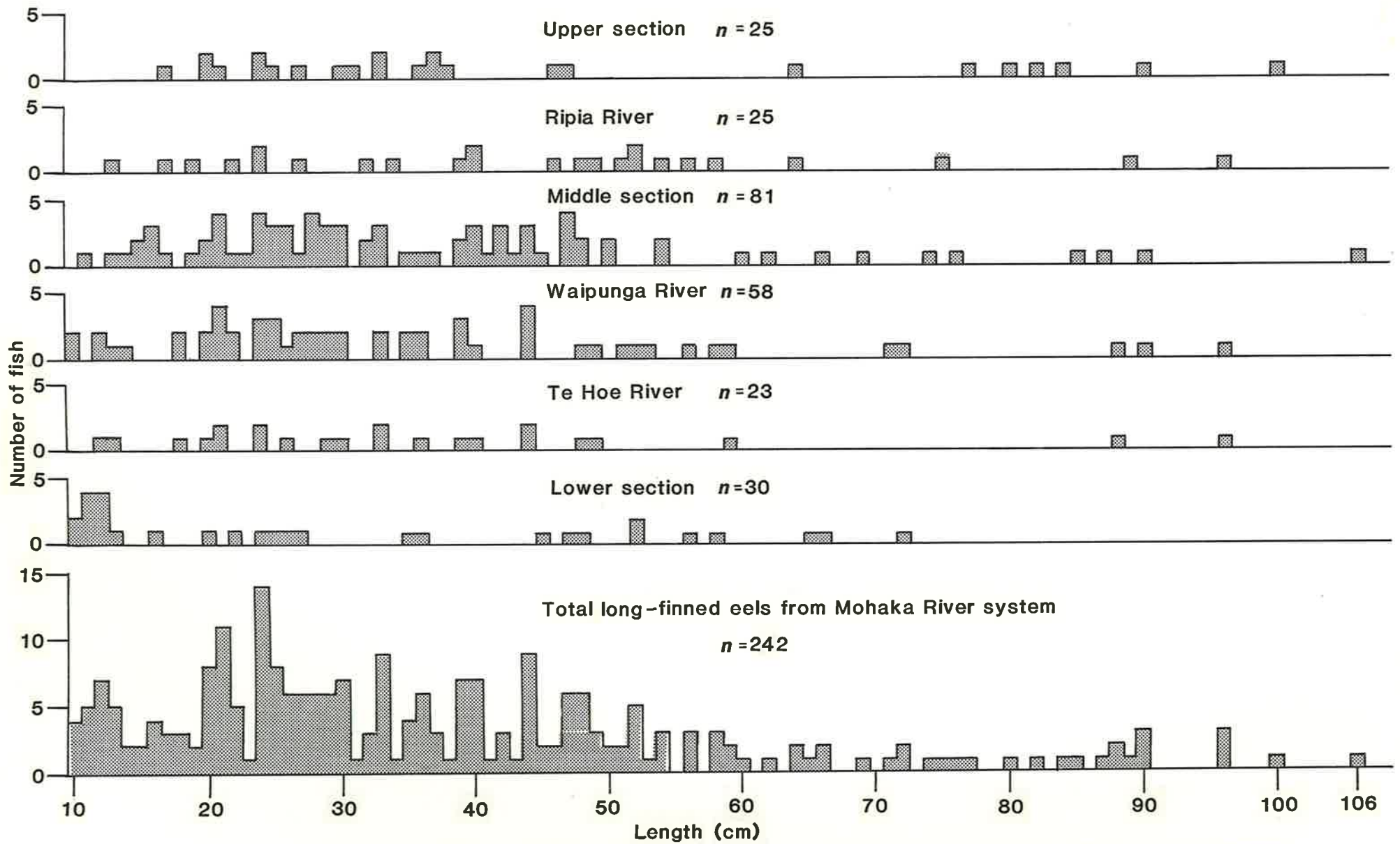


FIGURE 17. Length-frequency distributions of long-finned eels from various areas of the Mohaka River.

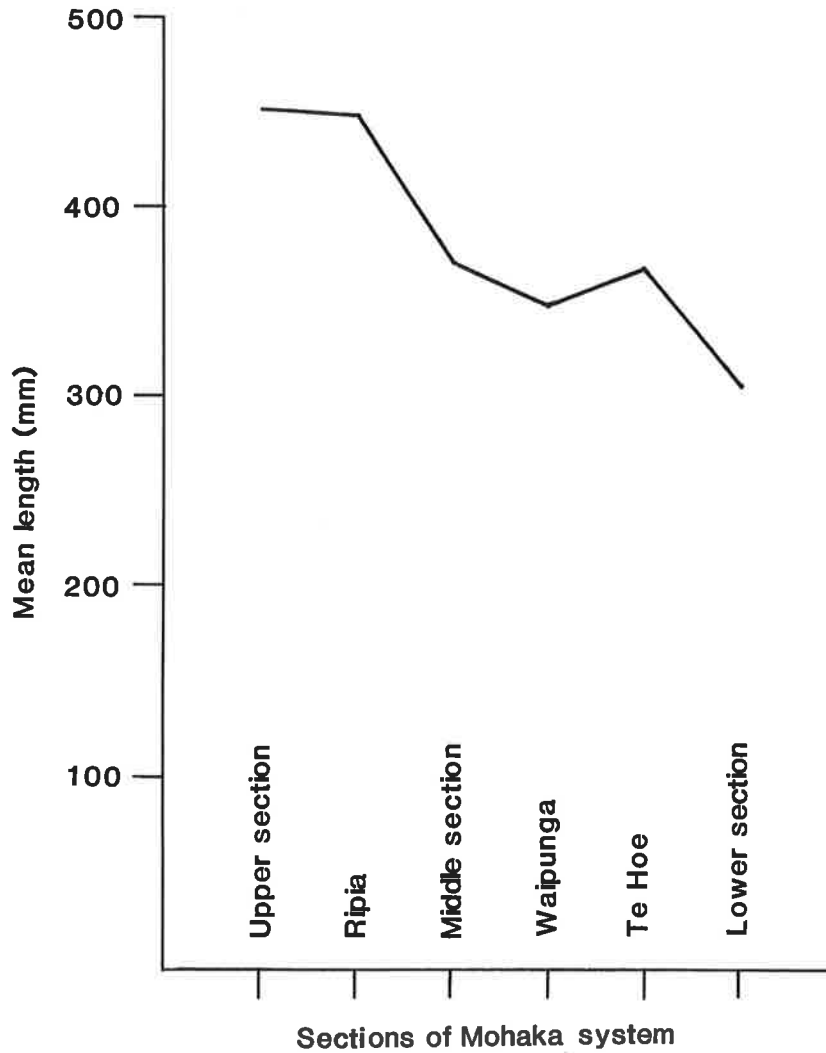


FIGURE 18. Mean lengths of long-finned eels from six areas of the Mohaka system.

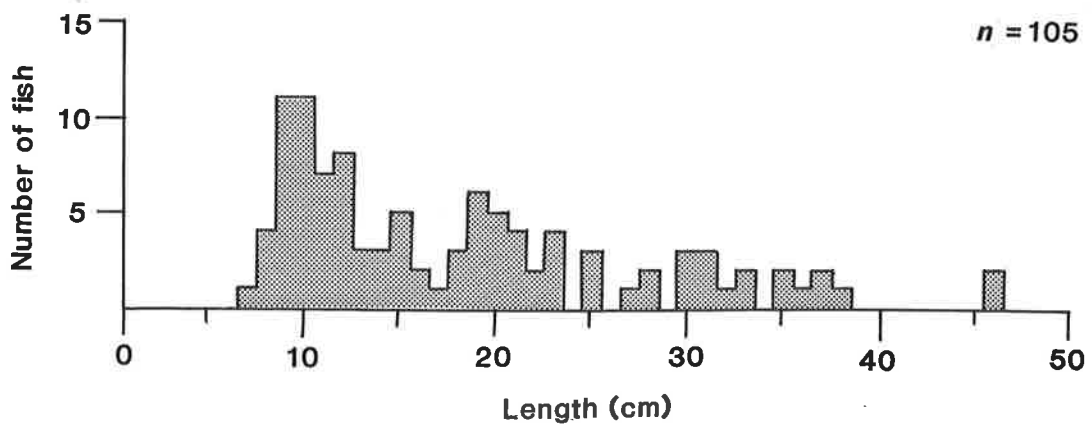


FIGURE 19. Length-frequency distribution of short-finned eels in the Mohaka River system.

Maungataniwha gorge (see Figs. 10 and 14). Only 12% of the total shortfin catch was found upstream of the gorge. Seventy percent of those found above the gorge were less than 12-cm long (possibly recent migrants) and the largest was 37 cm, which suggests that suitable adult habitat is lacking in the river upstream of Maungataniwha gorge.

