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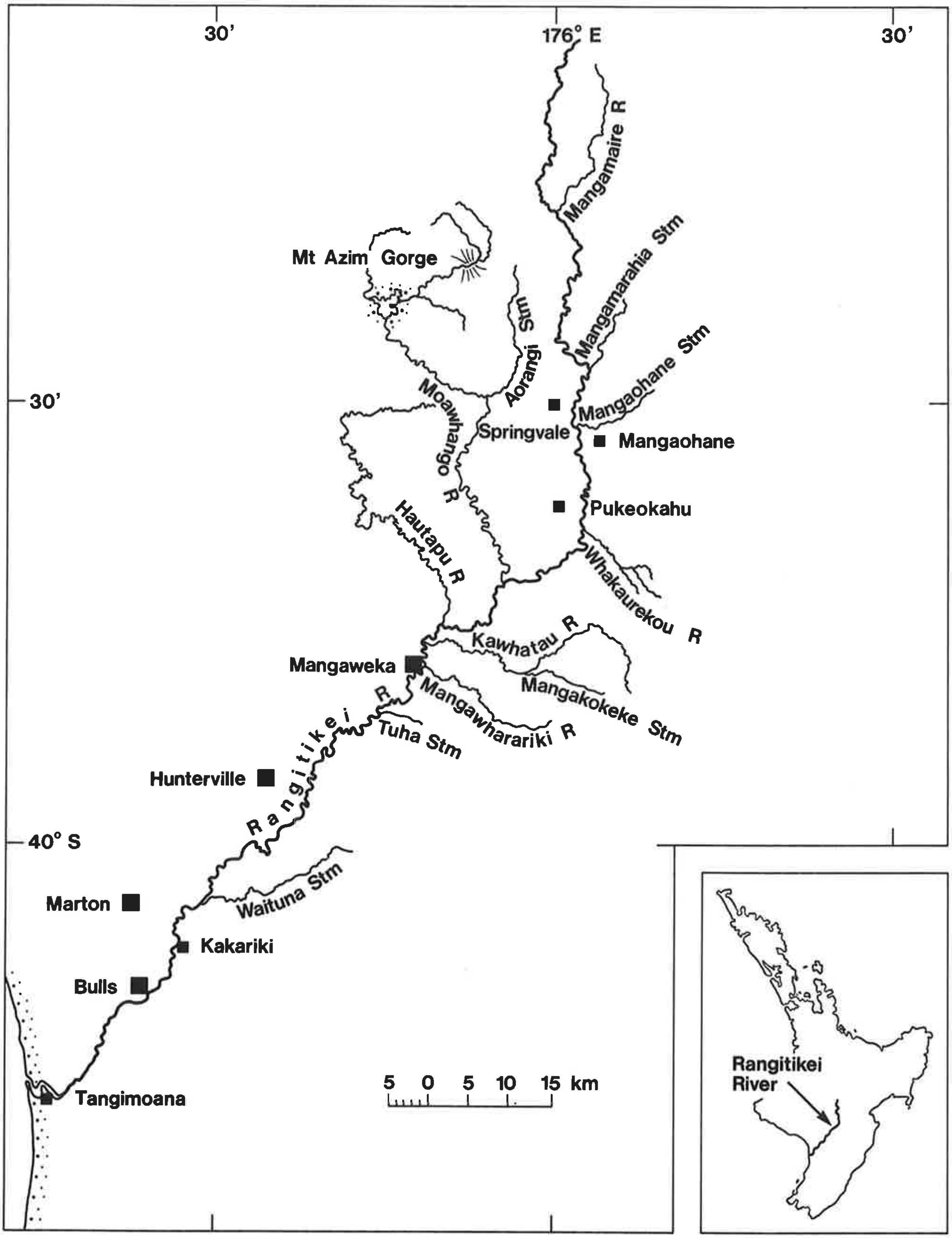

Fig. 1: The Rangitikei River, North Island, New Zealand.

Introduction

In 1978 local electrical supply authorities identified more than 30 potential hydro-electric schemes on New Zealand rivers. The study of the fish and fisheries of the Rangitikei River was prompted by this and by a prefeasibility study of hydro-electric schemes on the Rangitikei (Tonkin and Taylor 1978). The Rangitikei is highly valued by Wellington Acclimatisation Society (WAS) anglers because of its self-supporting brown and rainbow trout fisheries (Graynoth 1974a, 1974b, Teirney, Unwin, Rowe, McDowall, and Graynoth 1982, Richardson, Teirney, and Unwin 1984). Development of hydro schemes on the Rangitikei was not imminent in 1979 when Fisheries Research Division (FRD), Ministry of Agriculture and Fisheries and WAS began an extensive investigation of the fish and fisheries of the river.

The general effects of hydro-electric developments on rivers and their biota are well known (Trotzky and Gregory 1974, Efford 1975, Ruggles and Watt 1975). However, to determine the effects on fish in a specific river it is necessary to know the fish stocks and their seasonal variation and how their life history requirements, such as spawning migrations, are met. The amount and patterns of angler use must be determined to evaluate the impact of development on the fisheries. Analysis of the effects of hydro-electric development on the fish and fisheries was given by Hicks (1985), and results of drift diving investigations into seasonal abundance of trout stocks were reported by Hicks and Watson (1985). Although time was not critical, the aims of this study were limited by a shortage of resources to the following:

1. To assess the distribution and seasonal abundance of brown and rainbow trout stocks;
2. To establish where brown and rainbow trout spawn;
3. To measure average fish size, catch rate, and distribution of fishing effort;
4. To review and summarise the knowledge of native fish stocks and fisheries.

Physical characteristics

The Rangitikei River is 240 km long and flows south-west from the centre of the North Island to the Tasman Sea (Fig. 1). It has four main tributaries, the Kawhatau, Hautapu, Moawhango, and Whakaurekou Rivers, and drains a catchment area of about 4000 km^2. It has a mean annual flow of 80 m^3/s at the mouth, which makes it the sixth largest river in the North Island (Tonkin and Taylor 1980). For ease of description the river was divided into five sections delimited by tributaries (Table 1).

The main channel becomes less steep from the source to the sea, and the surrounding vegetation changes from tussock grassland and beech forest to pasture and crops. Tributary streams are steep in the headwaters and upper middle section and become progressively less so towards the sea. In the headwaters most tributaries join the main channel without creating a barrier to up-stream trout movement. However, in the upper middle, central, and lower middle sections small tributaries characteristically join the main channel by flowing over high cliffs, or have waterfalls not far up stream from their confluence with the main channel. The four main tributaries, which flow into the central section, all join the main channel without creating a barrier to up-stream trout migrations. Many lower middle and lower section tributaries are dry in summer.

Water quality

Water quality is high in the headwaters, but gradually deteriorates as the river flows down stream because of waste discharges and input from tributaries draining farmland. Conductivity, pH fluctuations, temperature, and suspended solids all increase from the source to the sea (Tonkin and Taylor 1980). Suspended sediment enters the main channel from subcatchments, and much of the load at Mangaweka comes from streams and rivers draining the steep headwaters of the Ruahine Range (Tonkin and Taylor 1980). Suspended sediment in the main channel increased in concentration down stream of the Whakaurekou River between 1979 and 1981, and below this point the Rangitikei was frequently turbid, even under normal flow conditions. However, the Whakaurekou appears to have had a lower suspended sediment concentration since 1983 (M. Rodway pers. comm.).

The major uses of the Rangitikei River system include instream recreational activities, abstraction for consumption, and waste disposal (Tonkin and Taylor 1980).

TABLE 1: Physical characteristics of the five sections of the Rangitikei River and its catchment

Section	Length (km)	Main channel gradient (m/km)	Mean annual flow (m³/s)	No. of tributaries ⩾ 5 km long	Mean gradient of tributaries (m/km)	Range of tributary gradients (m/km)	Predominant land use or vegetation	River bed composition
Headwaters (source to Mangamarahia Stream)	66	9	-*	9	53	21–115	Tussock, scrub, and beech forest	Greywacke outcrops, boulders, and gravel
Upper middle (Mangamarahia Stream to Whakaurekou River)	26	6	20	8	54	33–85	Grazing; scrub and beech forest	Limestone, sandstone, and greywacke outcrops, gravel, and boulders
Central (Whakaurekou River to Tuha Stream)	59	4	62	11	44	8–95	Grazing; patches of scrub and beech forest	Sandstone and siltstone cliffs, greywacke outcrops, and gravel
Lower middle (Tuha Stream to Waituna Stream)	53	2	-	7	32	13–51	Grazing and cropping	Sandstone and siltstone cliffs and gravel
Lower (Waituna Stream to sea)	46	2	75	7	9	5–16	Grazing and cropping	Sandstone and siltstone cliffs and gravel

* Unknown.

Salmonid species and their fisheries

Introduction

Salmonids and other fish species found in the Rangitikei River are listed in Appendix 1. Brown trout and brook char were first released into the Rangitikei and its tributaries in 1886; rainbow trout in 1899. In the initial phase of establishment, further releases of these species were made intermittently until 1907 (Table 2). Brown and rainbow trout were thought to have been established by 1907 or earlier; however, stocking was continued until 1969 when Pike (1970, 1972b) confirmed that stocking was ineffective, as Hobbs (1948) had found, because few hatchery-reared fish were caught by anglers.

Brook char became established in the headwaters of the Moawhango River above Mt Azim Gorge, and 100 of these fish were caught by electric fishing in 1972 and transferred to Aorangi Stream (Pike 1972a, Turner n.d.), where dense populations were seen recently (M. Rodway pers. comm.).

Methods

Trout distribution and abundance

Trout less than about 6 cm fork length (FL) (from the tip of the nose to the caudal fork) were caught by electric fishing, which was done with a standard unit (Burnet 1967). In the middle and lower sections where vehicle access was possible a mains set was used in a single-anode, earth-return configuration. In the headwaters where access was possible only by helicopter a battery-powered portable backpack shocker was used. Only a single pass was made; so all fish present were probably not caught. Distances fished usually varied between 20 and 200 m; where there were fewer fish a longer distance was fished. Sites where the water was more than about 4 m wide and 0.6 m deep were fished at the margins only, in a transect 2 m wide, parallel to the margin.

Thirty sites in the main river and its tributaries were fished between April 1979 and February 1981 (Fig. 2).

During previous surveys between 1961 and 1972, eight sites in the Moawhango River were fished by N.Z. Marine Department staff (New Zealand freshwater fish survey data base, FRD, Wellington), and data from these have been added to the data from this survey. The number of sites fished was too small to adequately describe fish distributions in the Rangitikei River catchment.

The abundance of trout greater than about 6 cm FL was assessed by drift diving. This was done at 10 sites in the headwaters and middle section between April 1979 and May 1980 (Fig. 3, Table 3) by use of methods described by Hicks and Watson (1985). Six middle section sites were dived at 2- to 4-month intervals during this study, but access and visibility prevented regular diving at other sites, and site 10 was abandoned because of poor underwater visibility.

Trout counted during drift diving were visually grouped into the following approximate size classes: fingerling (6–12 cm FL), small (12–23 cm FL), medium (23–38 cm FL), or large fish (over 38 cm FL). The dimensions of the sites were determined from aerial photographs taken between 1974 and 1980. No major changes in river channel morphology were evident when aerial photographs were compared with the sites at the time of diving.

Spawning and migrations

In the investigation of potential spawning tributaries it was assumed that streams shown as less than 5 km long on NZMS 1 Topographical Map series maps (scale 1 : 63 360) would not support trout spawning, and so they were excluded from the spawning analysis. This was because many tributaries less than 5 km in the lower section were ephemeral, and short middle section tributaries dropped into the main river over high waterfalls. However, it is not clear whether this assumption applies to headwater tributaries, most of which do not flow over waterfalls into the main channel. Some headwater tributaries less than 5 km long flowed in summer when small middle and lower section tributaries were dry, but the steep, cascading nature of small headwater tributaries, and their bed composition of cobbles and boulders with very little gravel, meant there was little likelihood of spawning.

