NEW ZEALAND FRESHWATER FISHERIES REPORT No. 125

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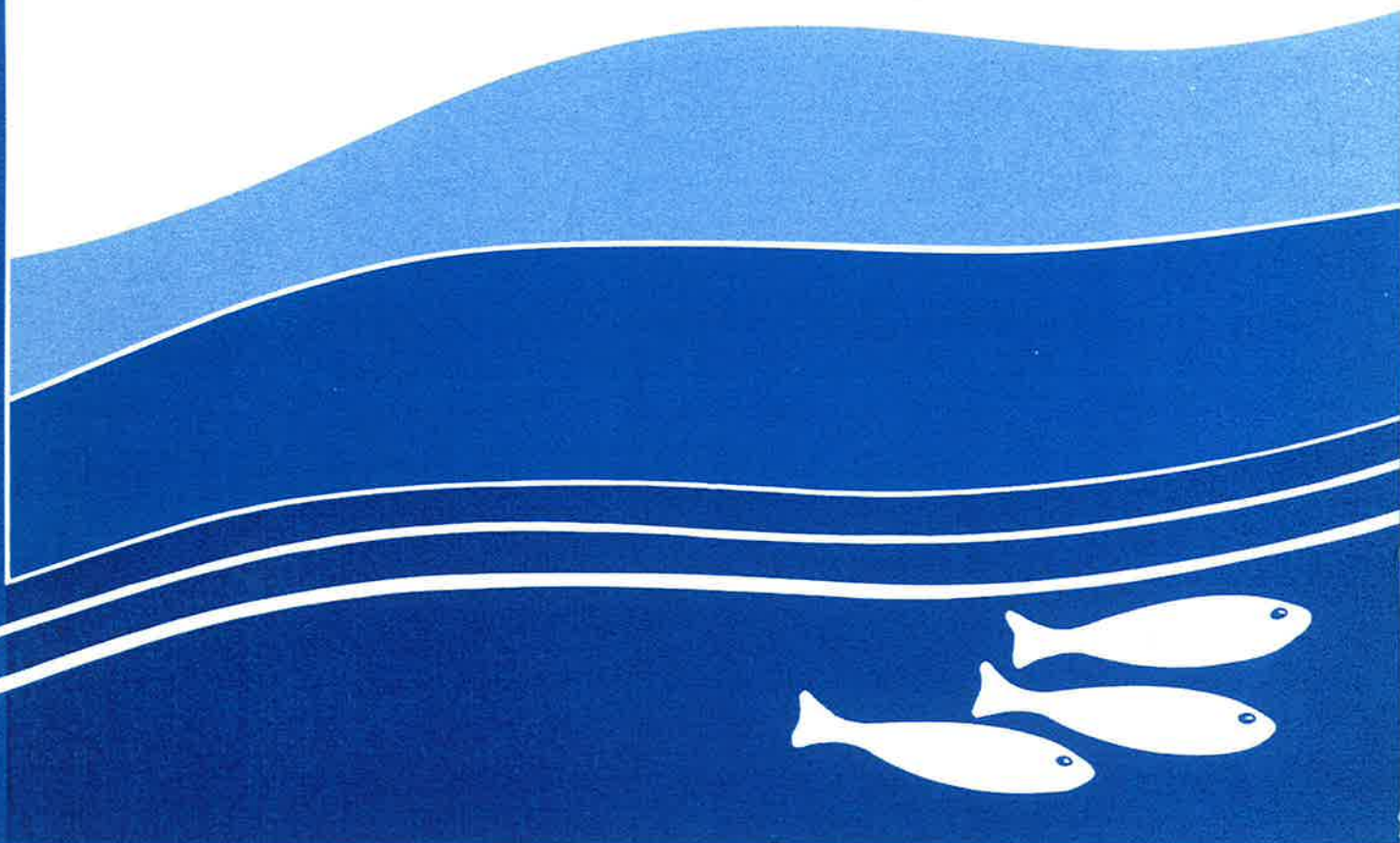
Brown and rainbow trout spawning migrations in tributaries of the lower Waitaki River, 1981 - 1983



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Brown and rainbow trout spawning migrations in tributaries of the lower Waitaki River, 1981 - 1983

by
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Report to Electricorp

Freshwater Fisheries Centre
MAF Fisheries
Christchurch

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SUMMARY

Since 1979, investigations have been undertaken into the potential impact of a major power development scheme on the fish stocks and fisheries of the lower Waitaki River. This report describes studies on the brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) spawning runs into the two major tributaries of the lower Waitaki, the Hakataramea and Maerewhenua Rivers, and into a minor tributary, Welcome Stream.