Todd (1980) found that from three different locations in New Zealand shortfins migrated to sea at lengths of between 33.8 and 59.8 cm for males and between 48.3 and 102.4 cm for females. In the Mohaka (Fig. 19) only 10 shortfins were within the length range for migrating males and none was in the range for migrating females.

The confinement of almost all shortfins to the lower Mohaka, and the virtual absence of individuals within the length range for mature adults, suggests that adult habitat may be lacking in the river. However, sample sites in the lower Mohaka were confined to small tributaries and shallow margins of the main channel, and further sampling to include larger habitats in the lower river would be required to determine whether shortfin adults use this area.

Water temperatures from sites where shortfins were most frequently caught ranged from 16 to 22°C (see Fig. 15), which was the upper end of the temperature range of long-finned eel sites. Shortfins were found in waters with a pH range of 7.6 to 9.0 (see Fig. 16), but, as with longfins, they were recorded in greater numbers with increasing alkalinity.

Most shortfins were less than 30 cm and were caught in silt, weed, and gravel habitats. The largest number caught at any one sample site was in a small, shallow, and sluggish stream which had a solid papa substrate with pockets of silt and weed, and occasional clumps of rubble sized papa fragments, all of which were used as cover.

4.5.3 Koaro (*Galaxias brevipinnis*)

Koaro are found throughout New Zealand in the fast flowing bouldery streams of native forests. Juvenile koaro are the second most important species in the New Zealand whitebait catch (McDowall 1978). After being spawned in fresh water, koaro larvae are washed out to sea during autumn and return as whitebait about 6 months later. This migration to adult habitat often leads them great distances inland, and they are able to negotiate obstacles such as waterfalls.

In the Mohaka, a total of 25 koaro was caught - the smallest was 50 mm long and weighed 1 g, and the largest was 200 mm long and weighed 103 g. Koaro were found at only seven sites (Fig. 20) ranging from 69 to 127 km from the sea, but most were found 70 to 80 km from the sea (see Fig. 11). All these sites were above Maungataniwha gorge and the majority were in the Te Hoe system (Fig. 20), though the greatest density of koaro was found in the middle section (see Table 2). Although koaro formed only 2% of the total catch (see Fig. 9), and were present at only 10% of the sites sampled (see Fig. 8), they were the next most widely distributed fish after both species of trout and long-finned eels.

Trout and eels were also caught at all but one koaro site, and because only one koaro was caught at this site the physical features recorded there were not necessarily characteristic of koaro habitat. It was assumed that the site where the highest density of koaro was found would be closer to the optimum habitat for koaro than any other site in the Mohaka. Therefore, physical features at this site which were different from the physical features of other sites were assumed to be features characteristic of koaro habitat.

Table 10a shows selected habitat measurements of all sites where koaro were found. Sites 20 and 22 contained the highest densities of koaro; 8 and 5 per 100 m² respectively. At the remaining sites koaro densities were less 2 per 100 m².

A feature which sites 20 and 22 had in common, and which was noticeably different from other koaro sites, was their steep gradient. A preference by koaro for steeper gradients than those preferred by other Mohaka fishes is shown in Table 4. Factors which all koaro sites had in common, with two exceptions, were an unmodified bush catchment and coarse substrates. Table 6 shows that the occurrence of koaro in the Mohaka was associated with a high percentage of boulders in the substrate and Table 10a shows that the highest density of koaro was found at a site which had a higher percentage of boulders in the substrate than any other site. Table 10b lists all the Mohaka sites which had gradients similar to or steeper than sites 20 and 22 and also sites which had substrate combinations similar to sites 20 and 22. Each of these sites is listed in the table in order of their similarity to sites 20 and 22, based on habitat features which appeared to have importance, (gradient, substrate, catchment, and surrounds).

Although the sites in Table 10b appear to have a general similarity in physical features to sites 20 and 22, subtle differences were recorded which may have accounted for the absence of koaro. For example, site 2 appeared to have most of the habitat features of site 20, except that it was twice the distance from the sea and had lower water temperature and pH. The other sites in Table 10b all have at least three features that are different to the features which make sites 20 and 22 so similar as habitat. (Site 22 is shown in Figure 7.)

No koaro were found at any of the sample sites in the lower section and neither were any habitat features similar to those at sites

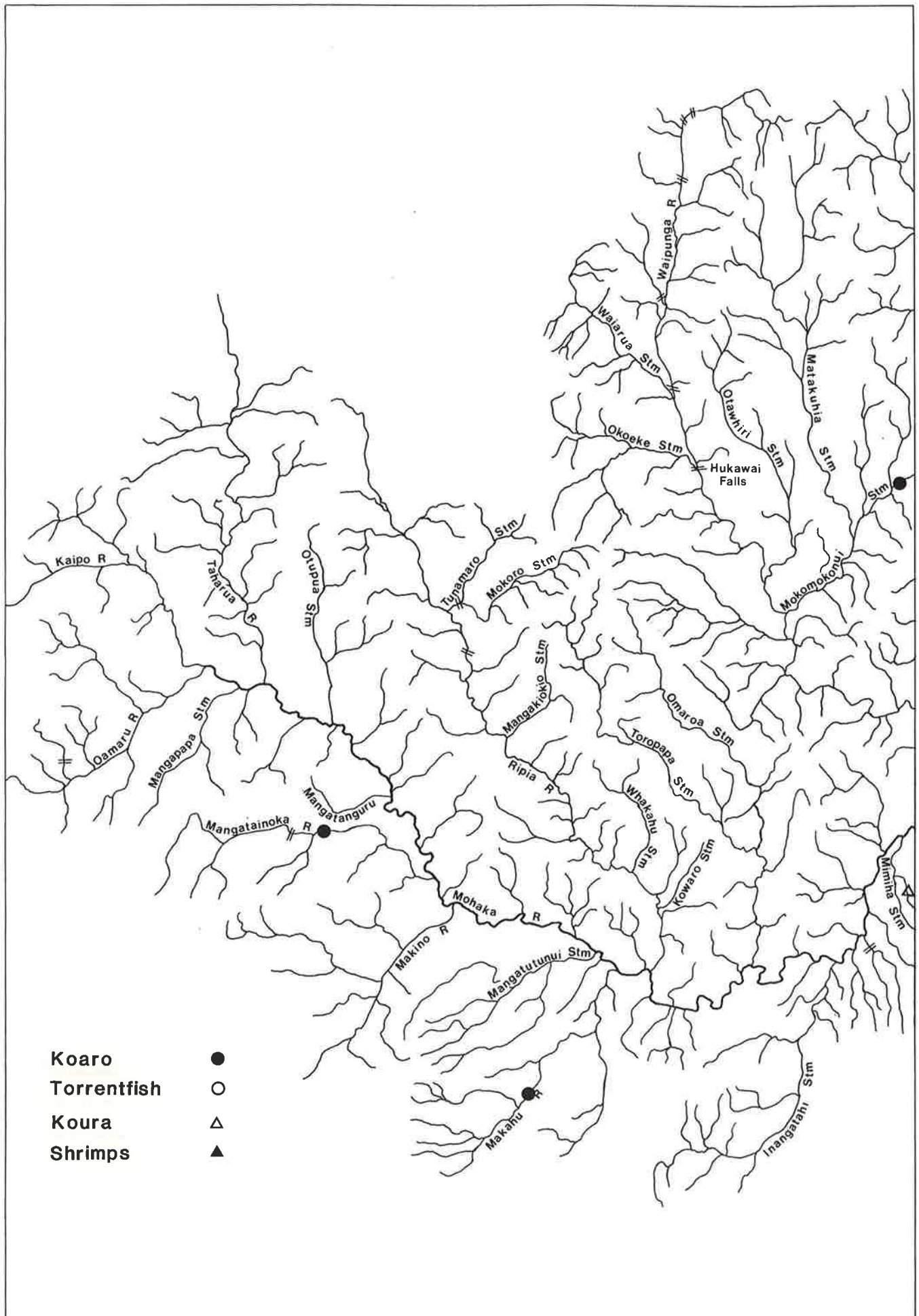


FIGURE 20. Distribution of koaro, torrentfish, koura, and shrimps in the Mohaka River system.