The other tributaries shown on the maps were inspected on foot or from the air to see if they allowed access to adult trout migrating up stream from the main channel, how suitable the bed was for spawning (including whether there was obvious sediment deposition), and whether they were dry. If small tributaries contained water when they were inspected, local residents were asked if the stream stopped flowing at any time. Tributaries were ranked for their estimated spawning potential on the following scale:

TABLE 2: Liberations of fry and fingerling brown trout, rainbow trout, and brook char into the Rangitikei River system recorded in Wellington Acclimatisation Society (WAS) and Hawke's Bay Acclimatisation Society (HBAS) annual reports from 1887 to 1907

Date	Brown trout	Rainbow trout	Brook char	Comment	Source
1886	1 530		2 000	First recorded release	WAS 1887
1887	50*				WAS 1888
1888–89	9 492†		7 000†		WAS 1890
1890	10 000†		5 000†		WAS 1891
1891	12 500†		5 500†		WAS 1892
1893	11 000†				WAS 1894
1893	720*†				WAS 1894
1894	40 000†			20 000 of these released into Hautapu River	WAS 1895
1895	10 000†				WAS 1896
1897	52 000†				WAS 1898
1898			10 000	Brook char released into a tributary of Moawhango River	HBAS 1898–99
1898	141 500†	2 500†		First release of rainbow trout, 17 500 brown trout released into Hautapu River	WAS 1899
1900	24 000†			"A few rainbows taken in the Hautapu"	WAS 1901
1902	35 000†	45 000			WAS 1903
1903	15 000†	40 000†			WAS 1904
1904	70 000†	12 000† 30*†		Stocking thought to be "very successful" by Marton subcommittee	WAS 1905
1905	32 000†	22 000†		78 fishing licences sold	WAS 1906
1906	40 000†	28 000†		"Efforts to establish rainbow trout have at last been successful", 99 full season licences sold in district	WAS 1907

* Yearlings.
† Distributed to the Rangitikei district fisheries managers, though the proportion released into the Rangitikei system is not known.

5. Ideal spawning conditions: flow regime apparently stable; substrate highly suitable; no barriers to up-stream movement of adult trout; redds seen; high density of juvenile trout.
4. Good spawning conditions: flow regime apparently moderately stable; good substrate; no barriers to up-stream trout movement; redds seen; some juvenile trout seen.
3. Mediocre spawning conditions: flow regime unstable; substrate poor, but some spawning potential; no barriers to up-stream trout movement; few, if any, juvenile trout.
2. Poor spawning conditions: stream ephemeral, but flowing when seen; water quality poor; significant sediment load; substrate poor, but some spawning potential; no barriers to up-stream trout movement.
1. Spawning possible, but unlikely to be successful.
0. No spawning potential for fish from the main channel; barriers to up-stream movement of adult trout.

Biomass

The average weight of trout in the size classes seen during drift diving was estimated from fish caught by seine netting, angling, and trapping. Seine netting was done at sites 4, 5, 6, 7, and 10 between 24 and 27 February 1981 by use of 70-mm-mesh multifilament nets 2 m deep and 20 m long. Fish were also caught by angling at the above sites in February 1981, and they were trapped in the Mangakokeke Stream ("Phyns Creek") from 1 June to 5 July 1979.

Biomass estimates were derived from results from these drift diving surveys and those reported by Hicks and Watson (1985). Ninety-five percent confidence limits (CL) were calculated from the mean weights by use of Student's t-test (Sokal and Rohlf 1981). The errors in population estimates were not taken into account.

Angler use

Patterns of angler use and catch data were determined from angler diaries, creel surveys, and reports of fishing trips. An angler diary scheme was run throughout the WAS district during this study. Diary forms were issued at the beginning of the fishing season (1 October) and were collected at the end of the season (30 April) in 1978, 1979, and 1980. The diary scheme and creel surveys were used to establish catch rate, fish size, distribution of angling effort, and method of fishing. Only 11 of 200 diaries sent out by WAS were returned with information about the Rangitikei. However, creel surveys of anglers fishing the main channel between Springvale and the mouth in 1980 and 1981

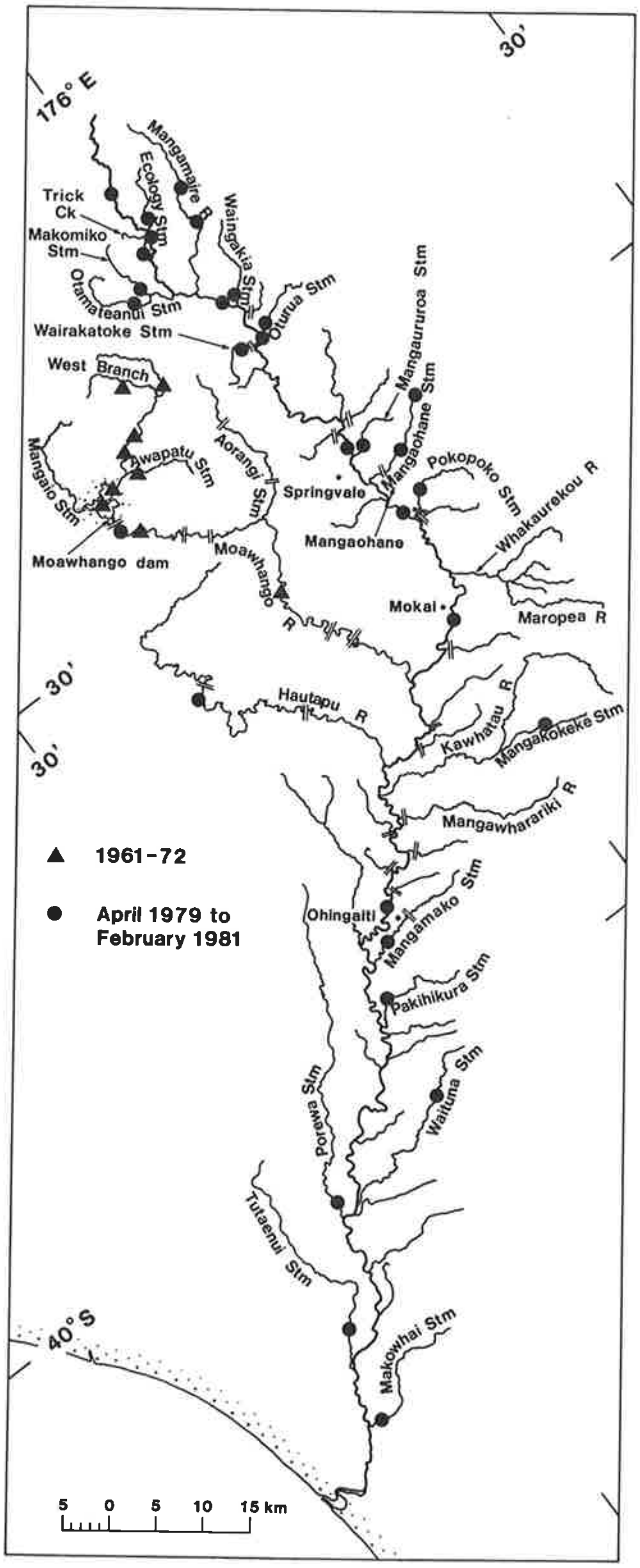

Fig. 2: Electric fishing sites in the Rangitikei River and its tributaries.

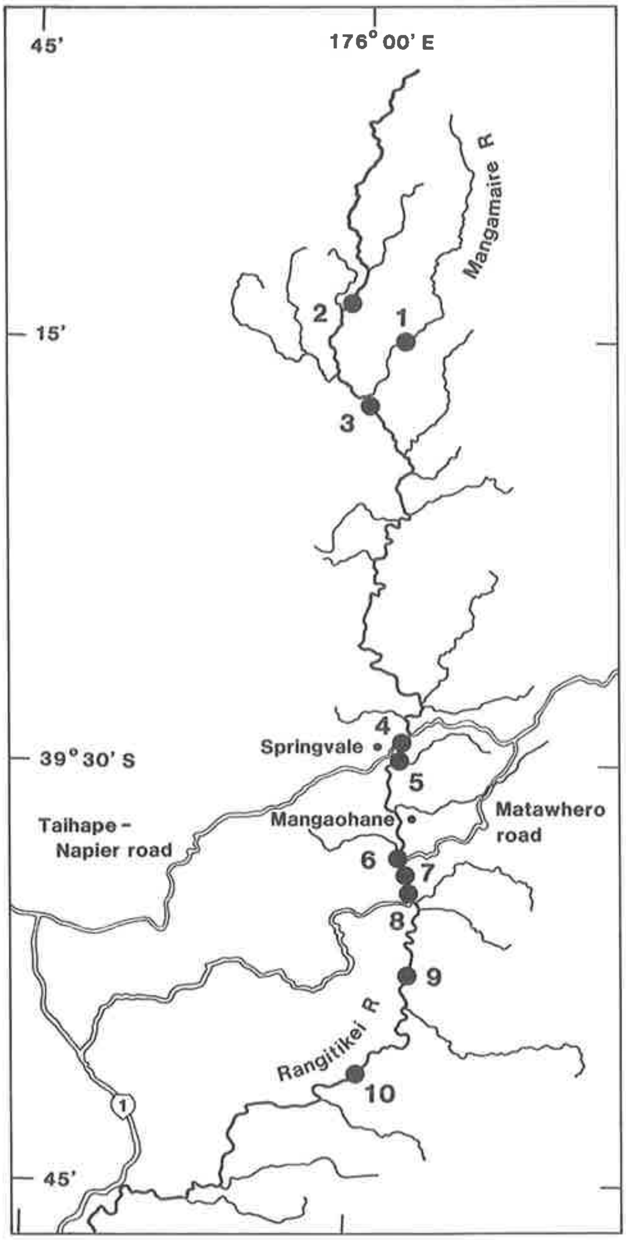

Fig. 3: Drift dive sites in the Rangitikei River and its tributaries.

were more successful; in the middle and lower sections, 114 and 183 anglers, respectively, were interviewed.

Catch data from the headwaters were taken from netting and angling surveys between 1970 and 1975 and from diary records from anglers who visited the area between 1976 and 1981. Catch rates were calculated from the number of fish caught per hour, which included takable-sized fish which were caught and returned. Undersized fish caught were not included in calculation of catch rates.

Fish length was recorded as fork length, and in some instances weights were also recorded. Condition factors were calculated for fish for which both weight and length measurements were taken. The formula $K = AW/L^3$ was used, where K is condition factor, W is weight in grams, L is fork length in centimetres, and A is an arbitrary constant (10^4) to give a convenient result of about 110 (Allen 1951).

Data on which assessment of angler use and catch was based have the limitation that most were collected during December, January, and February. Although fishing pressure was likely to have been greatest at this time, angling at other times of the year was not adequately assessed. In addition, few angler diaries were returned, and data from these were likely to be biased because of the higher catch rates achieved by the more experienced anglers, who tend to return diaries (Graynoth 1974b). Fishing regulations also varied between administrative areas; fish which could be kept in one area had to be returned in another (Table 4). The headwaters catch rates were based on data from too few anglers for the rates to be reliable, but they were used for comparison with angling use on the rest of the river.

Results

Distribution

The distribution and abundance of fish sampled by electric fishing are given in Appendix 2. Salmonids are widely distributed in the Rangitikei River system (Fig. 4). Data from anglers' records, previous surveys (Graynoth 1974a, Cudby 1978, Turner n.d., M. Rodway pers. comm.), and this survey show that rainbow trout occur in the main channel, from the headwaters to the lower section, in middle section tributaries (for example, the Kawhatau, Moawhango, Whakaurekou, and Maropea Rivers and the Pokopoko and Mangaohane Streams), and in most headwater tributaries.

Brown trout occur in the main channel from its confluence with the Mangamaire River to the lower section. They also occur in the Moawhango, Hautapu, and Kawhatau Rivers, and there is a sparse population in the MangawhararIki River (Graynoth 1974a, Cudby 1978, T. Kroos pers. comm.).

Brook char occur only in the headwaters of the Moawhango River (Turner n.d.). Adult quinnat salmon have occasionally been caught by anglers, and carcasses have also been found (Anon. 1933, Hicks and Watson 1983). A quinnat salmon fingerling was found at Springvale in 1981 (Hicks and Watson 1983).