Brown trout spawning runs were estimated at about 390 fish in the Hakataramea, 270 in the Maerewhenua, and 150 in Welcome Stream. Rainbow trout runs averaged 170 in the Hakataramea, and 90 in the Maerewhenua.

The main runs of brown trout into the tributaries occurred in May, whereas rainbow trout entered in August and September. Males of both species tended to arrive in the tributaries before the females. The time lag between the sexes was greater for rainbow than for brown trout. Brown trout spawning runs into the tributaries began earlier and lasted longer the further upstream that the tributary was situated.

Hakataramea trout generally were larger than Maerewhenua and Welcome Stream trout. Brown trout were larger than rainbow trout, and males were larger than females. The condition factor was higher for females than for males. The sex ratio for both species of trout was nearly 1:1.

Both species had high mortality after first spawning. The rate was particularly high for rainbow trout. Repeat spawners comprised 5.8% of the brown trout and 2.6% of the rainbow trout runs. All repeat spawners returned to the tributary in which they had previously spawned.

The conservation of rainbow trout stocks in any future residual river, constructed as part of the proposed power development scheme, will depend upon access to, and the maintenance of, adequate flows in the Hakataramea and Maerewhenua Rivers.

1. INTRODUCTION

The Waitaki River is a large, braided river on the east coast of the South Island, with a mean annual flow of 364 m^3/s. Since 1979, staff of the Freshwater Fisheries Centre (FFC) have investigated the potential impact of a major power development scheme on its fish stocks and fisheries (Graynoth *et al.* 1981, Graybill *et al.* 1988).

Little was known of the value of the tributary streams as spawning grounds for the river's brown and rainbow trout stocks. Therefore, during their spawning migrations, wire-mesh barrier traps were placed in the two major lower Waitaki tributaries, the Hakataramea and Maerewhenua Rivers, and in a minor tributary, Welcome Stream.

The purpose of the study was to determine the number of trout spawning in these tributaries so that their importance to the present Waitaki River and to the proposed residual river could be assessed. The opportunity also was taken to tag trout and to collect information on the timing of the runs and on the length, weight, condition factor, fecundity, and movements of the trapped fish.

2. STUDY AREA

2.1 Hakataramea River

The Hakataramea is the largest tributary of the lower Waitaki River, its confluence being approximately 65 km from the Pacific Ocean (Fig. 1). It is about 60 km long, and has a mean annual flow of 6.0 m^3/s. Pasture and tussock are the predominant bank vegetation, together with willow (*Salix* spp.) and matagouri (*Discaria toumatou*).

The Hakataramea is an important spawning stream for quinnat salmon (*Oncorhynchus tshawytscha*), rainbow trout (*O. mykiss*), and brown trout (*Salmo trutta*), and it supports a small population of brook char (*Salvelinus fontinalis*) in a headwater stream. Two species of bully (*Gobiomorphus cotidianus* and *G. breviceps*), one species of eel (*Anguilla dieffenbachii*), two species of galaxiid (*Galaxias brevipinnis* and *G. vulgaris*), and the lamprey (*Geotria australis*) also are present in this river system (FFC unpublished data).

2.2 Maerewhenua River

The Maerewhenua River is the second largest tributary of the lower Waitaki River, with its confluence at Duntroon, about 36 km from the sea (Fig. 1). It has a mean annual flow of 3.4 m^3/s and is about 40 km in length. The dominant vegetation cover in the upper catchment is snow tussock (*Festuca* spp.). In the lower reaches, riparian vegetation includes willow, gorse (*Ulex europaeus*), and broom (*Cystisus scoparius*).