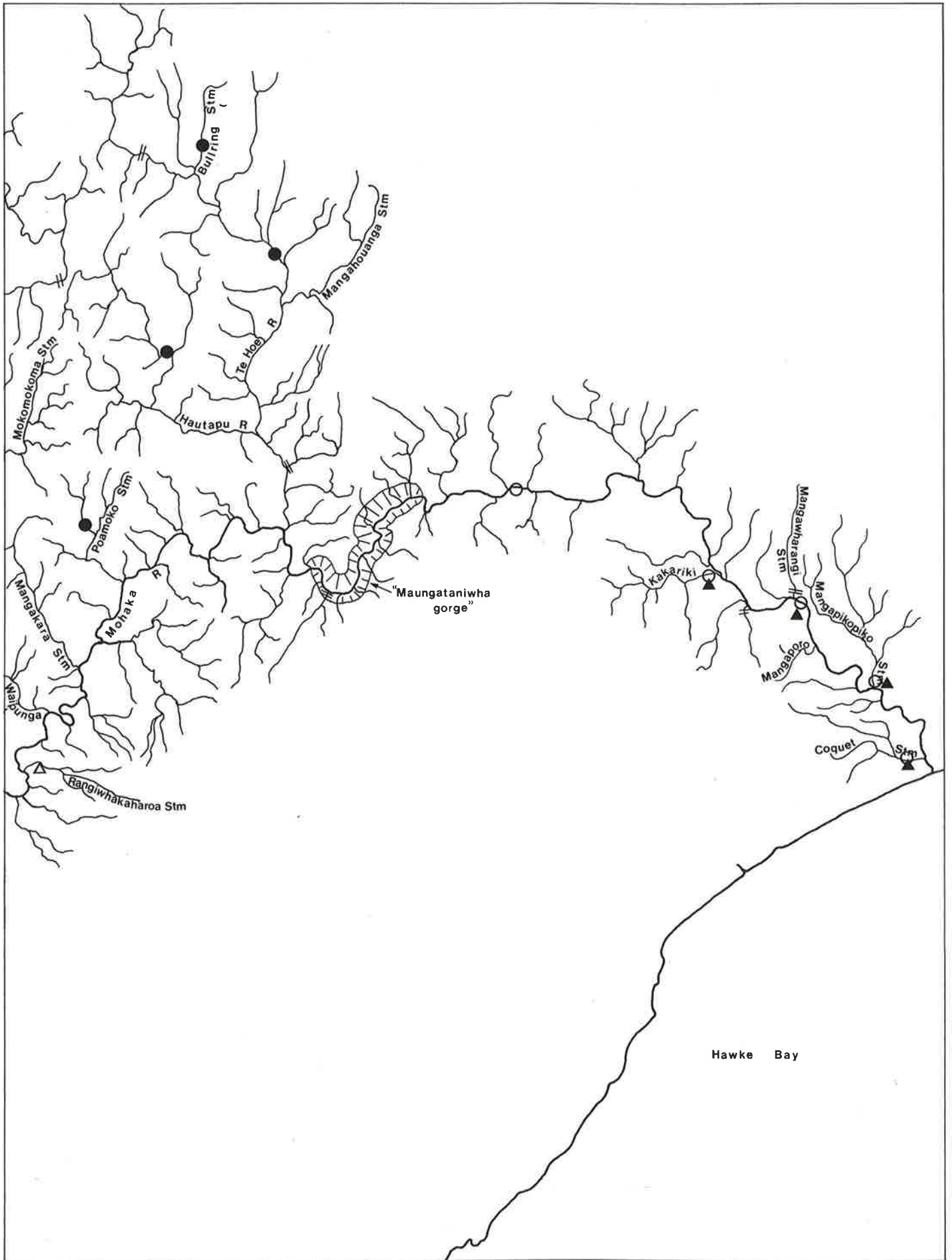


FIGURE 20 - continued.

TABLE 10.

(a) Habitat features at sites in the Mohaka River system where koaro were found.

Site No.	Catchment and surrounds	Density (No./100 m ²)	Distance from sea (km)	Gradient (m/100m)	Temperature °C	pH	% silt	% sand	Substrate		
									% gravel	% rubble	% boulder
5	Unmodified bush, closed aspect	0.5	127	1.75	11.5	7.0	0	10	30	30	20
19	Unmodified bush, open aspect	0.5	69	0.87	15.6	7.7	10	10	15	20	45
20	Unmodified bush, closed aspect	8.0	70	6.99	11.3	7.6	0	5	20	25	50
22	Unmodified bush, semi-enclosed aspect	5.0	78	4.37	11.0	7.8	0	10	20	30	40
34	Modified bush and pasture, open aspect	0.5	101	1.39	14.8	7.9	0	5	25	50	20
42A	Unmodified bush, open aspect	2.0	70	1.75	15.4	7.6	0	15	60	20	5
53	Unmodified bush, semi-enclosed aspect	1.0	117	4.36	17.0	7.2	10	10	20	20	40

(b) Habitat features at sites in the Mohaka River system where koaro were not found, but where habitat features were similar to those at sites 20 and 22.

2	Unmodified bush, closed aspect	0	146	6.98	9.1	6.7	0	0	30	20	50
37	Modified pasture, open aspect	0	81	6.12	19.7	9.0	10	10	10	15	55
12	Unmodified bush, closed aspect	0	122	4.36	14.9	7.6	0	5	40	25	30
63	Unmodified bush, open aspect	0	124	2.62	15.2	7.0	5	10	10	25	50
7	Unmodified bush, semi-enclosed aspect	0	123	2.10	14.5	7.5	0	10	20	30	40
20A	Modified bush and scrub, open aspect	0	62	21.63	19.8	7.8	10	20	10	20	30

20 and 22 (see Tables 3 and 5). This survey found low numbers of koaro in the Mohaka, but sampling of specific habitat types was not possible because of access limitations (see section 4.4.1). More detailed information on the distribution and abundance of koaro would require considerably more field work.

4.5.4 Torrentfish (*Cheimarrichthys fosteri*)

The torrentfish, as its name implies, lives in swift water habitats, generally in the lower reaches of river systems. Its life cycle requires a marine phase during its larval stage, after which juveniles enter fresh water (in spring). In the Mohaka it appears that torrentfish distribution is confined to the lower section, because none was found above Maungataniwha gorge (see Figs. 11 and 20).

A total of 20 torrentfish was captured and these ranged from 31 to 94 mm in length. Overall, torrentfish comprised 2% of the total catch and occurred at only 7% of the sites, but in the lower reaches they occurred at 45% of the sites.

Habitat measurements were made at only two of the five sites where torrentfish were caught and therefore provide little indication of this species' preference for any particular habitat feature or combination of features. However, in general torrentfish were caught in swift and broken water among fragmented papa rubble and boulders. Gradients, substrate, temperature, and pH at torrentfish sites where measurements were taken are shown in Tables 4, 6, and 9.

Torrentfish are found in similar habitats to blue-gilled bullies (McDowall 1978, Davis *et al.* 1983) and so it seems reasonable to assume that both species may have a similar ability to swim and to penetrate

upstream. It is assumed that torrentfish are better able to negotiate fast water than common bullies, and the mean gradient for sites where torrentfish were found was greater than that recorded for common bullies (see Table 4). Therefore, because both blue-gilled and common bullies were found above Maungataniwha gorge (Fig. 21) there is some likelihood that torrentfish are present above the gorge, but were missed during the survey.

4.5.5 Common bully (*Gobiomorphus cotidianus*)

River populations of common bullies can be found throughout New Zealand, usually in the quieter reaches of rivers and streams. Adult life is spent in fresh water but after hatching from eggs the larvae are washed out to sea. During spring and early summer juveniles migrate from the sea back into fresh water and may penetrate considerable distances inland.

The distribution of common bullies in the Mohaka River appears to be confined to the first 21 km from the sea (see Fig. 11). The gradient of the Mohaka follows a gentle rise in the first 20 km from the sea, but between 20 and 30 km upstream there is a marked increase in gradient which continues to increase upstream past Maungataniwha gorge (see Fig. 12). Common bullies were found at sites in the lowest of the gradient range sampled (see Table 4). A single common bully was found 75 km from the sea at the mouth of the Waipunga River (Fig. 21).

In the lower section of the Mohaka, common bullies were present in higher densities than any other species (see Table 2), but because of their limited distribution they occurred at only 11% of the sample sites (see Fig. 8), and made up only 15% of the total catch (see Fig. 9).