TABLE 3: Details of drift diving sites in the Rangitikei River from April 1979 to May 1980

				Dates dived					
Site	Length (m)	Mean width (m)	Area (ha)	Apr 1979	Jun 1979	Jul 1979	Oct 1979	Jan 1980	May 1980
1	1 700	13	2.14			✓			
2	1 590	26	4.13			✓			
3	2 270	24	5.51			✓			
4	1 670	32	5.37	✓	✓		✓	✓	✓
5	2 010	40	7.97	✓*	✓		✓	✓	✓
6	1 890	32	6.14	✓†	✓		✓	✓	✓
7	1 510	31	4.75	✓	✓‡		✓	✓	✓
8	1 600	16	2.50	✓			✓	✓	
9	1 100	34	3.70	✓	✓		✓	✓	✓
	15 340		42.21						

* Length (1 330 m) and area (5.69 ha) dived.
† Length (1 280 m) and area (4.39 ha) dived.
‡ Length (1 340 m) and area (4.42 ha) dived.

TABLE 4: Comparison of fishing regulations applying to the Rangitikei River in the Wellington and Hawke's Bay Acclimatisation Society districts and Central North Island Wildlife Conservancy (CNIWC)

District	Daily bag limit	Size restriction (cm)	Open season	Methods allowed	Hours when fishing is prohibited
Wellington	12	22	1 Oct to 30 Apr above Mangaohane bridge; river below Mangaohane bridge open all year	Artificial fly, spinner, all legal natural baits	None
Hawke's Bay	8	30	1 Oct to 30 Apr	Artificial fly, spinner, all legal natural baits	None
CNIWC	8	35	1 Oct to 30 Jun	Artificial fly, spinner, natural fly	Midnight to 5 a.m.

Where brown and rainbow trout had equal access to headwaters, rainbow trout occupied the most up-stream sites; where rainbow trout and brook char had equal access, brook char occupied the most up-stream sites.

Abundance

The populations of salmonids were usually sparse, but numerous brown trout (up to 100 per 100 m²) less than about 12 cm FL were found during electric fishing in side channels at Springvale during summer. Brook char were abundant (up to 97 per 100 m²) in a tributary of West Branch, Moawhango River. Drift diving showed seasonal fluctuations in numbers of brown and rainbow trout over about 6 cm FL in the middle section (Hicks and Watson 1985). In the headwaters the abundance of rainbow trout over 12 cm FL varied between 11 and 23 fish per kilometre (most (69%) were over 38 cm FL); brown trout (2 per kilometre) were seen at the most down-stream site only (Table 5). These densities were low in terms of fish per 100 m². Abundance in the headwaters increased down stream from sites 1 to 3.

Biomass of trout

Although brown trout were caught in similar proportions to the numbers seen during drift diving, more medium rainbow trout were seen in the middle section than were caught (Fig. 5). No small brown trout were caught. Of 56 trout caught by netting and angling in the headwaters from 1971 to 1981 for which individual weights were recorded, 55 were rainbow trout, and all fish were large. The mean weights of trout caught in the middle section and the headwaters are shown in Table 6. There was no significant difference between the weights of large brown and rainbow trout from the middle section (*t*-test, 95% CL), or between medium brown and rainbow trout. However, there were significant differences between the weights of large rainbow trout in the headwaters and large rainbow and brown trout in the middle section and between the size classes of each species.

The biomass of trout was calculated by use of the mean weights from the density of trout seen during drift diving and by substituting the mean weight of small rainbow trout for brown trout of the same size (Table 7). Large fish accounted for more than 80% of the total biomass of brown and rainbow trout.

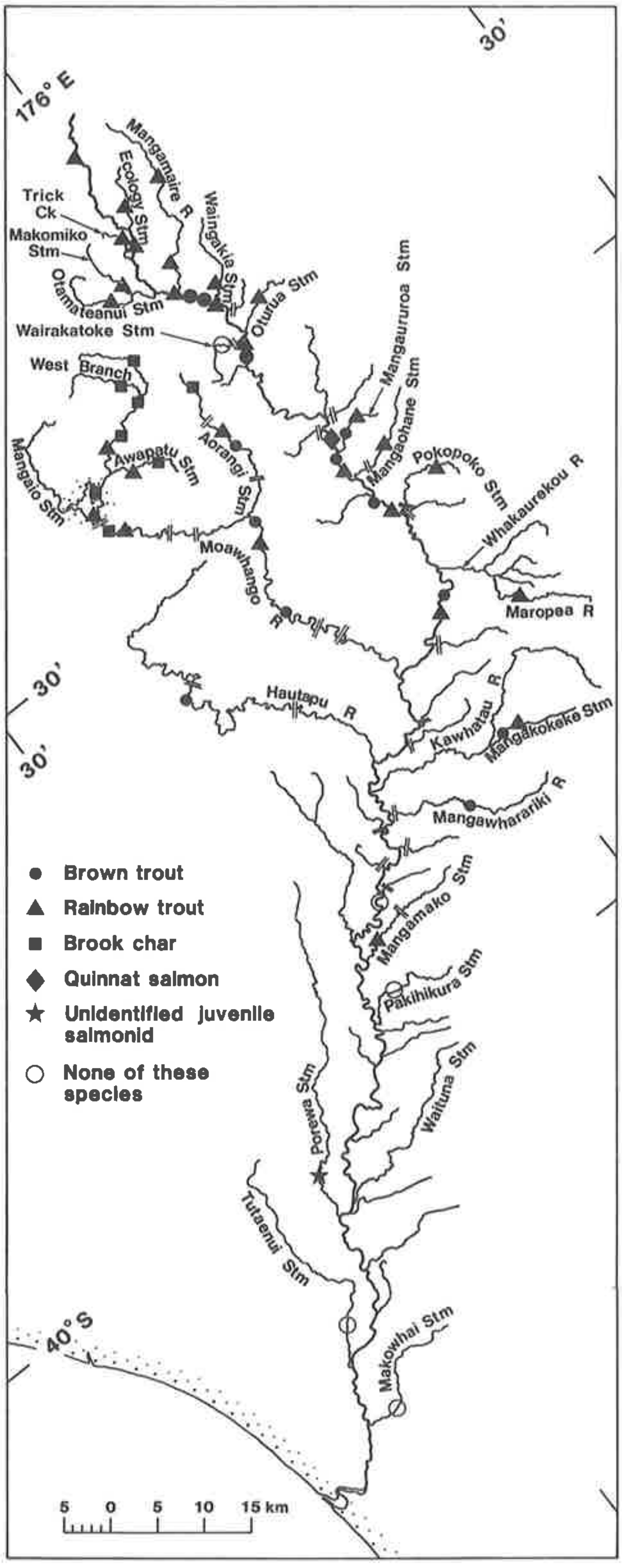

Fig. 4: Distribution of salmonids in the Rangitikei River and its tributaries from electric fishing and drift dive surveys.

Fingerlings were seen only in January 1980, when densities of 64–147 fish per kilometre occurred at sites 4, 5, 6, 7, and 9 (Hicks and Watson 1985). If these fish were assumed to have a mean length of 9–10 cm FL, their mean weight would have been about 15 g (Allen 1951), and their biomass would have been about 0.3–0.7 kg/ha. As the biomass of fingerlings was less than the variation in mean weight, their contribution to total fish biomass was disregarded.

The biomass estimates had different patterns of variation for brown and rainbow trout. The biomass of rainbow trout showed pronounced seasonal differences, which were largely independent of site. A two-way analysis of variance (Sokal and Rohlf 1981) of rainbow trout biomass at sites 4, 5, 6, 7, and 9 showed that this seasonal variation was highly significant (*F*-value significant at the 99% level). However, variation of brown trout biomass at the same sites was less attributable to season and more attributable to site than rainbow trout

TABLE 5: Density of rainbow and brown trout longer than about 12 cm FL seen during drift diving in the headwaters of the Rangitikei River (sites 1, 2, and 3) in July 1979

	Trout density (fish per kilometre)					
	Rainbow			Brown		
Site	L*	M†	S‡	L	M	S
1	8.2	2.9	0	0	0	0
2	13.8	2.5	1.9	0	0	0
3	15.0	7.9	0.4	2.2	0	0

* Large fish (> 38 cm FL).
† Medium fish (23–38 cm FL).
‡ Small fish (12–23 cm FL).

TABLE 6: Mean weights of three size classes of brown and rainbow trout from trapping, netting, and angler catch data

	Mean weight (g)	Standard deviation	Confidence limits (95%)	No. of fish
Headwaters:				
Rainbow				
L*	2 975	897	358	55
Middle section:				
Rainbow				
L	1 536	759	435	14
M†	455	227	163	10
S‡	108	30	48	4
Brown				
L	1 920	631	249	27
M	300	123	153	5
S	0	0	0	0

* Large fish (> 38 cm FL).
† Medium fish (23–38 cm FL).
‡ Small fish (12–23 cm FL).

biomass (*F*-value significant at the 99% level). Rainbow trout biomass was highest in January and April at all sites. Brown trout biomass was highest at sites 4 and 6, especially in May and June.

Spawning and migrations

Trout spawning areas in the Rangitikei and its tributaries are shown in Fig. 6. The occurrence of fry and fingerlings showed that rainbow trout spawn in headwater tributaries and brown trout spawn in the main channel in the upper middle section. Rainbow trout also probably spawn in the upper middle section. The spawning potential of the mainstem and its tributaries is compared with evidence of actual spawning (Appendix 3). Most headwater streams allow adult trout access from the main channel, whereas few middle section tributaries do; the Whakaurekou and Kawhatau Rivers are notable exceptions. Although many lower section tributaries allow adult trout better access than do middle section tributaries, they are dry for part, if not most, of the year.

Fluctuations in numbers, species, and sizes of trout seen during drift diving showed that rainbow trout probably migrated to and from the middle section.

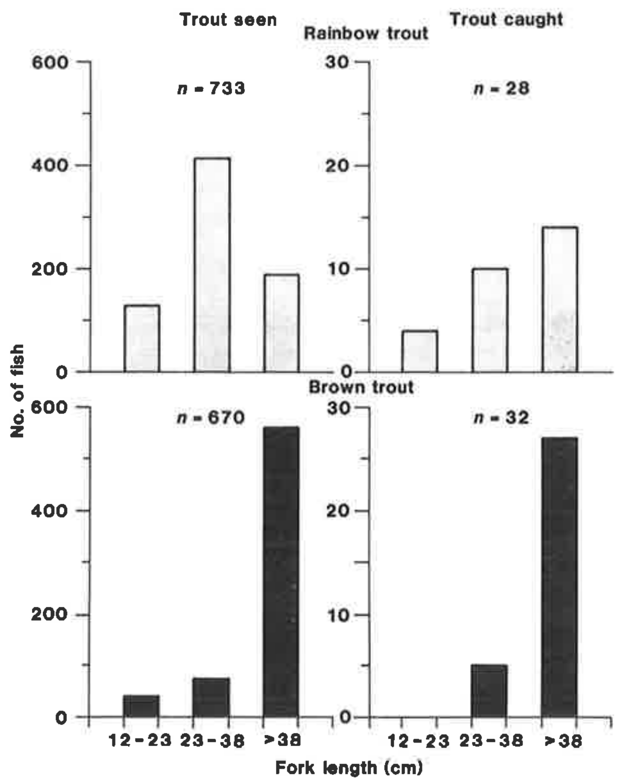

Fig. 5: Length-frequency distributions for brown and rainbow trout seen during drift diving and caught in the middle section of the Rangitikei River.

Angler use

Data from the diaries of 11 anglers who fished the Rangitikei between 1978 and 1981 were compared with the results of the national angler diary scheme between 1947 and 1968 (Table 8). There was no evidence of a consistent change in catch rate or fish size from 1947 to 1981. However, the proportion of undersized fish in the catch fluctuated from 0% to 29%, and the proportion of rainbow trout fluctuated between 38% and 93%. Both proportions fluctuated less between 1978 and 1981, but the results from the two periods of low angler activity (1957–58 and 1967–68) may not have been representative.

Catch data from the headwaters of the Rangitikei are based on 1 brown trout and 166 rainbow trout caught between 1970 and 1981 (Table 9). Although mean weight, mean length, and mean condition factor of fish fluctuated from year to year, there was no significant difference between those samples for which means and standard deviations were available (*t*-test, 95% CL). The mean weight of all rainbow trout from the headwaters for which individual weights were available was 2980 g ($n = 55$, s.d. = 900 g), the mean length was 59.9 cm FL ($n = 45$, s.d. = 6.1 cm), and the mean condition factor was 132 ($n = 45$, s.d. = 19).

Results of the analysis of angler diaries and creel surveys from the middle and lower sections are compared in Table 10. The angler diary and creel survey results both showed that brown trout were larger than rainbow trout in the middle and lower sections. Length-frequency distributions for brown and rainbow trout are shown in Fig. 7. A comparison of the size distribution of rainbow trout found in the lower section during this survey with that found by Parrott (1935) from 1930 to 1934 showed no significant difference (*G*-test, probability greater than 0.5 (Sokal and Rohlf 1981)).

The proportion of the two trout species caught varied in different sections of the river. Rainbow trout, which constituted almost the entire catch in the headwaters, formed 53–60% of the catch in the middle section and 87–92% of the catch in the lower section. The proportion of undersized fish reflected the decrease in size of takable fish between the middle and lower reaches.

Catch rates in the headwaters were based on the results of two surveys in which the catches of four anglers in 8 days' angling were 1.0 and 2.8 fish per day. If an angling day was assumed to vary between 4 and 8 h, catch rates probably varied between 0.70 and 0.13 fish per hour. Creel surveys showed that catch rates in the middle section were much lower (0.06 fish

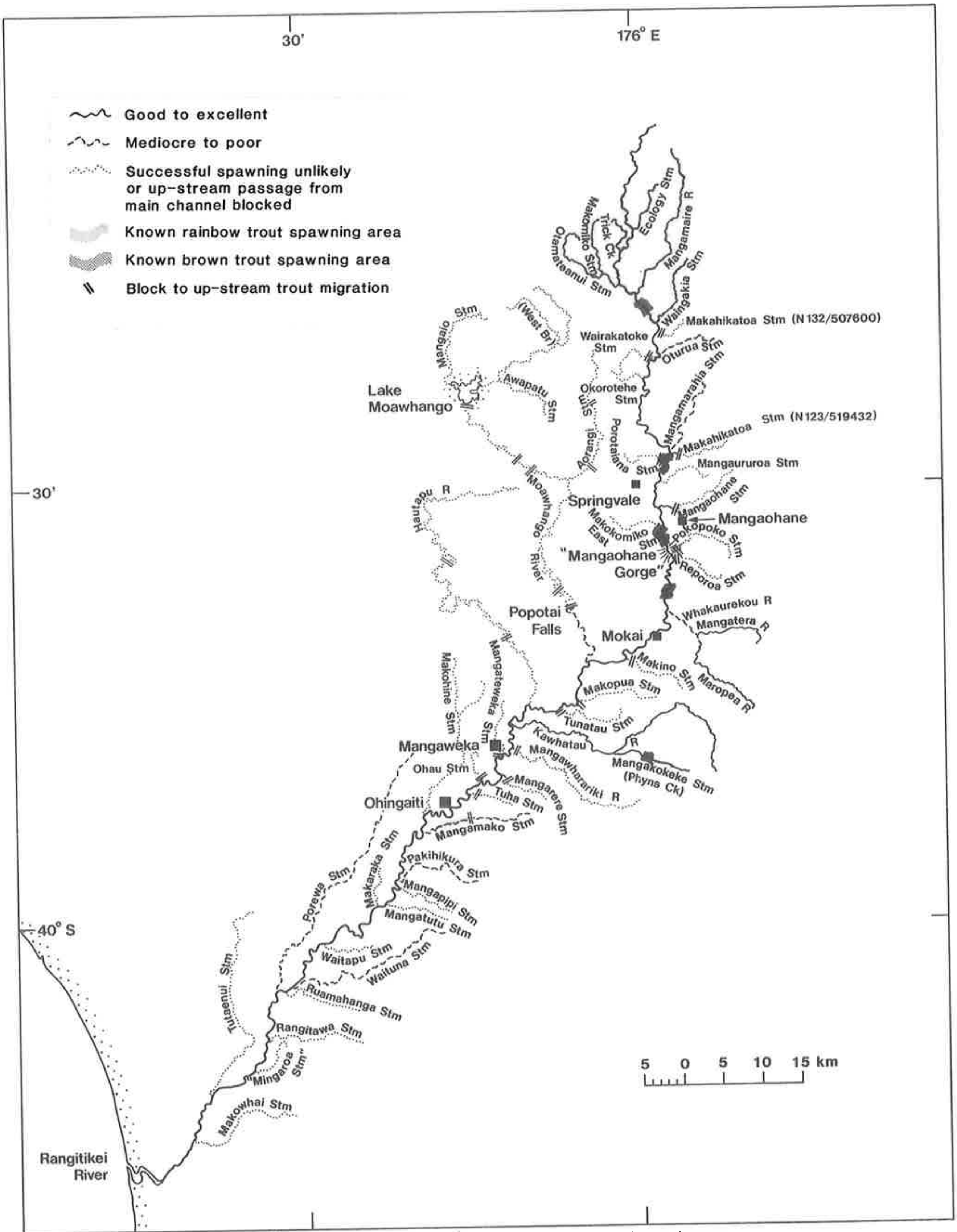

Fig. 6: Trout spawning areas in the Rangitikei River and its tributaries.

TABLE 7: Biomass of brown and rainbow trout longer than about 12 cm FL seen during drift diving at nine sites in the Rangitikei River between April 1979 and May 1980

	Trout biomass (kg/ha)											
	Apr 1979		Jun 1979		Jul 1979		Oct 1979		Jan 1980		May 1980	
Site	Rainbow	Brown	Rainbow	Brown	Rainbow	Brown	Rainbow	Brown	Rainbow	Brown	Rainbow	Brown
1					20.5	0						
2					16.4	0						
3					19.9	1.7						
4	9.9	5.7	1.4	31.6			0.9	4.9	3.9	9.5	3.1	9.2
5	3.6	2.7	1.2	5.5			0.8	3.4	3.4	5.0	0.1	5.7
6	10.8	0.9	1.2	10.6			1.1	6.3	5.9	9.4	1.6	9.7
7	7.6	5.0	0.2	5.7			0.7	5.3	6.5	4.9	2.2	4.5
8	16.6	24.1					1.5	8.5	8.5	8.5		
9	4.6	5.9	0	4.2			0.9	2.6	7.9	4.4	5.5	7.8

TABLE 8: Angling data from diarists who fished the Rangitikei River during 1978–81 compared with 1947–68 data from the national angler diary scheme*

	No. of angler days	No. of hours fished	No. of under-sized fish returned	No. of takable fish returned	No. of takable fish kept	No. of fish measured	Mean length (cm)	Catch rate (fish per hour)	Catch rate (fish per day)	Catch rate (grams per hour)†	% under-sized	% brown trout	% rainbow trout	No. of anglers
National angler diary scheme														
1947–52	198	882	85	14	405	411	41.6	0.48	2.12	415	17	19	81	–‡
1957–58	17	72	0	0	8	8	40.6	0.11	0.47	88	0	62	38	–
1962–63	226	835	68	20	281	281	38.0	0.30	1.12	198	21	21	79	–
1967–68	54	136	1	1	19	19	42.3	0.14	0.35	127	5	54	46	9
This survey														
1978–79	48	138	18	9	41	19	47.7	0.36	1.04	469	26	7	93	2
1979–80	25	77	8	0	21	19	41.1	0.27	0.75	225	29	19	81	3
1980–81	64	257	8	8	32	38	44.0	0.16	0.62	164	17	27	73	6

* Graynoth 1974b.
† A condition factor of 120 is assumed.
‡ Unknown.

per hour), and in the lower reaches they were 0.12 fish per hour. This is probably because only skilled anglers are likely to make the arduous or expensive trip to the headwaters, whereas the middle and lower sections are readily accessible and attract anglers with a range of skills. The higher catch rate of diarists compared with anglers interviewed in the creel survey in the middle and lower sections is also likely to reflect the greater angling skill of diarists. A bias towards skilled anglers has been observed previously in postal angler diary surveys (Graynoth 1974b).

In addition to the number of fish caught per hour, weight of fish caught per hour has also been used to measure catch rate (Allen and Cunningham 1957). In the headwaters, catch rates of 450–2010 g/h were obtained. Creel survey data showed about equal catch rates of 78 g/h for the middle section and 60 g/h for the lower section; however, angler diary data gave much higher catch rates for the middle section. The catch rate in grams per hour varied greatly from 1947 to 1981 and fluctuated between 88 and 469 g/h.

The proportion of days in which an angler caught no takable fish was determined from creel survey data. In the middle section 71% of 114 anglers interviewed had caught nothing, 5% had caught and released under-sized fish, and 24% had caught and kept takable fish. In the lower section 83% of 188 anglers interviewed had caught nothing, 2% had caught and released under-sized fish, and 15% had caught and kept takable fish.

The relative effectiveness and popularity of different angling methods was also determined from creel survey data for the middle and lower sections and from volunteered information for the headwaters. Anglers fishing the headwaters from 1976 to 1981 used dry flies, wet flies, nymphs, and spinners. Method was not surveyed specifically, but was given by anglers for 61 landed fish. Of these, 10 were caught by a combination of dry fly and nymph, 12 by a combination of wet fly

TABLE 9: Length, weight, and catch data for trout caught in the headwaters of the Rangitikei River

	Mean length (cm)	Length range (cm)	Mean weight (g)	Weight range (g)	Mean K*	No. of rainbow trout	No. of brown trout	No. of angling days	No. of anglers	Catch rate (fish per day)
1970–71	59.1 (4.9)†	50.8–68.5	3 060 (101)	1 480–5 570	144 (20)	18	0	–‡	–	–
Jun 1975	61.4 (7.4)	45.0–70.0	2 790 (896)	1 100–4 200	117 (7.4)	15	0	–	–	–
Apr 1976	–	–	3 700 (–)	1 590–4 800	–	10	0	–	–	–
Jan 1977	–	–	2 940 (–)	Up to 5 680	–	62	0	–	–	–
Jan 1978	–	–	2 850 (–)	–	–	27	0	–	–	–
Dec 1978	–	–	4 050 (–)	–	–	12	0	–	–	–
18–21 Feb 1981	–	–	3 460 (825)	2 500–4 700	–	10	1	4	1	2.8
26 Feb–1 Mar 1981	59.1 (6.1)	45.0–71.1	2 870 (789)	1 460–4 500	133 (14)	12	0	4	3	1.0

* Condition factor.
† Standard deviation is in brackets.
‡ Unknown.

TABLE 10: Angling data from creel surveys and angler diaries for the middle and lower sections of the Rangitikei River, 1978–81

	No. of angler days	No. of hours fished	Average length of visit (h)	No. of under-sized fish returned	No. of takable fish returned	No. of takable fish kept	No. of fish measured	Mean length of brown trout (cm)	Mean length of rainbow trout (cm)	Mean length of both trout species (cm)
Middle section										
Creel survey	114	512	4.5	7	0	32	23	49.2	45.6	47.0
Diaries	39	198	5.1	2	11	29	33	60.9	50.0	54.2
Lower section										
Creel survey	188	327	2.0	11	3	35	31	50.3	33.5	35.0
Diaries	101	275	3.0	32	6	44	36	45.3	38.7	39.2

	Catch rate (fish per hour	Catch rate (fish per day)	Catch rate (grams per hour)*	% under-sized	% brown trout	% rainbow trout
Middle section						
Creel survey	0.06	0.28	78	18	47	53
Diaries	0.20	1.02	386	5	40	60
Lower section						
Creel survey	0.12	0.20	60	22	11	89
Diaries	0.18	0.50	131	38	8	92

* A condition factor of 120 is assumed.

and nymph, 27 by wet fly alone, 1 by nymph alone, and 11 by spinner.

The middle section was fished mainly by use of spinner and fly (Table 11 A). Natural bait was used by only 7% of anglers, but was by far the most effective method; it gave a catch rate of 0.16 fish per hour. Too few fish were caught to distinguish between the effectiveness of each method for the two species.