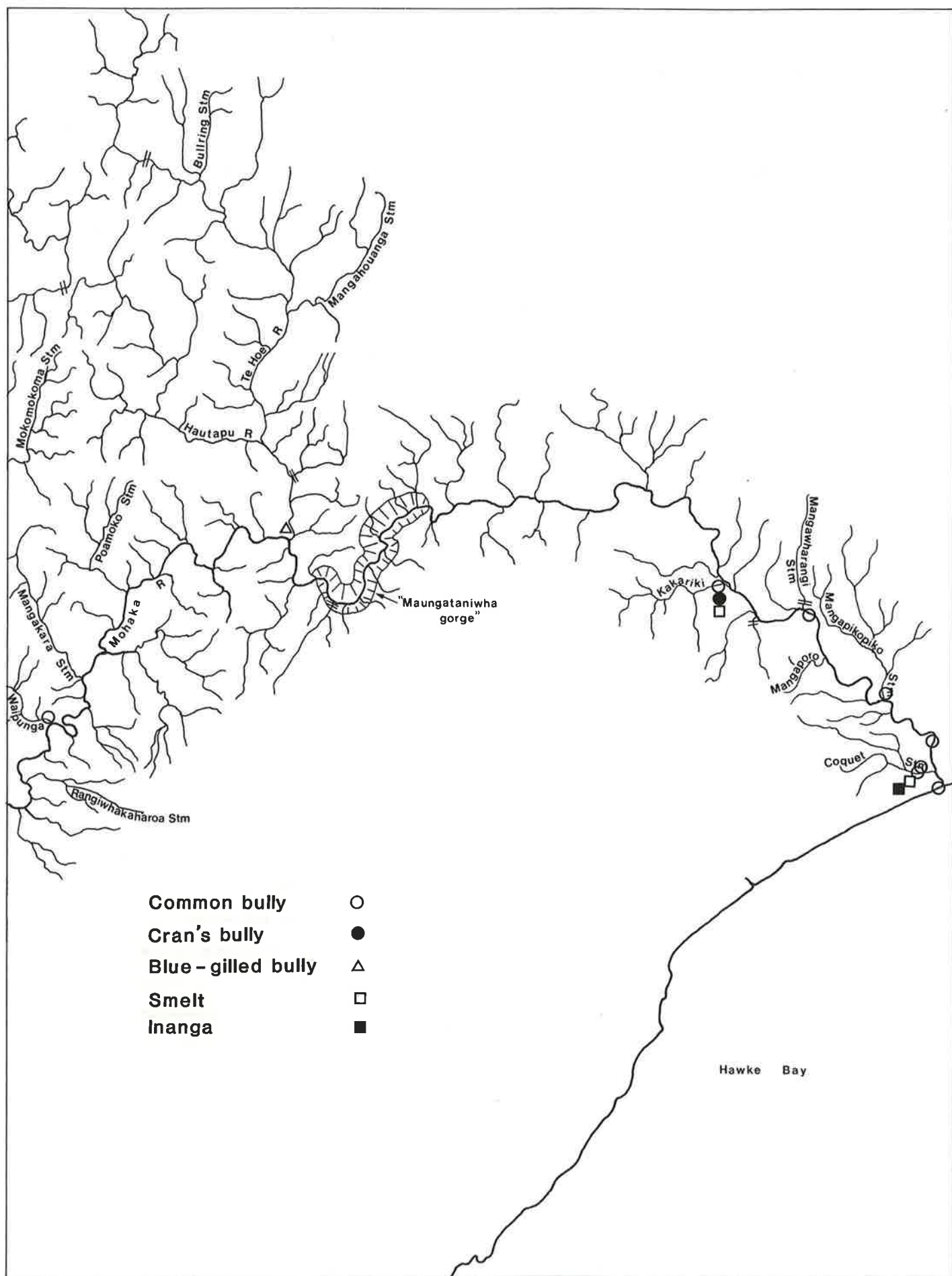


FIGURE 21. Distribution of bullies, smelt, and inanga in the Mohaka River system.

Sites at which common bullies were found had a variety of substrates, and any preference that the species may have had for a particular substrate component, or combination of components, was not found. However, the sites where common bullies were found commonly had slow meandering runs and still shallow margins. The temperature and pH range for these sites were typical of sites in the lower section (see Tables 8 and 9).

Length-frequency distribution of common bullies sampled is shown in Figure 22. Small juvenile bullies (less than 30 mm) were observed more frequently at sites closest to the sea, but they were not often caught because they were less affected by the electric fishing machine than larger fish. Apart from the specimen found 75 km from the sea, the length-frequency distribution of bullies larger than 30 mm appeared to be unaffected by distance upstream.

4.5.6 Blue-gilled bully (*Gobiomorphus hubbsi*)

The biology of the blue-gilled bully is similar to that of the common bully, but its preferred habitat is swift flowing water of gravelly streams and rivers, similar to that of the torrentfish.

In the Mohaka, blue-gilled bullies were found at a single site 55 km from the sea in the Te Hoe River (Fig. 21). They were caught along the margins of the river among rubble in swift and shallow water, and they were 70 and 79 mm long. These were large adults, and the 79 mm specimen is 2 mm longer than the maximum recorded by McDowall (1978).

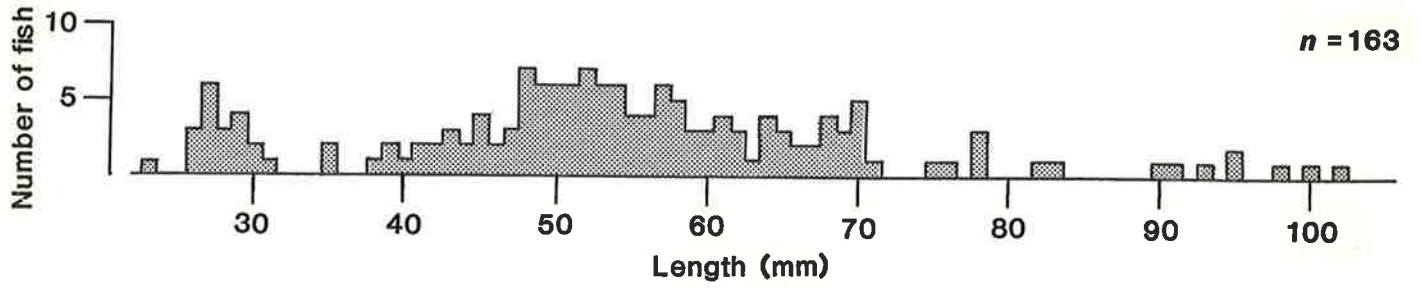


FIGURE 22. Length-frequency distribution of common bullies in the Mohaka River.

4.5.7 Cran's bully (*Gobiomorphus basalis*)

Cran's bully is mainly a river dwelling species and does not have a marine phase in its life cycle.

In the Mohaka, Cran's bully was found at a single sample site 21 km from the sea in the Kakariki Stream (Fig. 21). It was found in a sluggish area of the stream which was devoid of cover except for small fractures in the papa substrate. The two Cran's bullies caught measured 67 and 70 mm in length.

4.5.8 Common smelt (*Retropinna retropinna*)

Common smelt are found around the coast of New Zealand and in streams and rivers that can be reached from the sea. They are most often encountered in lowland rivers during spring and summer when large shoals move in from the sea. Spawning takes place in fresh water and larvae are washed out to sea.

In the Mohaka, the furthest upstream that smelt were found was 21 km, in the Kakariki Stream (Fig. 21). They were found at only two sample sites and represented barely 1% of the total catch (see Fig. 9). Because sampling did not include pools in the main river, where smelt would probably have been found shoaling, smelt abundance in the Mohaka's lower section was probably far greater than that indicated by the numbers found during the survey. Smelt lengths ranged from 64 to 98 mm.

4.5.9 Inanga (*Galaxias maculatus*)

The juvenile of this fish is the most important species in the New Zealand whitebait catch (McDowall 1978). It is a fish of lowland coastal rivers and, like other members of this family, spawns in fresh water. Larvae are washed out to sea and juveniles migrate into fresh water as whitebait.

In the Mohaka inanga were found only in the immediate coastal region of the river at one site 2 km inland from the sea (Fig. 21). The catch of inanga represented less than 1% of the total catch. It is very likely that more inanga would have been collected if pools in the Mohaka's lower section had been sampled. Like smelt, inanga are normally a shoaling fish likely to be found in pool habitats in the lower reaches of the river. Inanga lengths ranged from 64 to 81 mm.

4.5.10 Brown trout (*Salmo trutta*)

Brown trout are widespread throughout New Zealand and are one of two introduced trout species found in the Mohaka River. The first liberation of brown trout in the Mohaka took place during 1878 in the Taharua River and was followed in the 1890s by another liberation which included the stocking of the upper Waipunga River (Wellwood 1968).