In contrast to the middle section and the headwaters, in the lower section natural bait was most popular and was used by 38% of anglers interviewed (Table 11 B). Spinning was the second most commonly used method (used by 30% of anglers), 18% used unspecified methods or a combination of methods, and only 14% used fly fishing. Natural bait was again the most effective method; it gave 0.23 fish per hour, whereas spinning and fly fishing gave very poor results. Anglers who

TABLE 11: Popularity and relative effectiveness of different angling methods used on the middle section (A) and the lower section (B) of the Rangitikei River, 1978–81, assessed by creel survey

	No. of anglers	% of anglers using each method	Hours fished	% of hours fished by anglers using each method	No. of rainbow trout caught	No. of brown trout caught	Total catch	Catch rate (fish per hour)	Hours fished per visit
A. Natural bait	8	7	31	6	3	2	5	0.16	3.8
Fly	49	43	256	50	6	9	15	0.06	5.2
Spinner	53	47	206	40	8	4	12	0.06	3.9
Combination	4	3	23	4	0	0	0	0	5.8
B. Natural bait	69	38	114	31	23	3	26	0.23	1.7
Fly	26	14	76	21	2	0	2	0.03	2.9
Spinner	54	0	124	34	7	1	8	0.07	2.3
Combination	34	18	51	14	0	1	1	0.02	1.5

used a combination of methods, or whose method was not specified on the form, had the lowest rate of success (0.02 fish per hour). Natural bait and spinners caught mainly rainbow trout; however, this may have reflected the small number of brown trout present.

The number of anglers holding different licence types is shown in Table 12 A. Most anglers in the middle and lower sections held adult whole season licences, but there were almost four times as many junior whole season licence holders (anglers aged 16 years or under) in the lower section as in the middle section. This shows that the lower reaches are particularly important to young anglers. In both the middle and lower sections most anglers held WAS licences (Table 12 B).

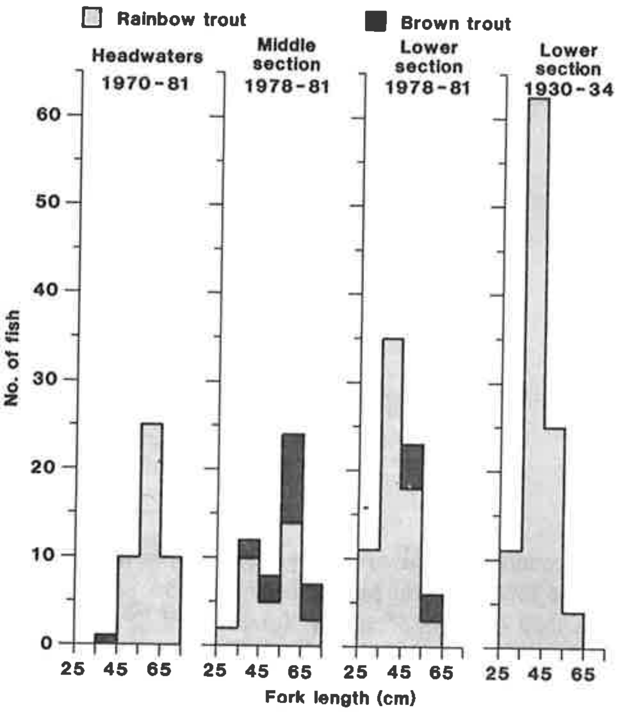

Fig. 7: Length-frequency distributions of brown and rainbow trout from creel surveys and angler diaries. (The 1930–34 data are from Parrott 1935.)

TABLE 12: Type of fishing licence held (A) and acclimatisation society district of origin (B) of anglers interviewed while fishing in the middle and lower sections of the Rangitikei River

	Middle section anglers		Lower section anglers	
	No.	% of total	No.	% of total
A. Adult whole season	100	88	121	66
Junior whole season	9	8	56	31
Week	4	4	1	1
Tourist	1	1	5	3
B. Wellington	78		161	
Hawke's Bay	30		5	
Wanganui	0		11	
CNIWC*	3		0	
Auckland	2		1	

*Central North Island Wildlife Conservancy.

Discussion

Distribution

Brown and rainbow trout were found sympatrically throughout the main river channel in the middle and lower sections. However, the main channel and tributaries of the Rangitikei above the confluence with the Mangamaire River appear to be occupied by rainbow trout, but not by brown trout; though there are no physical barriers to brown trout migrations.

Brook char were found in the headwaters of the Moawhango River, but rainbow trout were not, though both species occur sympatrically down stream. Further down stream in the Moawhango River, brown trout live sympatrically with rainbow trout (Cudby 1978). Physical barriers account in part for this distribution.

The phenomenon of brook char holding the most up-stream habitat in the same river system as other salmonids has also been observed in the Hinds River, in which brown trout and brook char occurred (Lane 1964), and it has been noted by Stokell (1955), Allen (1956), and Woods (1963, 1964). Brook char also occur up stream of brown trout in the United States (Fausch and White 1981). This may be because brown trout tolerate higher temperatures than brook char (Scott and Crossman 1973).

Where brook char and rainbow trout have been seen in the same river system overseas (for example, in streams in the Sierra Nevada (Newman 1956) and Montana (Holton 1953)) brook char occupied reaches up stream of rainbow trout. The reason for the segregation of brook char and brown and rainbow trout is likely to be a combination of size, feeding habits, spawning requirements, and temperature tolerance.

Spawning and abundance

Although up-stream spawning migrations probably occur, they may not be necessary to maintain mainstem populations because the trout populations in the headwaters and tributaries may provide sufficient numbers of juveniles to support the down-stream populations. However, fluctuations in the seasonal abundance of trout in the upper middle section suggest that migration does take place (Hicks and Watson 1985). Rainbow trout abundance there was lowest from May to October, which was probably due to a spawning migration from the middle section to the headwaters during winter and a return to the lower regions in summer and autumn. Rainbow trout biomass per unit area was higher in the headwaters than in the middle section, mainly because of the high mean weight of large fish in the headwaters.

Brown trout, in contrast to rainbow trout, appear to redistribute themselves around the optimum spawning sites rather than emigrate from the area in winter. The lack of spawning tributaries in the middle section, the absence of brown trout fry in the headwaters, and the redds that were seen at site 1 in July 1979 (Hicks and Watson 1985) show that brown trout in the middle section spawn mainly in the main channel. The abundance of fry at Springvale and Mangaohane suggests that rainbow trout may also spawn in the main channel.

In the lower section, brown and rainbow trout may spawn in the main channel, though the bed instability seen during drift diving at site 10 at normal flows suggests that floods would severely limit the success of spawning there. Some lower section tributaries, such as the Porewa, Waituna, Mangamako, and Pakihikura Streams, may provide spawning habitat, but their value for rearing is limited because in summer they flow only intermittently. The Mangakokeke Stream supports spawning, and other tributaries of the Kawhatau River may also do so. Similarly, tributaries of the Whakaurekou River may provide spawning sites, though the turbidity of the lower Whakaurekou may limit spawning there. The presence of shoals of juvenile trout in the main channel of the Rangitikei near its confluence with the Hautapu River from January to March suggested there was a spawning area of substantial importance not far up stream (M. Rodway pers. comm.). These fish may have been recruited from the Whakaurekou or its tributaries. Rainbow and brown trout may also migrate from the lower section to the middle section and headwaters to spawn.

Angler use

There is a brown trout fishery in most of the main channel of the Rangitikei except the headwaters and a rainbow trout fishery throughout the main river, including the headwaters. This is consistent with the findings of Graynoth (1974a, 1974b). The Hautapu River has a locally significant brown trout fishery (Richardson *et al.* 1984). This fishery had larger than average fish, which sustained a high cropping rate (Graynoth 1974a). There are brown trout fisheries of uncertain significance in the Mangawhararìki River (T. Kroos pers. comm.) and in the Moawhango River, where rainbow trout are also caught. Despite evidence of substantial angler use of the Moawhango in the past (Donne 1927, McCulloch 1971, Graynoth 1974a, Cudby 1978), the present status of its fishery is uncertain because it has not been studied since the commissioning of the Moawhango dam, when the flow below the dam was substantially reduced (Hicks 1985). There is also a little-used, but excellent, rainbow trout fishery in the remote lower Maropea River in the Whakaurekou catchment (M. Rodway pers. comm.). It is not known to what extent brook char are fished in the Moawhango headwaters, but it is unlikely to be great because of the small fish size and the inaccessibility of the area.

The different sections of the river provide different angling experiences. The headwaters contain very large rainbow trout (mean weight 3 kg) which anglers regard as trophy fish. The headwaters are also highly regarded because of their extremely limited access and high scenic attributes (Teirney *et al.* 1982).

In the middle section, which also has restricted access in parts, about equal numbers of both trout species were caught, and the brown trout were all large. Access to the river is easy at the road crossings at Springvale and Mangaohane, and scenic values are high (Teirney *et al.* 1982).

The lower section provides diverse recreational trout angling, though the brown and rainbow trout are smaller than in the headwaters or middle section. Access is generally easy, and rainbow trout are caught more often than brown trout. About one-third of lower section anglers are juniors, probably because the river here is close to Hunterville, Marton, and Bulls, and access is easier. Young anglers are probably also attracted to the Rangitikei by the liberal angling regulations, which allow the use of all legal angling methods, including natural bait fishing, in the parts of the river in the WAS district. Natural bait fishing gave the highest catch rate of any method in the middle and lower sections, which would encourage young anglers.

Native fish species and their fisheries

Introduction

Before this survey little had been published on the native fish and their fisheries in the Rangitikei River system. Woods (1964) documented fish distribution in the Moawhango River and its tributaries as part of investigations into the effects of the Tongariro hydroelectric development, and unpublished data on distribution are held in the New Zealand freshwater fish survey data base, stored by FRD, Wellington.

Methods

The single-pass sampling technique used during electric fishing almost certainly underestimated fish numbers. Accurate estimation of total numbers can only be achieved by fishing a site several times by use of a mark-recapture technique, or by use of a correction based on diminishing returns (Burnet 1959). The extent of whitebaiting was established by interviewing whitebaiters during the season (the beginning of August to the end of November) at or near the river mouth. The forms used in this survey were developed by the Taranaki Catchment Commission (1981) to give standardised creel surveys. The species caught were not identified. Whitebaiters, people associated with them, and their vehicles were counted on the river banks within 4 km of the river mouth during the day on incoming tides.

People who fished for other native fish species were interviewed in July 1982 at Bulls and Tangimoana, near the mouth of the Rangitikei. Local Maoris at the marae in Bulls were also interviewed about the species of fish taken, the methods used, and the extent and seasonality of fishing.

Results

Distribution and abundance

Native fish were found at 24 of 39 sites that were electric fished in the Rangitikei and its tributaries. Although only limited areas and habitats were fished, results show that long-finned eels were the most abundant native species, then Cran's bullies, short-finned eels, and upland bullies. Few torrentfish and red-finned and common bullies were found, probably because no lower section main channel sites were fished, and koaro were rare. The electric fishing sites are shown in Fig. 2, and the densities of fish found at these sites are given in Appendix 2.

The distribution of long-finned and short-finned eels, whitebait, and koaro is shown in Fig. 8. Long-finned eels were distributed widely throughout the Rangitikei system, from tributaries close to the sea to the most up-stream site fished. One 7-kg long-finned eel was found immediately down stream of the Moawhango dam site, an area that Woods (1964) had not expected that eels could reach.

Short-finned eels were usually less abundant than long-finned eels, but were more abundant (28 per 100 m²) in the Makowhai Stream. Short-finned eels were common at most lower sites fished, but penetrated a shorter distance up stream than long-finned eels. Juvenile long-finned and short-finned eels between 70 and 120 mm TL were abundant (19 and 16 per 100 m² respectively) in gravels in slow-flowing shallow water at Ohingaiti, 96 km from the sea, in February 1981, though eels of this size were not found at this site in December 1980.

A few koaro were found 200–240 km up stream from the sea, in the headwaters of the main channel and in the Moawhango River in an area now inundated by Lake Moawhango.

The distribution of red-finned, common, upland, and Cran's bullies, torrentfish, and black flounder is shown in Fig. 9. Red-finned bullies were found up to 100 km from the sea in the Mangamako Stream and in the main channel at Ohingaiti at low densities (2 per 100 m²) in December 1980. They were not found at Ohingaiti in February 1981.

Common bullies were found in the Tutaenui Stream and in the main channel at Ohingaiti. Abundance in the Tutaenui Stream was very low (less than 1 per 100 m²). Open pores on these bullies' heads showed that they were diadromous (McDowall 1978).

Upland bullies occurred at middle section sites of the Rangitikei, Hautapu, and Moawhango Rivers, between 80 and 210 km from the sea, and in the Oturua Stream (Fig. 9). Their abundance was between 1 and 3 per 100 m², except during October 1979, when between 22 and 67 per 100 m² were found at Mangaohane and Springvale.

Cran's bullies were the most widely distributed of the bully species in the Rangitikei; they occurred from Porewa Stream to the headwaters, 40–210 km from the sea.

Torrentfish were only found up to 75 km from the sea in three of the five sites in lower section tributaries where fish were found.

Black flounder have been recorded as far as 70 km up stream from the sea in the Rangitikei (McDowall 1978).

Whitebait fishery

A maximum of 141 whitebaiters was observed in mid October (Table 13), and most were more than 500 m up stream from the mouth. Daily catches were highly variable and ranged from less than 1 kg to up to 30 kg. Four out of six whitebaiters interviewed caught up to 10 kg in a season.

Fisheries on other native species

Twenty people who had fished the river were interviewed, and fisheries for nine native fish species in addition to whitebait were identified. These fisheries were for long-finned and short-finned eels, smelt, black and yellow-belly flounders, kahawai, grey mullet, yellow-eyed mullet, and stargazers. In addition to these species, snapper, red cod, sole, and barracouta have been taken occasionally from nets set in the estuary.

Eels. Eels have been commercially fished in the Rangitikei and its tributaries, particularly about 1978, when the best catches reputedly came from the Hautapu River. Catches in the estuary appear to have been larger than those in the middle section of the main river, and in 1979 a catch of 200–300 kg was recorded from 1 night's fishing with eight nets near the estuary. Recent fyke netting in the main river, between Vinegar Hill and Bulls, yielded 100–200 kg from 12–15 nets set for 2 days at a time (K. Rowley pers. comm.).

Recreational and subsistence eel fishing are widely practised on the Rangitikei. Eels are caught by baited line and by hinaki and fyke net. An old Maori method involves searching for eels in shallow water at night with a piece of lighted car tyre on a stick for illumination. When found, eels are stunned with a flat iron hook (called a "hoop iron") the size of a hockey stick. The Maori community at Bulls reported fishing for eels for food, as did a commercial marine fisherman living at Tangimoana. The commercial fisherman fished with fyke nets from October to December each year and caught from 5 to 30 eels, of both species, per set. During 60 days' fishing in 1 year he caught about 600 eels, which usually weighed between 500 and 1000 g. He fished from the river mouth to about 6 km up stream, and the eels were used for bait and food (P. Roach, Tangimoana, pers. comm.).

TABLE 13: The number of whitebaiters, associated people, and vehicles at the mouth of the Rangitikei River on 3 days in 1980

Date	Weather	No. of whitebaiters	No. of associates	No. of cars
11 Oct	Cloudy and mild	141	76	91
29 Nov	Fine and warm	23	–*	12
30 Nov	Raining	47	8	21

* Unknown.

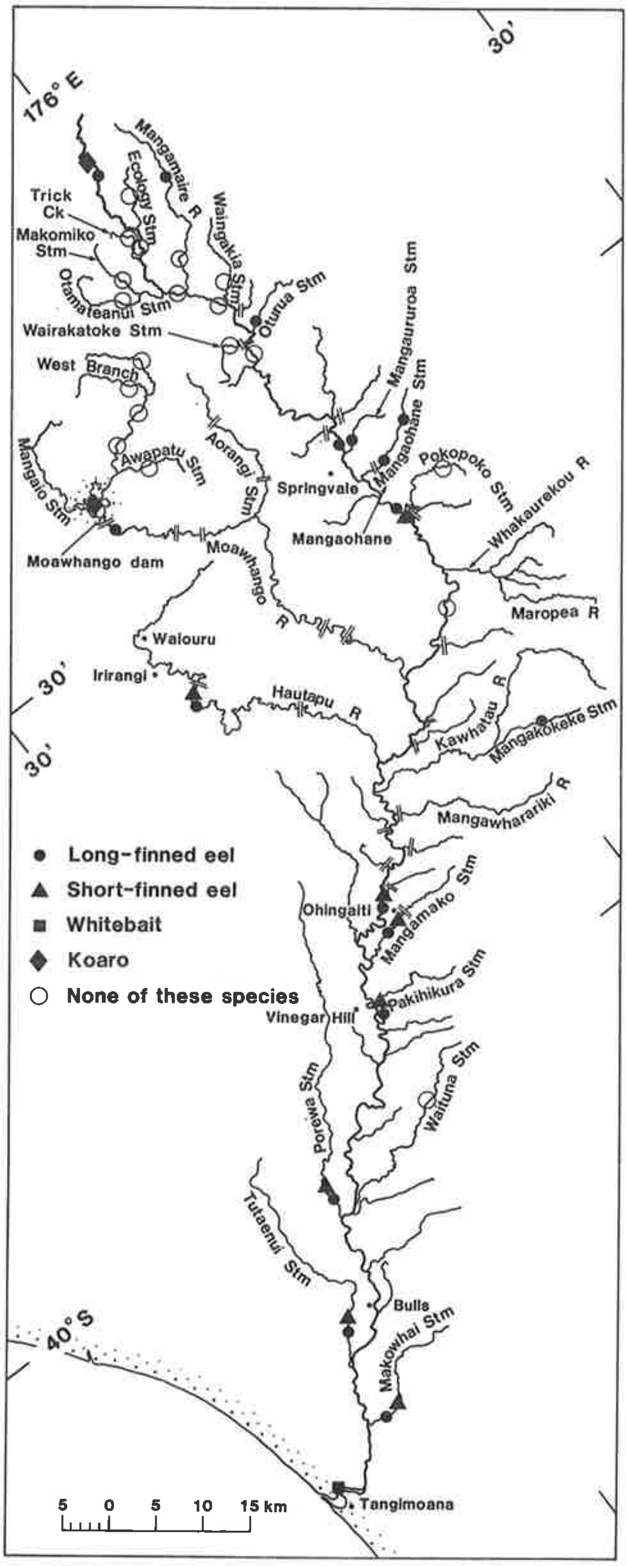

Fig. 8: Distribution of long-finned eels, short-finned eels, white-bait, and koaro in the Rangitikei River.

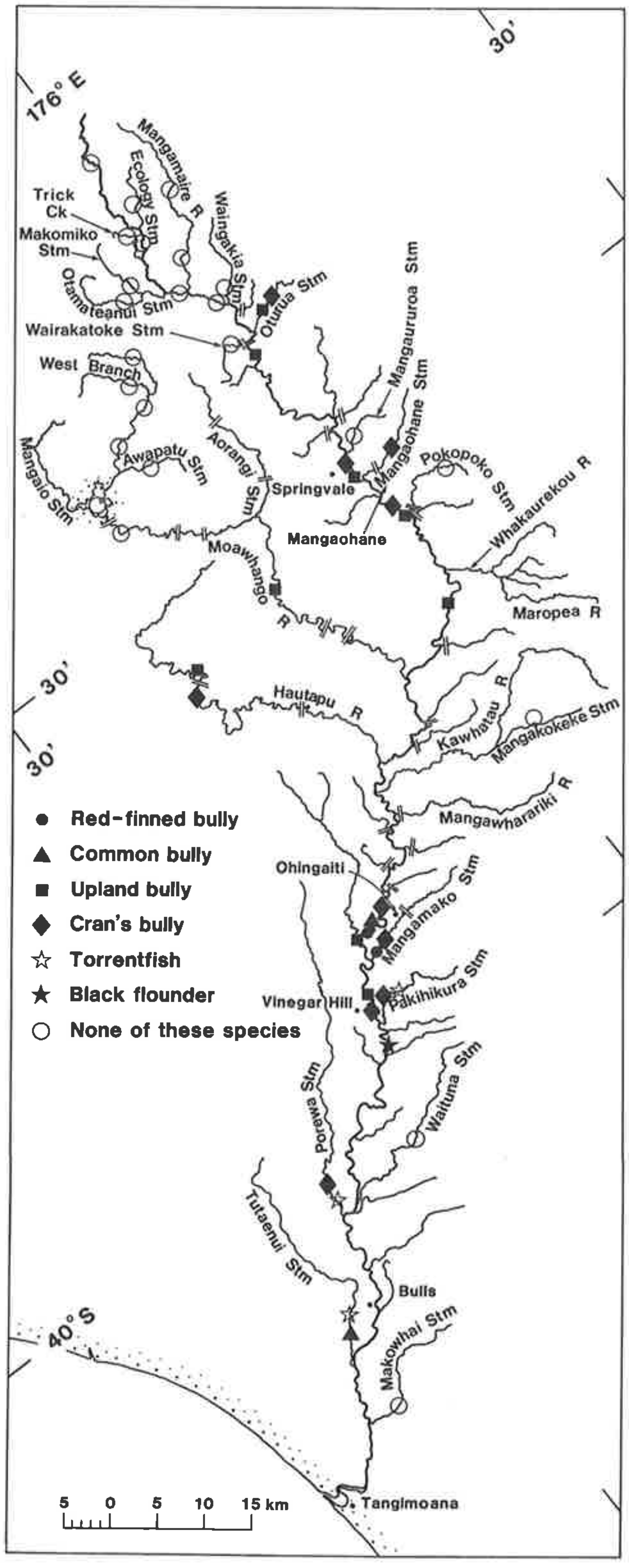

Fig. 9: Distribution of red-finned, common, upland, and Cran's bullies, torrentfish, and black flounder in the Rangitikei River.

Smelt. Smelt are the basis for a traditional Maori fishery in the Rangitikei when they migrate up stream in shoals during spring. They are caught up to 55 km from the sea by means of low stone weirs, similar to those in the Wanganui River (Hubbard 1979). Smelt are dried and used as food during winter. The Rangitikei smelt fishery is used less than it was, but up to 50–60 local Maoris still fish for smelt.

Flounder. Both species of flounder have been recently fished commercially, and catches of 100–200 flounder per set were common. Catches appear to have declined in the last few years, and no commercial fishermen were found fishing for flounder.

Recreational fishing still occurs, and black flounder are speared in the shallows as far as 45 km from the sea. Black and yellow-belly flounder are caught in the estuary by netting and by hand spearing at night. Sole are occasionally taken with flounder in the estuary.

Kahawai. Kahawai were caught in the Rangitikei during recreational fishing by 5 out of 20 people interviewed and were usually taken by spinning with a rod and line. Several fishermen reported that they visit the river as often as once every 2 weeks during summer. Some catches were large: 56 were caught by a single fisherman in one afternoon (J. Laws, Bulls, pers. comm.). Usually a single angler caught 3–4 per day. Kahawai are also taken in gill nets set overnight in summer.

Grey mullet. Grey mullet are caught in gill nets, and they are most abundant in February and March. Catches are variable, but are occasionally substantial. Twenty fish per set is common, and a single net set overnight caught 100 fish in the summer of 1980–81. The fish are usually large, weighing about 2000 g (P. Roach, pers. comm.).

Yellow-eyed mullet. Yellow-eyed mullet are often taken as a by-catch during netting for other species. They are also the target of line fishing by children and elderly people, who use them for food. The fish caught are often large for the species, commonly 400–500 g.

Stargazers. Stargazers were reported to be abundant in the Rangitikei estuary and were taken for food by two people interviewed. They are caught by hand-spearing or as a by-catch during netting for flounder, mullet, or eels. This fishery appears to be of minor importance.

Discussion

Distribution

The abundance of native fish was low at many electric fishing sites. Woods (1964) assessed eel populations at 30 sites in the Wanganui River and its tributaries by electric fishing, and he found that the abundance of long-finned and short-finned eels together was up to 229 per 100 m^2. However, most (93%) of his estimates of abundance were below 30 per 100 m^2. Combining both species of eels in our data gave densities of up to 37 per 100 m^2, similar to the abundance of eels in streams in the adjacent upper Wanganui catchment. However, these densities are low compared with other estimates of eel populations in New Zealand (Burnet 1952, 1959, 1968).

Of the eight native fish species caught by electric fishing, only two (Cran's bully and upland bully) are not diadromous. Distribution of the six diadromous species is controlled by their ability to migrate up stream and by habitat suitability. Long-finned eels and koaro were distributed farthest from the sea, though koaro were found only at a few up-stream sites and not in the lower and middle sections of the Rangitikei because they require cool bouldery streams with a high percentage of instream cover (Rowe 1981).