During the 1983 survey, brown trout were found widely distributed throughout the Mohaka River system (Fig. 23). They occurred at 51% of the sample sites (see Fig. 8) and were the most abundant species in the total catch (see Fig. 9). Most of the total catch of brown trout came from headwater reaches of the Mohaka River where they were the most abundant species (see Table 2). Brown trout were recorded in their lowest densities in the middle and lower sections of the Mohaka. The

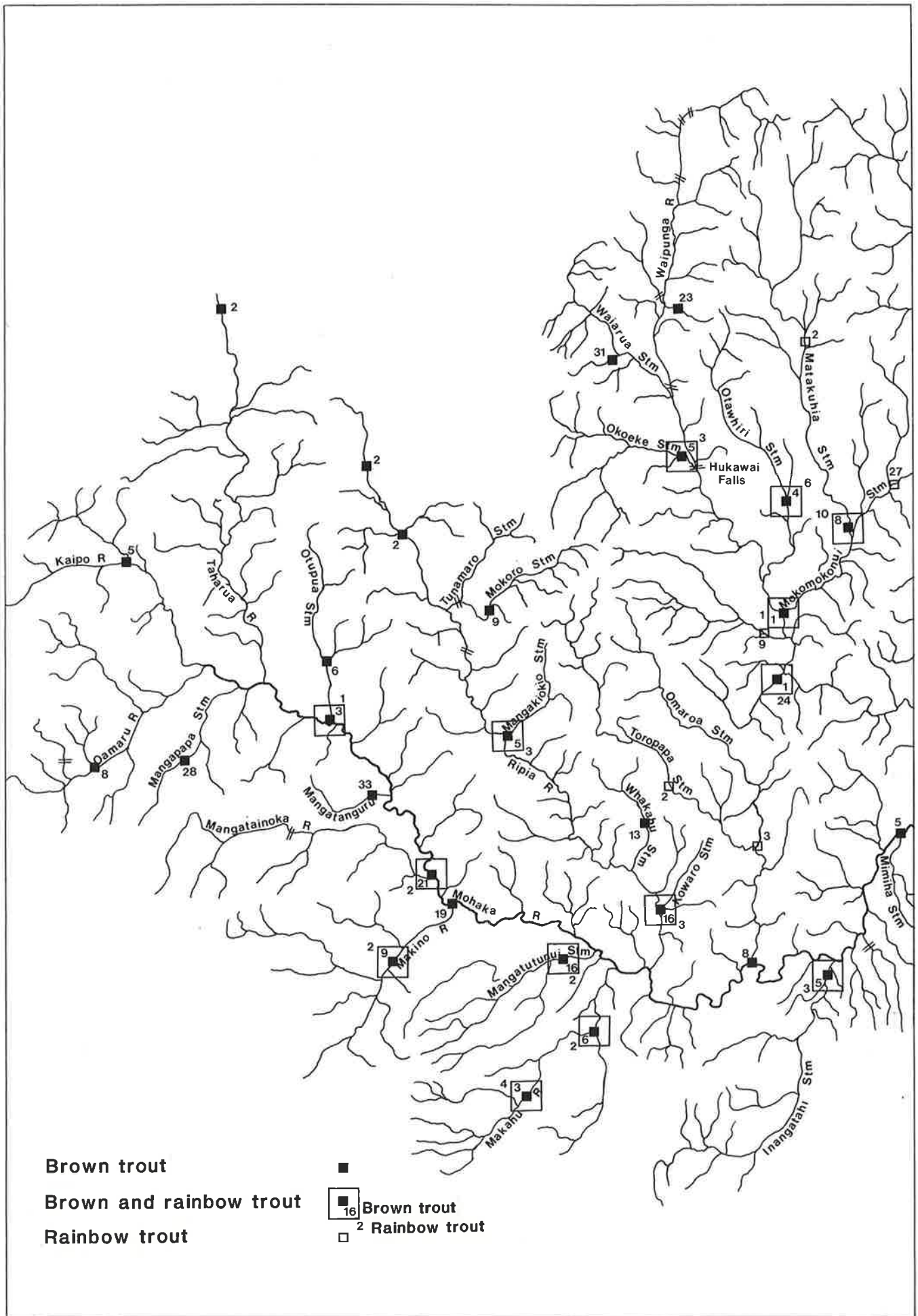


FIGURE 23. Distribution of brown trout and rainbow trout in the Mohaka River system.

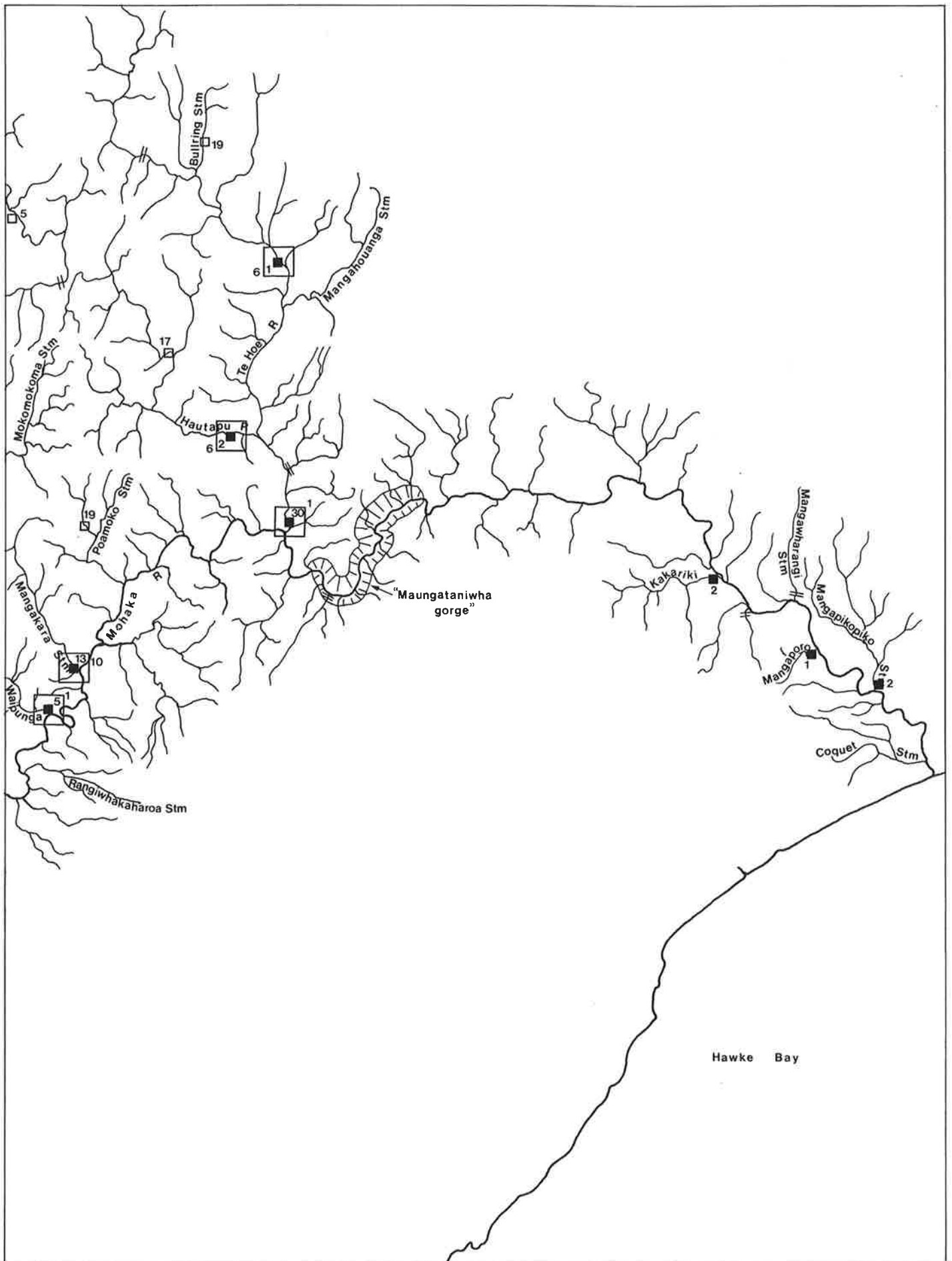


FIGURE 23 - continued.

highest density of brown trout was found in the Waipunga River (see Table 2) where a very high average density of 44 per 100 m² was recorded above Waipunga Falls. Below Waipunga Falls average brown trout density was only 1.4 per 100 m².

Because sampling was concentrated on the smaller tributaries, all but three brown trout were less than 20 cm long. Though ages were not determined, most brown trout taken were assumed to be juveniles and yearlings; the smallest caught were in the 3-4-cm length class and came from two sample sites in the Waipunga River above Waipunga Falls (Fig. 24). Brown trout in the 4-5 cm length class were caught in the Ripia River and upper section of the Mohaka, and in every instance occurred at sites where no rainbow trout were caught. Modal length of brown trout was lowest in the upper section, but increased downstream (Fig. 24). The increase in modal length of brown trout, especially from the upper section to the middle section, corresponded with a distinct decrease in brown trout density from the upper to the middle sections (see Table 2).

Habitat features specific to each species of trout were derived from measurements at sites where only one species of trout was collected (Table 11). Brown trout only were located at 18 sites, whereas rainbows alone occurred at only 9 sites. A comparison of the range of each habitat feature in Table 11 indicates that brown trout may be less specific in their choice of habitat than rainbow trout.

Brown and rainbow trout occurred together at 19 sites. Brown trout densities were greater at 13 of these sites, rainbow trout densities were greater at 5 sites, and densities were equal at 1 site (Table 12).