Common and red-finned bullies, torrentfish, and short-finned eels did not occur as far up stream as long-finned eels, and their distribution may be controlled to some extent by their ability to migrate. Long-finned eels are able to reach most suitable habitats and have a remarkable ability to surmount physical barriers. Woods (1964) thought that a series of cascades and waterfalls at the confluence with the Aorangi Stream defined their up-stream limit in the Moawhango River, but in this survey one long-finned eel was found 22 km further up stream, below the dam site of Lake Moawhango. Turner (n.d.) reported that large eels were abundant in the headwaters of the mainstem. We did not see evidence of this population during drift diving in July 1979, but this was probably because the water temperature (5 °C) restricted eel movement at this time. The inaccessibility of the headwaters means the eel population there is not likely to be commercially fished. The abundance of short-finned eels in the Hautapu River is unusual because they do not normally penetrate that far from the sea. This river was also one of the most fished by commercial eel fishermen in the area, an indication that the eel population was probably fairly dense. The wetlands in the Hautapu headwaters around Waiouru and Irirangi may account for the attraction of this river for short-finned eels.

Of the two species of non-diadromous bullies in the Rangitikei, Cran's bully was slightly more widely distributed. The two species have many similar characteristics and occur sympatrically in the south of the North Island (McDowall 1975). They occurred sympatrically in the Rangitikei system in the Oturua Stream, the Hautapu River, and the main river at Mangaohane, Springvale, Ohingaiti, and Vinegar Hill, and the species were sometimes difficult to distinguish. Characters such as the number and size of gill rakers, the number of rays in the pectoral fins, and the number of spines in the first dorsal fin were in the regions of overlap between the ranges for the species reported by McDowall (1975).

Woods (1964) reported finding Cran's bully (a synonym for Maui's bully, Woods 1963) and upland bullies in the Aorangi Stream. He also found Cran's bully in the Moawhango River, where we found upland bullies. Thus it appears that both species are also sympatric in the Moawhango system.

Fisheries

The whitebait fishery is discussed below because there are data to compare it with the whitebait fisheries in other rivers in New Zealand. Eel fishing in the Rangitikei was thought to be culturally, but not commercially, important. The abundance of eels in some lower tributaries (for example, the Makowhai Stream) suggests that an expanded fishing effort is possible.

The recreational kahawai fishery is probably widely used; one-quarter of the anglers interviewed fished for this species. In addition to the established use by locals, this fishery is probably also used by anglers from the nearby city of Palmerston North.

There is no commercial fishery for flounders, but they are of local, and possibly regional, importance for recreation. Flounders are caught an unusually long distance up stream (45 km). Fisheries for grey mullet, yellow-eyed mullet, stargazers, and smelt are of cultural and subsistence value locally.

Discussion and conclusions

Whitebaiting

The October maximum daily count of 141 whitebaiters on the Rangitikei is similar to that of 150 on the Rakaia River (Davis 1979) and to counts on rivers in Taranaki (Taranaki Catchment Commission 1981), where in the 1980 season only the Waitara River had a higher maximum daily count (205) than the Rangitikei River. Maximum daily counts on the 18 other Taranaki rivers in the Taranaki Catchment Commission analysis ranged from 3 to 82. Although maximum daily counts are not an accurate way to assess fishing effort (Taranaki Catchment Commission 1981), they are useful to make a rough comparison between rivers. The numbers of whitebaiters using the Rangitikei were similar to those using the Rakaia, Waitaki, and Waitara Rivers. In a survey of the Waitaki River it was found that up to 100 whitebaiters fished the river at one time and that the lower 1 km of the river was used (Graynoth, Pierce, and Wing 1981). The catch per person per day was similar on the Waitaki and the Rangitikei. Thus, the whitebait fishery based on the lower section of the Rangitikei River appears to be similar in importance to that on the Rakaia, Waitaki, and Waitara Rivers.

Abundance

Both numbers of fish per unit area and fish biomass per unit area were low in the Rangitikei. The abundance of small fish and eels sampled by electric fishing was always less than 200 per 100 m^2 and was usually less than 50 per 100 m^2. The greatest abundance of trout seen during drift diving was at site 6 in January 1980, when 220 per kilometre (0.65 per 100 m^2) were seen (Hicks and Watson 1985). Population density estimates (fish per 100 m^2) from drift diving surveys were not significant compared with those from electric fishing surveys. In the Rangitikei, biomass estimates derived from drift diving data were similar to most biomass estimates for the Rakaia, another large New Zealand river (Davis, Eldon, Glova, and Sagar 1983). However, in run habitats, and at sites where the biomass was increased by the presence of large eels, biomass per unit area was higher in the Rakaia than in the Rangitikei.

Small New Zealand streams also usually have a higher biomass per unit area than the Rangitikei. Burnet (1968, 1969) estimated that brown trout biomass in the "South Branch" of the Waimakariri River ranged from 9 to 308 kg/ha, and Allen (1951) estimated that brown trout biomass in the Horokiwi Stream ranged from 65 to 286 kg/ha. The biomass of fish in the small Hinau and Hinaki Streams was even greater: it ranged from 120 to 1400 kg/ha (Hopkins 1971). The maximum estimated biomass of brown and rainbow trout in the Rangitikei was 41 kg/ha, which suggests that fish biomass per unit area appears to decrease with increasing stream size.

Trout in the Rangitikei are large by New Zealand standards. The largest mean length of rainbow trout in the headwaters, and of brown trout in the middle section, exceeded the mean lengths of trout reported in all major waters in New Zealand between 1948 and 1968, except in the Travers River from 1957 to 1958 (Graynoth 1974b). There appears to have been little change in the size of rainbow trout in the lower section of the Rangitikei over the 50 years between a 1930–34 survey (Parrott 1935) and this survey. Similarly, rainbow trout size in the headwaters fluctuated little between 1970 and 1981.

Catch rate

Angler catch rates of trout in the Rangitikei in fish per hour were low compared with rates in other rivers in the WAS district and in the whole of New Zealand from 1947 to 1968 (Allen and Cunningham 1957, Graynoth 1974b). Rangitikei catch rates from 1978 to 1981 showed no consistent change from those from the 1947 to 1968 period. However, a recent survey of anglers' perception of catch rate showed that catch rates in the Rangitikei were thought to be high compared with those in other WAS rivers (Richardson *et al.* 1984). This difference may have been due to inaccuracies in the measurement of catch rate or changes in catch rate. It may also have been because some other factor (for example, fish size) compensated in anglers' minds for low numbers of fish caught per hour and caused them to over-value catch rate.

Measuring catch rate in weight rather than number of fish per hour removes the bias of large fish. Allen and Cunningham (1957) found that catch rates varied between 230 and 910 g/h in New Zealand and Graynoth (1973) estimated that catch rates were between 220 and 470 g/h in Hawke's Bay rivers. The catch rates of trout by angler diarists during this survey in the lower and middle sections of the Rangitikei combined were between 164 and 469 g/h, which is similar to Graynoth's estimates for Hawke's Bay rivers. However, catch rates in the Rangitikei headwaters were higher than those in other New Zealand rivers, mainly because of the large fish taken. Thus, it appears that large fish size does compensate for low catch rate in fish per hour in the Rangitikei.

There is evidence that catch rates depend on stock density in rivers (Allen 1951, McFadden 1961, Gard and Seegrist 1972), though they do not always do so (Thorpe, Rayner, and Webster 1947, Shetter 1950, Shetter and Alexander 1962). Graynoth (1974b) concluded from national angler diary scheme results that there was a positive relationship between trout numbers per kilometre and anglers' catch rates. He compared densities and catch rates in Wellington and Hawke's Bay rivers and used the linear equation: takable trout per kilometre = 14.3 + 135.8 × catch rate (Fig. 7 in Graynoth 1974b). Densities calculated from this equation for summer Rangitikei middle section catch rates of 0.06 fish per hour (creel survey data) and 0.20 fish per hour (angler diary data) were 22 and 41 takable fish per kilometre respectively. These densities were within the range of numbers of trout greater than 23 cm FL seen per kilometre during drift diving in January (20–53 fish per kilometre). Thus, the data suggest that catch rates are related to trout abundance in the middle section of the Rangitikei.

Importance

Although most anglers who fished the Rangitikei had WAS licences, one-fifth had Hawke's Bay Acclimatisation Society licences, and other anglers came from all over the North Island (Richardson *et al.* 1984). For those who fish the headwaters, access often includes expensive helicopter travel. Thus, some anglers travel long distances and spend a lot of money to fish the Rangitikei.

Teirney *et al.* (1982) concluded that anglers expended more effort on this river than on any other in the North Island except for the tributaries of Lake Taupo. The ranking of the Rangitikei by 139 respondents to the national angler survey showed that it was thought to be one of the most important recreational river fisheries in the North Island (Teirney *et al.* 1982). Although the middle section attracted the most anglers, the headwaters and lower section were also fished by more than 30% of the respondents. The headwaters qualified as a wilderness river fishery of national importance because they were awarded the highest possible scenic beauty and solitude ratings and because of the size of the trout they contained.

Teirney *et al.* (1982) ranked the middle and lower sections as a scenic and recreational river of national importance, and they concluded that the entire river system, including several important tributaries, should be recognised as nationally important in order to protect the wilderness, scenic, and recreational fishery values of the main channel. Of the rivers in the WAS district, the use made of the Rangitikei by WAS anglers was second only to the Manawatu, which did not have wilderness and scenic beauty ratings as high as the Rangitikei (Richardson *et al.* 1984).

Summary

1. Populations of rainbow trout, brown trout, and native fish species in the Rangitikei River were assessed by drift diving and electric fishing between April 1979 and February 1981.
2. Rainbow trout biomass in the middle section varied seasonally. The biomass of fish longer than about 12 cm FL was highest in January and April, when it reached 17 kg/ha, at a density of 60 fish per kilometre. The biomass was lowest in June and October, when the maximum biomass was 1.5 kg/ha (density nine fish per kilometre).
3. The biomass of brown trout longer than about 12 cm FL was more dependent on site than on season, and the maximum biomass was 32 kg/ha in June, when a maximum density of 59 fish per kilometre was counted in a spawning reach.
4. Rainbow trout biomass was assessed in the headwaters only once, during July. It ranged from 16 to 21 kg/ha (density 11–23 fish per kilometre), and only 1 brown trout was found, at the most down-stream site. In the headwaters the mean length of rainbow trout was 60 cm FL, and the mean weight was 3.0 kg.
5. Fisheries for rainbow and brown trout occur in the Rangitikei and its tributaries. Brook char are found in the Moawhango River, a substantial tributary of the Rangitikei, though the fisheries use of this species is not known.
6. Although trout catch rates in fish per hour are not high, the Rangitikei is highly regarded by anglers. The main reasons for this are the trophy rainbow trout fishery in the headwaters, the large brown trout in the middle section, and the high scenic attributes of both areas. The trout fishery in the Rangitikei is of national importance.
7. The size of rainbow trout has been stable in the Rangitikei from 1970 to 1981 in the headwaters and from 1930 to 1981 in the lower section.
8. There are few tributaries suitable for trout spawning in the lower and middle sections of the Rangitikei, but brown trout spawn in the main channel in the middle section. It is not known if rainbow trout spawn in similar main channel areas, but seasonal biomass fluctuations suggest that spawning migrations from the middle section towards the headwaters probably occur.
9. The Rangitikei River supports fisheries for whitebait, eels, kahawai, flounder, smelt, grey mullet, yellow-eyed mullet, and stargazers. The whitebait fishery is regionally important, but the importance of fisheries for other native species is not known.