Table 12 shows that brown trout occurred in their highest densities when they were the only trout species, and in their lowest densities

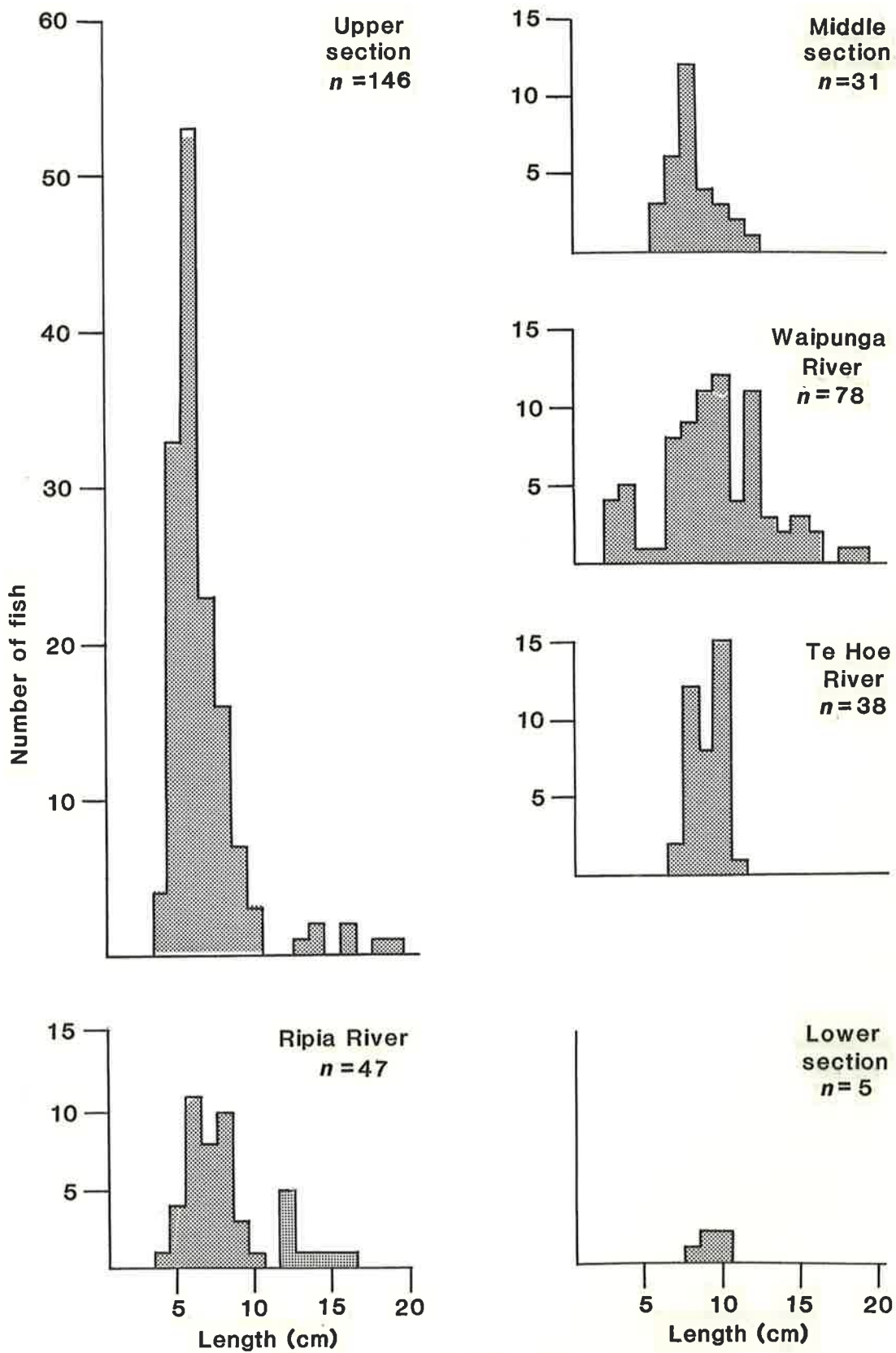


FIGURE 24. Length-frequency distributions of brown trout smaller than 20 cm from six different areas of the Mohaka River system.

TABLE 11. Habitat measurements from sites in the Mohaka River system where only one species of trout occurred.

Habitat data*	Brown trout			Rainbow trout		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Temperature (°C)	13.8	9.1	20.2	13.2	11.0	15.6
pH	7.4	6.4	9.0	7.5	7.0	7.9
Flow (m ³ /sec)	0.230	0.006	0.663	0.284	0.085	0.662
Gradient (m/100m) [†]	2.36	0.52	6.98	2.33	0.87	6.99
Average wetted width (m)	4.6	1.2	15.0	5.6	2.2	9.0
(Silt	4	0	40	1	0	10
(Sand	18	0	100	8	1	15
Substrate (Gravel	24	0	87	33	15	60
% (Rubble	20	0	50	35	20	60
(Boulder	17	0	70	22	0	50
(Bedrock	16	0	100	0	0	0

* Habitat data for brown and rainbow trout shown in tables elsewhere in this report include data from sites where both trout species occurred.

† Gradient was measured at only 16 brown trout only sites.

TABLE 12. Mean density of brown and rainbow trout for various associations of the two species in the Mohaka River system.

	Number of sites	Mean density of brown trout (No./100 m ²)	Number of sites	Mean density of rainbow trout (No./100 m ²)
Brown trout only	18	10.1	-	-
Rainbow trout only	-	-	9	4.5
Brown and rainbow trout (B + R)	19	4.2	19	3.0
B + R but higher density of B	13	5.6	13	1.4
B + R but higher density of R	5	1.4	5	7.4
B + R in equal density	1	0.2	1	0.2

when rainbow trout were present. Therefore, if brown trout were less specific than rainbow trout in their choice of habitat, the decrease of brown trout density in the presence of rainbow trout was probably due to some form of competitive interaction between the two trout species. A similar interaction between brown trout and other species, particularly long-finned eels, was indicated in areas where brown trout densities were high and other species low, and vice versa (see Table 2). Further examination of these interactions will require more data collection.

Other than in Table 11, habitat differences for each trout species association were not analysed, because some associations were found in only a few sites. However, in general, streams where both trout species were present together were larger in mean width and flow and had higher mean temperatures and pH than streams where only one species of trout occurred.

4.5.11 Rainbow trout (*Salmo gairdnerii*)

Introduction of rainbow trout to the Mohaka River probably occurred about 1900 (Wellwood 1968). The 1983 survey of the Mohaka found that distribution of rainbow trout was concentrated in the middle section (Fig. 23). Rainbow trout were not found in the lower section and densities were low in the upper section (see Table 2). However, records in the New Zealand Forest Service's Oamaru hut books indicate that large rainbow trout have been caught by anglers in the vicinity of the Kaipo and Oamaru confluence, which is further upstream than the upper limit of rainbow trout distribution shown in Figure 23.

Rainbow trout comprised 17% of the total catch, slightly less than half the catch of brown trout (see Fig. 9). The average density of

rainbow trout (3 per 100 m²) was half the average density of brown trout (6 per 100 m²) (from Table 2). The highest densities of rainbow trout were in the middle section and lower half of the Waipunga (see Table 2). The lower Waipunga (below Hukawai Falls - see Fig. 6) is essentially part of the middle section as it is not separated by waterfalls or steep gradients and joins the Mohaka midway through the middle section.

As with brown trout, all but three rainbow trout collected were less than 20 cm long. The smallest rainbow trout were in the 4-5 cm length class (Fig. 25) and were found in the same section as the highest densities of rainbow trout (see Table 2). Modal length of rainbow trout was highest in the upper section where rainbow trout density was lowest, but where brown trout density was high. This is the converse of the trend shown by brown trout.

Table 12 shows the highest mean density of rainbow trout was in the presence of a low mean density of brown trout: it appears that rainbow trout are less affected by the presence of brown trout than browns are by the presence of rainbow trout.

Habitat variables at sites with rainbow trout only were confined to a narrower range than those at sites with brown trout only (Table 11). Even in the presence of a low density of brown trout, habitat variables for rainbow trout were confined to a similar narrow range. Compared with brown trout, rainbow trout presence was associated with specific substrate types (Table 11) and in particular gravel and rubble combinations of not less than 15 and 20% respectively.

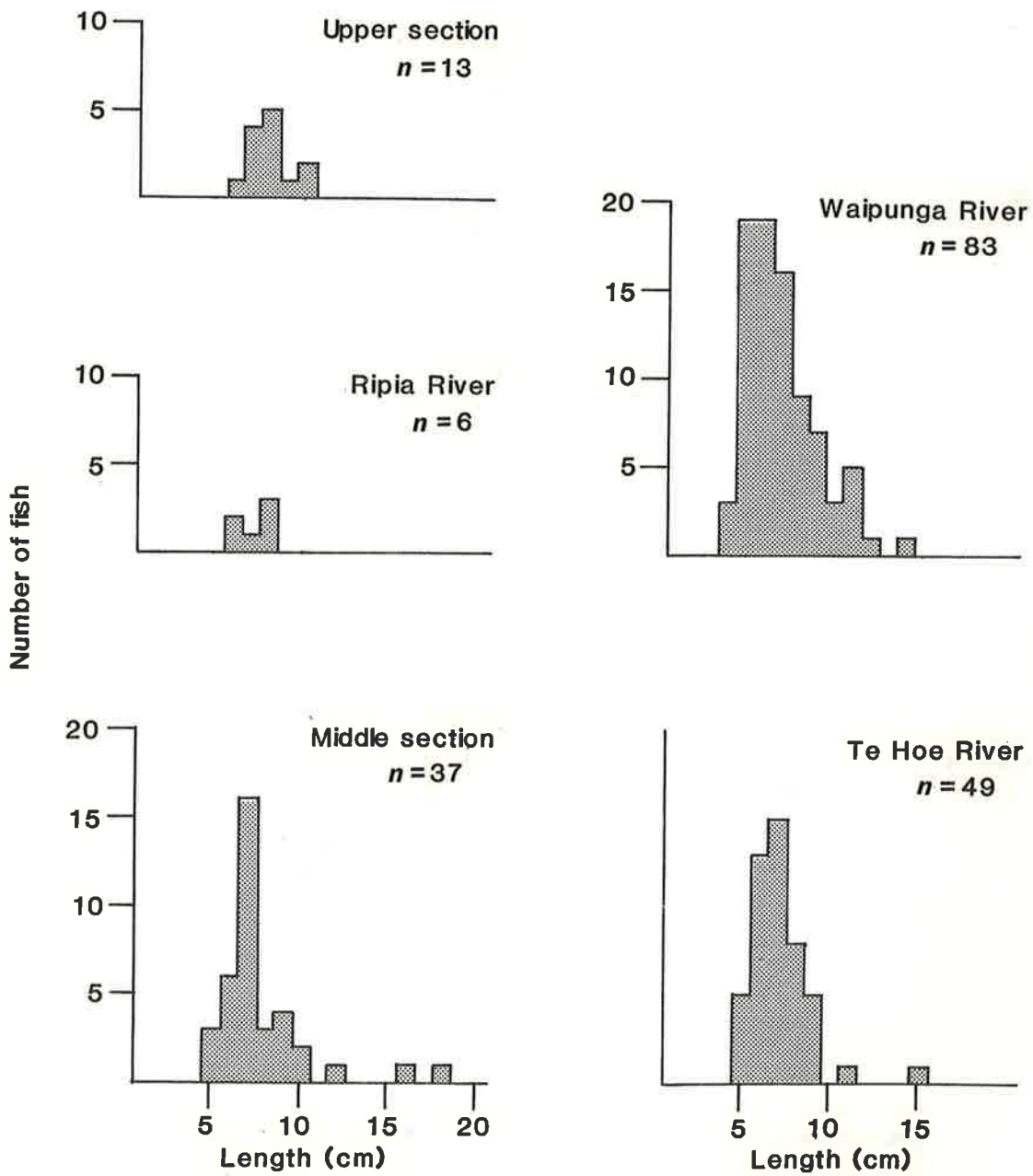


FIGURE 25. Length-frequency distributions of rainbow trout smaller than 20 cm from different areas of the Mohaka River system.

5. DISCUSSION

The Mohaka's extensive catchment contains many large tributaries all of which join the Mohaka in the top two-thirds of the river's course. In the lower third, the river enters a gorge (Maungataniwha) which appears to contribute in a major way to the observed distribution, diversity, and density of fish species in the Mohaka River.

The 1983 survey established the main fish species present in the river, and the main features of their distribution, and collected some data on their habitat. The three most abundant species in the Mohaka River were long-finned eels, brown trout, and rainbow trout.

Owing to the developed catchment and papa country through which the lower river flows, tributaries of the Mohaka's lower reaches lack the range of physical characteristics present in upstream reaches. However, the diversity of fish habitat in the upper reaches was not utilised by a corresponding diversity of fish species. In fact, it was in the first 21 km from the sea that the greatest diversity of fish species was found (or has been reported). The number of species appeared to decrease upstream with the increase in river gradient. Gradient was highest in Maungataniwha gorge, above which were found migrant species known for their ability to negotiate natural obstacles such as rapids and waterfalls. Densities of stronger swimming species were greater above the gorge, whereas below it densities of weaker swimmers were greater. The decline in density and diversity of native fish fauna above Maungataniwha gorge could be due to the nature of the gorge or to interactions between trout and native fish. Resolution of this issue could be important in understanding how the fish community functions and therefore be an important aspect of hydro-electric impact assessment.

The most abundant species found in the Mohaka above Maungataniwha gorge were trout. Because almost all the sample sites were in the Mohaka's tributaries, where streams were small enough to wade and electric fish, nearly all the trout sampled were fish less than 20 cm long, and were probably juveniles. However, sightings of large trout in pools of many of the larger headwater tributaries were made from the air and banks. Adult trout appeared to be confined to deepwater habitats in the main channel of the Mohaka and its larger tributaries. High densities of juvenile trout found in small tributaries indicate that adult trout must at some stage move into these areas to spawn. Fish trapping by the Hawke's Bay Acclimatisation Society has shown that trout move about the system during the spawning season. Therefore, it is important that areas of the Mohaka where trout spawn, and where significant densities of juveniles are reared, are not isolated from the fishery which they support.

Tributaries of the Ripia, middle section of the Mohaka, Waipunga, and Te Hoe Rivers all supported significant densities of rainbow trout juveniles. If rainbow trout recruited from these areas support a fishery elsewhere in the Mohaka, dams placed across the path of their movement would downgrade the quality of the Mohaka fishery.

Although the trout fishery is not confined to the middle section of the Mohaka, there are indications that this section is the most important. Based on angling information, Wellwood (1968) reported that brown trout predominated in the Mohaka above Pakaututu (the upper section), but for nearly all the river downstream brown and rainbow trout were present in about equal numbers. Despite the predominance of juvenile trout sampled in the 1983 survey, the trout species composition and distribution found supported Wellwood's findings. Wellwood (1968)

also reported that rainbow trout were more easily caught than brown trout and this is reflected in composition of the Mohaka angling catch (83% rainbow and 27% brown trout) reported by Graynoth (1973). If the species composition and distribution of juvenile and adult trout were similar throughout the Mohaka system, the middle section, which supported the highest density of juvenile rainbow trout, is also likely to support the highest density of adult rainbow trout. Therefore, rainbow trout abundance combined with easy access for anglers indicates that the middle section is the most exploited and important area of the Mohaka trout fishery. Results from a national survey of river anglers by FRD (Richardson, Unwin, and Teirney 1984) showed that, despite the higher level of use and catch rate in the middle reaches, the Mohaka's headwaters were the most highly valued section of the river, because wilderness qualities, scenic beauty, and large trout were rated highly.

Of the Mohaka tributaries, density of juvenile trout was highest in the Waipunga, then the Ripia. Data from FRD's National River Angling survey show that these two tributaries were also the most popular with anglers (L.D. Teirney pers. comm.). Twice as many anglers as fished the Ripia fished the Waipunga, which is accessible in the middle reaches from S.H.5. Good catch rates of fairly large trout were reported from both tributaries, which indicates that the tributaries support stocks of adult trout as well as the juveniles sampled in this survey.

Current knowledge about the distribution of trout throughout the Mohaka system highlights the need for a better understanding of several aspects of trout biology; for example, brown and rainbow trout interactions, patterns of (and reasons for) movement of each life stage within the Mohaka system, and the interrelationship between tributary and mainstem habitats.

Several results show an association between the absence of some species and the abundance of another. For example, only brown trout were found above Waipunga Falls and occurred in their highest densities there. As a corollary to this, brown trout densities decreased in the presence of rainbow trout and long-finned eels.

Burnet (1968) showed that the removal of eels may increase numbers of trout, but not necessarily increase the return to the angler or the quality of trout. Further investigation in the Mohaka may show that the quality of the trout fishery in the middle reaches is partly dependent on the presence of eels in those reaches. Such an association would be jeopardised if the construction of dams excluded eels from these reaches.

Short-finned eels were not found above the second gorge and the density of long-finned eels in the upper section decreased to a quarter of the density at which they occurred in the middle section. Jellyman (1977) reported that in large river systems some eel elvers may take several years to migrate upstream to adult habitats, and that their ability to climb declined after they had grown to a length of 12 cm. In the Mohaka system the size of long-finned eels increased with distance upstream; there was a distinct increase in size from the middle to upper sections. Apart from the 40-60-cm length class of longfins, a small, but representative, selection of all length classes was sampled from the upper section. However, a comparatively large proportion of longfins in the 40-60-cm length class was found in the middle section. The accumulation of 40-60-cm-long longfins in the middle section may have resulted from the rapid early growth of these eels which reduced their upstream migration chances at obstacles such as rapids. Therefore the nature and situation of the second gorge in the Mohaka River and the

size of eels before they arrive at this gorge, may be all that causes a decline in eel densities from the middle to the upper section. A series of dams constructed in the Mohaka could stop eels migrating into the system above the dams, and only those eels less than 12 cm would stand a good chance of climbing a dam. A further migration check would occur for eels which increased in length between dams or other migratory obstacles.