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Appendix 1

Fish species in the Rangitikei River system

Common name	Scientific name
Salmonids	
Brown trout	*Salmo trutta*
Rainbow trout	*S. gairdnerii*
Brook char	*Salvelinus fontinalis*
Quinnat salmon	*Oncorhynchus tshawytscha*
Native freshwater fish	
Long-finned eel	*Anguilla dieffenbachii*
Short-finned eel	*A. australis*
Whitebait (juvenile galaxiids)	*Galaxias maculatus*
	G. brevipinnis
	G. postvectis
	G. fasciatus
	G. argenteus
Koaro (adult)	*G. brevipinnis*
Common smelt	*Retropinna retropinna*
Red-finned bully	*Gobiomorphus huttoni*
Common bully	*G. cotidianus*
Upland bully	*G. breviceps*
Cran's bully	*G. basalis*
Torrentfish	*Cheimarrichthys fosteri*
Black flounder	*Rhombosolea retiaria*
Estuarine fish and marine visitors	
Kahawai	*Arripis trutta*
Yellow-belly flounder	*Rhombosolea leporina*
Grey mullet	*Mugil cephalus*
Yellow-eyed mullet	*Aldrichetta forsteri*
Stargazer	*Leptoscopus macropygus*
Snapper	*Chrysophrys auratus*
Red cod	*Pseudophycis bachus*
Common sole	*Peltorhamphus novaezeelandiae*
Barracouta	*Thyrsites atun*

Appendix 2

Distribution and abundance* of fish sampled by electric fishing in the Rangitikei River system

	Distance from sea (km)	*Anguilla dieffen-bachii*	*Anguilla australis*	*Galaxias brevipinnis*	*Gobiomorphus huttoni*	*Gobiomorphus cotidianus*	*Gobiomorphus breviceps*	*Gobiomorphus basalis*	*Gobiomorphus* spp.	*Cheimar-richthys fosteri*	*Salmo trutta*	*Salmo gairdnerii*	*Salvelinus fontinalis*	*Oncor-ynchus tshaw ytscha*	Salmonid fingering
Makowhai Stream	16	9	28												
Tutaenui Stream	25	2–40	3–4			1				2					
Porewa Stream	44	3	✓†					✓		2					✓
Pakihikura Stream	76	6–11	2–11					4–14		1					
Mangamako Stream	86	5	4		2			18				1			
Rangitikei River at Ohingaiti	96	6–19	1–16		3	2		2–6							
Mangakokeke Stream	145	1													
Rangitikei River at Mokai	148						2				1				
Hautapu River	166		5				1	4			1				
Moawhango River	169						✓								
Moawhango River at Imjin Camp	196								✓			✓	✓		
Moawhango River at dam site	200	✓										4	3		
Mangaio Stream	201			✓								1	✓		
Moawhango River between Mangaio Stream and Awapatu Stream	203			✓								✓	✓		
Awapatu Stream	207											7	10		
Moawhango River above confluence with Awapatu Stream	207											9	6		
Moawhango River below confluence with Otokoro Stream	211											✓			
Moawhango River above confluence with West Branch	220											✓			
Tributary, West Branch, Moawhango River	226												97		
Pokopoko Stream	171										10				
Rangitikei River at Mangaohane	170	1	2				22	4			1–22	2			
Mangaohane Stream	180	2						✓			1				
Mangaohane Stream	184	2													
Mangaururoa Stream	180	✓									28	3			
Rangitikei River at Springvale	180	1–7					3–67	6			✓ to 100	✓ to 18		1	
Rangitikei River above confluence with Wairakatoke Stream	202			✓							5	1			
Oturua Stream	205	✓					‡	‡				1			
Waingakia Stream	210											5			
Rangitikei River above confluence with Waingakia Stream	210										✓	9			
Mangamaire River	224	1										3–4			
Makomiko Stream (north)	222											17			
Otamateanui Stream	222											17			
Trick Creek	223											12			
Rangitikei River below confluence with Ecology Stream	227											15			
Ecology Stream	227											3			
Rangitikei River	235	1										1			
Unnamed tributary	235			✓								1			

* Fish per 100 m^2.
† Fish present, but density not recorded, or less than 1 per 100 m^2.
‡ Density of both species combined was 4 fish per 100 m^2.

Appendix 3

Spawning potential for brown and rainbow trout in the Rangitikei River system

Site	Distance from sea (km)	Spawning potential	Gradient (m/km)	Abundance* Rain-bow trout	Brown trout	Fished	Comments
Headwaters							
Main river near source	235	5	20	Fry† C	-	✓	Mountain stream in dense beech forest; ideal spawning substrate and water quality; permanent water
Ecology Stream	227	4‡	61	Fry C	-	✓	Steep, bouldery tributary in beech forest; areas of gravel between boulders; permanent water
Main river at confluence with Ecology Stream	227	4	9	Fry A	-	✓	Steep valley sides covered in dense beech forest; deep pools; areas of gravel common; permanent water
Trick Creek	223	4‡	115	Fry A	-	✓	Very steep tributary; tussock to margins; bouldery, with limited gravel areas; permanent water
Otamateanui Stream	222	5‡	61	Fry A	-	✓	Dense beech forest to margins; gravel abundant; permanent water
Makomiko Stream (north)	222	5‡	67	Fry A	-	✓	Tributary of Otamateanui Stream; dense beech forest to margins; bank edges very stable; abundant gravel; permanent water
Mangamaire River	224	5‡	21	Fry A	-	✓	Tussock and scrub to margins; bouldery with gravel patches common; permanent water
Main river at confluence with Waingakia Stream	210	5	11	Fry A	Fry R	✓	Beech forest to margins; gravel abundant; permanent water
Waingakia Stream	210	5‡	43	Fry A	-	✓	Dense beech forest to margins; abundant gravel; permanent water
Makahikatoa Stream (N132/507600)	209	0	44				Waterfall (2 m high) at its confluence with Rangitikei River
Oturua Stream	205	3‡	58	Fry R	-	✓	Tussock to margins; coarse, angular rubble substrate with bedrock bars; permanent water
Main river at confluence with Wairakatoke Stream	202	5	6	Fry R	Fry A	✓	Beech forest and tussock to margins; gravel in shallows; deep pools; permanent water
Wairakatoke Stream	202	0	43	-	-	✓	Small waterfall and velocity barrier just above confluence with main river; no fish found; permanent water
Okorotehe Stream	199	0	30				Very short and small; substrate rocky
Upper middle section							
Mangamarahia Stream	184	2‡	33				Scrub to margins; coarse angular substrate; one redd seen, July 1979; permanent water
Makahikatoa Stream (N123/519432)	184	1	46				Scrub and pasture to margins; 16-m waterfall, 400 m from confluence with main river; little spawning potential below waterfall
Porotaiana Stream	182	0	71				Very small rocky stream; 0.3–1.0 m wide; substrate of angular cobbles and silt; 1.5-m-high cascade, 20 m from confluence with main river
Main river at Springvale	180	5‡	4	Fry C Unidentified fing.§ A	Fry A	✓	Pasture and scrub to margins; abundant gravel; permanent water; fry seen, October 1979 and December 1980; unidentified fingerlings seen, January 1980; abundant redds seen June 1979
Mangaururoa Stream	180	1	52	Fing. R.	Fing. A	✓	Pasture to edges; coarse, angular gravel and rubble on papa bed; fingerlings presumed to have moved in from main river; rearing only

Site	Distance from sea (km)	Spawning potential	Gradient (m/km)	Abundance* Rain-bow trout	Abundance* Brown trout	Fished	Comments
Mangaohane Stream	180	3‡	51				Pasture and scrub to edges; abundant gravel in first 1 km from confluence with main river up to 2-m waterfall; spawning and rearing in this area; redd seen July 1979; permanent water; fingerling rainbow trout found in April 1979 above waterfall, probably part of a resident population
Makokomiko East Stream	172	0	42				Papa bed with 20-cm boulders; very small stream, possibly dry in summer; pasture to margins, poplars blocking stream
Main river at Mangaohane	170	4‡		Fry R; Unidentified fing. A	Fry A	✓	Pasture and scrub to margins; abundant gravel; permanent water; fry seen, October 1979; fingerlings seen, January 1980 (not identified); rearing in shallow, slow-flowing margins; redds seen, June 1979
Main river in Mangaohane Gorge	168	1‡	5	Unidentified fing. R			Scrub and beech forest to margins; steep greywacke and limestone walls; deep pools; permanent water
Popopoko Stream	171	0‡	49	Fing. A		✓	Pasture and scrub to margins; permanent water; spawning run blocked by numerous waterfalls, the first of which is at the confluence with the main river; stunted resident rainbow trout population could contribute to recruitment in main river (40 rainbow trout, 80- to 150-mm fork length, caught April 1979)
Reporoa Stream	166	0	85				Waterfalls at confluence with Rangitikei River
Main river at Pukeokahu	160	4‡	4	Unidentified fing. A		✓	Scrub and pasture to margins; abundant gravel; permanent water; unidentified fingerlings seen during drift diving, January 1980
Central section							
Whakaurekou River	158	1	14				Scrub and beech forest to margins; permanent water; coarse gravel; high suspended sediment load
Maropea River	163	?	59				Tributary of Whakaurekou River; beech forest to margins; permanent water; gravel substrate; spawning possible if migrating trout not deterred by poor water quality of Whakaurekou River
Main river at Mokai	148	1	5	–	Fing. R	✓	Pasture and scrub to edges; papa cliffs up to 80 m high; gravels suitable for spawning, but water velocity high and gravel bright, clean, and unstable; any spawning is likely to be unsuccessful
Makino Stream	144	0	95				Waterfall close to confluence with Rangitikei River
Moawhango River	138	2‡	8				Velocity barrier 13 km up stream from confluence with the Rangitikei; spawning possible up to this point (redds seen, but spawning success likely to be low since the dam closed); resident rainbow trout populations in Moawhango River above barriers and Aorangi Stream might contribute to recruitment in the main river; headwaters diverted by dam
Makopua Stream	132	0	53				Waterfall close to confluence with Rangitikei River
Tunatau Stream	128	1	46				Spawning possible up to waterfall 1 km above confluence with main river
Hautapu River	124	0	11				Not suitable for spawning up to first velocity barrier; poor water quality and unsuitable substrate; dam at Taihape; resident brown trout fishery above Taihape might contribute to recruitment in the main river

Appendix 3—*continued*

Site	Distance from sea (km)	Spawning potential	Gradient (m/km)	Abundance* Rainbow trout	Brown trout	Fished	Comments
Kawhatau River	145	4‡	30	Run	Run	✓	Headwaters in beech forest; substantial gravel bed load; tributaries and main river have spawning potential; Mangakokeke Stream has spawning run of brown and rainbow trout—trapped July 1979
Mangawharariki River	114	0	47				Scrub and pasture to margins; dam just up stream of confluence with main river prevents spawning run; resident brown trout population could contribute to recruitment in the main river
Mangateweka Stream	110	0	54				Waterfall at confluence with main river
Mangarere Stream	107	1	31				Waterfall 400 m up stream of confluence with main river; dries up in summer
Ohau Stream	102	0	57				Waterfall at confluence with main river
Lower middle section							
Tuha Stream	99	1	51				Waterfall 1 km up stream of confluence with main river; dries up in summer
Main river at Ohingaiti	96	2	3	–	–	✓	Surrounded by steep cliffs; gravel and papa boulder bed; high suspended sediment load; farmland and scrub to margins; poor rearing area
Makohine Stream	87	1	13				Surrounded by steep cliffs; papa and boulder bed; high suspended sediment load; farmland and scrub to margins; dries up in summer
Mangamako Stream	86	3‡	18	Fry R	–	✓	Gravel abundant; pasture and scrub to margins; 20-m waterfalls, 3–4 km up stream of confluence with main river
Pakihikura Stream	76	2	20	–	–	✓	Coarse gravel abundant; high suspended sediment load; poor water quality; dries up in summer
Mangapipi Stream	72	1	41				Steep; dries up in summer; probably has waterfalls
Mangatutu Stream	68	1	47				Steep; dries up in summer; probably has waterfalls
Makaraka Stream	67	1	44				Steep; dries up in summer; probably has waterfalls
Waitapu Stream	55	1	37				Steep; dries up in summer
Lower section							
Waituna Stream	46	2	16	–	–	✓	Abundant gravel; no fish found at point fished, but spawning is possible down stream; dries up in summer
Ruamahanga Stream	45	0	10				Dry when inspected; gravel bed, but unlikely to have flow except when in flood
Porewa Stream	44	2	11	–	–	✓	No fry or fingerlings found; one unidentified 20-cm trout seen; dries up in summer; gravel bed, but very poor water quality—enriched by Hunterville oxidation pond effluent; high suspended sediment load
Rangitawa Stream	35	1	6				Papa bed; pasture to margins; dries up in summer; spawning unlikely to be of any significance
Mingaroa Stream	30	0	8				Tributary parallel to Mingaroa road; dry for much of the year
Tutaenui Stream	25	1	6	–	–	✓	Pasture and willows to margins; poor water quality; dries up in summer
Makowhai Stream	16	1	5	–	–	✓	Thick weed beds; pasture and willows to edges; poor water quality; dries up in summer

* Abundance: A, abundant; C, common; O, occasional; R, rare; –, not found.
† Fry are less than 6 cm FL.
‡ Spawning occurs.
§ Fingerlings, 6–12 cm FL.

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