A recreational eel fishery occurs in the Mohaka (L.W. Spooner pers. comm.), but its extent and the existence of a commercial fishery are not known. To establish the importance of eels in the Mohaka, other than perhaps their role in maintaining a balanced trout population, eel fisheries in the Mohaka will need to be investigated in detail. The importance of other fisheries such as kahawai and whitebait will also need to be investigated. The whitebait fishery will be of particular concern if the main species in the catch is koaro, because dams constructed in the Mohaka between the sea and middle section could prevent koaro whitebait from reaching their adult habitat. Such an impact on the life cycle of koaro would eventually exclude it from the system unless a lake population became established, but this would not support a fishery in the Mohaka's estuary.

If the Mohaka's whitebait fishery is based on inanga, the other galaxiid found in the Mohaka, its ecology in this system would need to be investigated (only six inanga were caught in the present survey).

The data base provided by the Mohaka fisheries survey has resulted in some appreciation of how this river fishery functions. From this information, areas requiring further investigation have been identified. Some of the possible impacts of hydro development on the fishery have

been discussed, but a more detailed assessment is dependent on knowledge of specific development proposals.

6. RECOMMENDATIONS

The following recommendations are for the working party which may be formed to decide on further fisheries investigations related to impact assessment of hydro-electric developments on fish in the Mohaka River. Work which should be ongoing if development proposals are imminent are prefixed by an A. Work which is dependent on knowledge of a specific development proposal is prefixed by a B.

- A1 Determine the presence and level (or potential) of commercial, recreational, or Maori fisheries present in the Mohaka. Identification of these fisheries is an important prerequisite to any further work because it will enable both fisheries managers and developers to allow for them in future investigations and proposals.
- A2 Sample, by drift diving and netting, large pools and deep water areas of the Mohaka system. These areas could not be sampled during the 1983 survey, but constitute a large proportion of the river system and are therefore likely to provide significant habitat for several fish species. Results from such an exercise should identify the species, size composition, distribution, and density of fish occupying this type of habitat in the Mohaka.
- B3 Investigate the movement of trout in the Mohaka system. Results should identify which movements occur (for example, spawning, feeding, recruitment of juveniles, sea-run fish) and examine

differences between the two species. Such an investigation would be a major undertaking, but its extent would depend on the sites proposed for hydro-electric development.

- B4 Determine density and size distribution of eels, particularly in trout waters, so that if dams are built the need for eel passes can be assessed.
- B5 Whichever galaxiid(s) is(are) significant in the whitebait catch (identified by 1 above), further investigation of adult distribution and important habitat areas will be required to evaluate the effect that dams would have on the Mohaka's whitebait fishery.

ACKNOWLEDGMENTS

The initial preparation and running of the survey was largely the responsibility of Errol Cudby. Assistance with the survey was received from: Jody Richardson and Roger Ashworth (FRD), Mr W. Spooner (Hawke's Bay Acclimatisation Society), and Messrs Ewing, Gibbs, Nissen, McLay, Richmond, and Marsh of the Department of Internal Affairs. A Lakeland Helicopters Ltd's "Bell Jetranger", piloted by Toby Clark, was used for this exercise and financed by MWD. Ground support, landowner liaison, and access checking was also provided by MWD. Dale Hyde of MWD was responsible for these tasks. Accommodation, and hospitality beyond the call of duty, was provided by Jack and Dot Clarke of the Rangitaiki Lodge. Philip Kirk from the Department of Internal Affairs assisted with the processing of fish at the Turangi laboratory. Carol Whaitiri and Jan Gregan typed and assembled the draft manuscript. Comments and

advice on the draft manuscript were given by Don Jellyman, David Rowe, and Laurel Teirney. I thank all those mentioned for their help towards production of this report.

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APPENDIX I. Sample site map references.

Sample Site No.	Map Reference	Name of Stream
1	N113 688958	Tikitiki/Kaipō
2	N113 673852	Oamaru
3	N113 728907	Kaipō/Oamaru
4	N113 791906	Otupua
5	N113 788821	Mangatainoka
6	N113 844797	Mangatainoka
7	N113 822749	Makino
8	N113 856783	Makino
9	N113 831973	Ripia
10	N113 862943	Tunamaro
11	N113 876931	Mokoro
12	N113 886869	Mangakiokio
13	N114 966775	Kowaro
13A	N114 965774	Ripia
14	N114 973839	Toropapa
15	N114 013751	Puneketoro
16	N114 054749	Inangatahi
17	N104 024095	Matakuhia
18	N104 117095	Pukahanui (Right branch)
19	N104 189059	Hautapu (Left channel)
20A	N114 192959	Mangakurupatu
20	N114 142967	Poamoko
21	N104 159184	Te Hoe (Upper)
22	N104 205175	Te Hoe trib. (Bull Ring)
23	N103 735098	Taharua
24	N113 758905	Taharua
25	N114 932718	Anawhenua
26	N124 014655	Inangatahi
27	N114 005858	Omarowa
28	N114 022923	Stoney
29	N114 031933	Mokomokonui
30	N114 030901	Waione
31	N104 979015	Okoeke
32	N104 942064	Waiarua
33	N114 066975	Matakuhia (Mth)
34	N114 089998	Mokomokoma
35	N114 143872	(Not sampled - dried up)
36	N114 162918	-
37	N114 119837	Rangiwhakaharoa
38	N114 250970	Te Hoe
39	N104 215015	Hautapu (Side channel)
40	N104 236025	(Not sampled - inaccessible)
41	N104 252085	Mangahouanga (Hook)
42	N104 240119	Te Hoe tributary
42A	N104 243112	Te Hoe
43	N114 318982	(Not sampled - inaccessible)
44	N115 443996	(Not sampled - inaccessible)
45	N115 483939	Kakariki
46	N115 523943	Mangawharangi
47	N115 568879	Mangapikopiko
48	N115 541892	Mangaporo
49	N115 586840	Coquet
49A	N115 586841	Mohaka
50	N104 101133	Pukahanui tributary

51	N104	985193	Harakeatanemate
51A	N104	975088	Waipunga tributary
52	N114	957823	Whakahu
53	N123	898689	Makahu
54	N114	017812	Omarowa
55	N114	991869	Omarowa
56	N114	095789	Mimiha tributary
57	N114	138888	Mangakara
58	N114	031992	Otawhiri
59	N114	123864	Waipunga
60	N114	094818	Mohaka
61	N113	794878	Otupua
62	N113	813837	Mangatanguru
63	N113	866871	Ripia tributary
64	N114	917816	(Not sampled - inaccessible)
65	N115	482942	(Not sampled - dried up)
66	N103	812031	Ripia
67	N114	906754	Mangatutunui
68	N113	716857	Mangapapa
69	N113	750819	Mangatainoka
70	N114	090883	(Not sampled - inaccessible)
71	N113	870734	(Not sampled - inaccessible)
72	N115	598829	Mohaka
73	N115	596858	Mohaka
74	N115	528925	Mohaka
75	N115	374986	Mohaka
76	N114	268939	Mohaka

APPENDIX II. Habitat data sheet

MOHAKA RIVER SURVEY

STATION NO. _____ DATE _____ TIME _____ OBSERVER _____

FISHING METHOD & TECHNIQUE _____ VOLTAGE _____ DISTANCE _____

TEMP. _____ °C pH _____ BENTHIC SAMPLES YES/NO WATER SAMPLES YES/NO

WATER CLARITY Clear Opaque Turbid

GRADIENT (/100m) _____ POOLS/100m _____ POOL LENGTH _____

WIDTH _____

BANKFULL WIDTH _____

THALWEG DEPTH: Riffle _____ Run _____ Torrent _____ Pool _____

SUBSTRATE (% in reach sampled)

Silt (0.06mm) Sand (<2mm) Gravel (<64mm) Rubble (<256mm) Boulder (>256mm) Bedrock

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COVER (% in reach sampled)

Deep water Rubble O'hang bank-veg Submerged logs Boulders White water

--	--	--	--	--	--

small
large

MACROPHYTES (% coverage of bottom)

0 1-25 26-50 51-75 76-100

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DIATOMS/ALGAE (% coverage of bottom)

0 1-25 26-50 51-75 76-100

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DISCHARGE _____

Distance (m) _____

Depth (cm) _____

Head (mm) _____

or Seconds _____

COMMENT _____

AERIAL DATUM _____



ORIGINALS