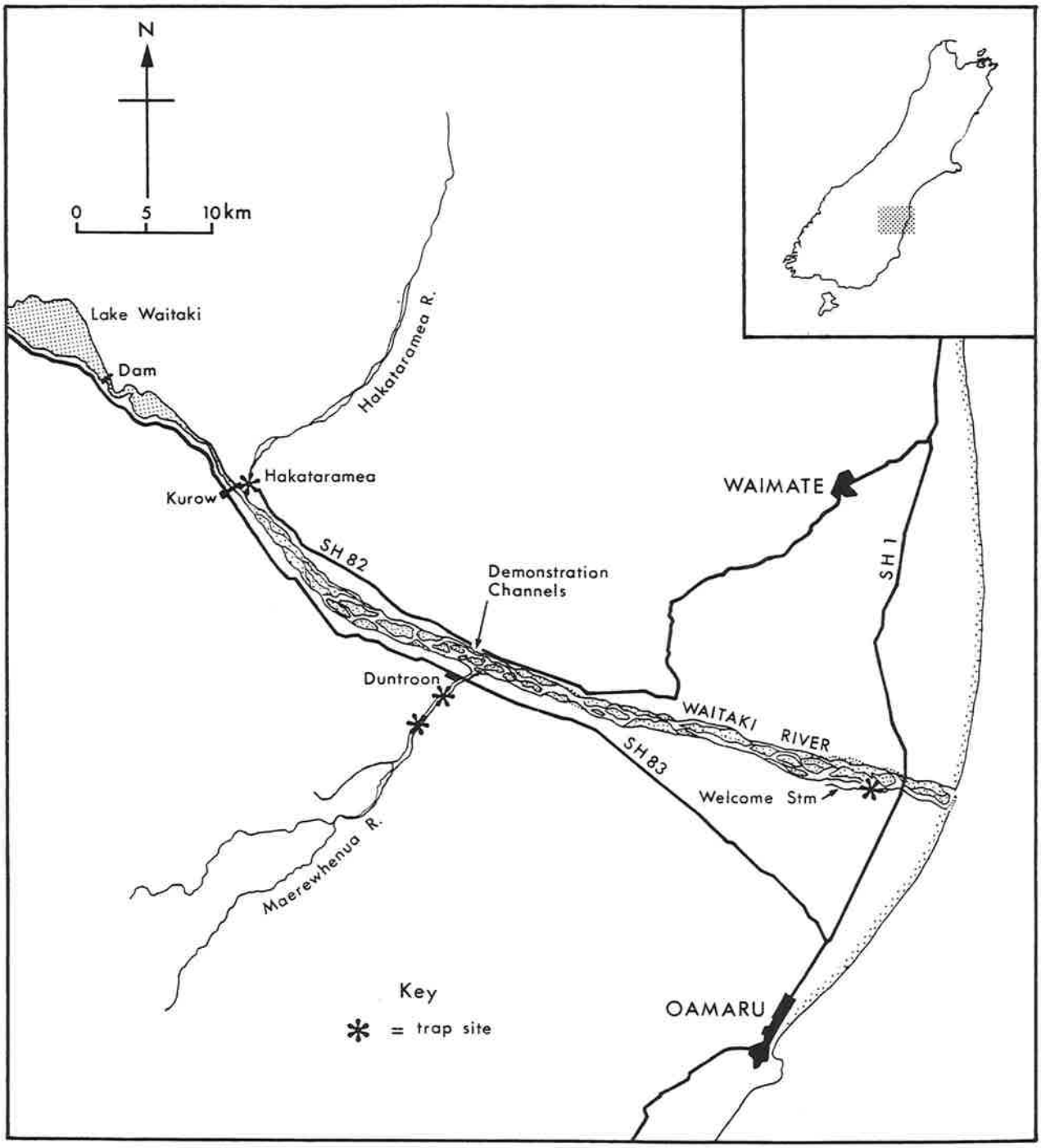

FIGURE 1. The lower Waitaki River and its tributaries, showing localities mentioned in the text.

Brown and rainbow trout are found throughout most of the river. Native fish include the six species found in the Hakataramea River, together with torrentfish (*Cheimarrichthys fosteri*).

2.3 Welcome Stream

This small, stable, side stream of the lower Waitaki River is about 5 km long, and enters the river 1 km above the State Highway 1 (S.H.1) bridge (Fig. 1). The flow is usually about 1 m^3/s. Bank vegetation consists of willow, gorse, and broom.

The stream supports a spawning run of brown trout, with occasional quinnat salmon and rainbow trout. Eleven native fish species have been recorded, including all those found in the Maerewhenua River, together with shortfinned eel (*Anguilla australis*), inanga (*Galaxias maculatus*), bluegilled bully (*Gobiomorphus hubbsi*), and black flounder (*Rhombosolea retiaria*).

3. METHODS

From 1981 to 1983, traps were located in each of the three tributaries described above, at various distances upstream from the Waitaki River. In 1981, traps were placed about 500 m upstream on the Hakataramea River, about 7 km upstream on the Maerewhenua River, and 1 km upstream on Welcome Stream (Fig. 2). In 1982, the Maerewhenua trap was moved 3 km downstream. In 1983, only the Hakataramea trap was operated.

The holding pen of the trap was constructed from 90-cm-high farm gates made of galvanised pipe and covered with galvanised wire mesh (aperture 55 mm) (Fig. 3). The "lead-in" wings, which were made of the same mesh, had wire cables laced through them and were anchored to each bank. Sand bags were used to prevent the base of the trap being eroded during freshes. In 1983, wire mesh was placed over the top of the Hakataramea holding pen to reduce predation by black shags (*Phalacrocorax carbo*) and human interference with trapped fish.

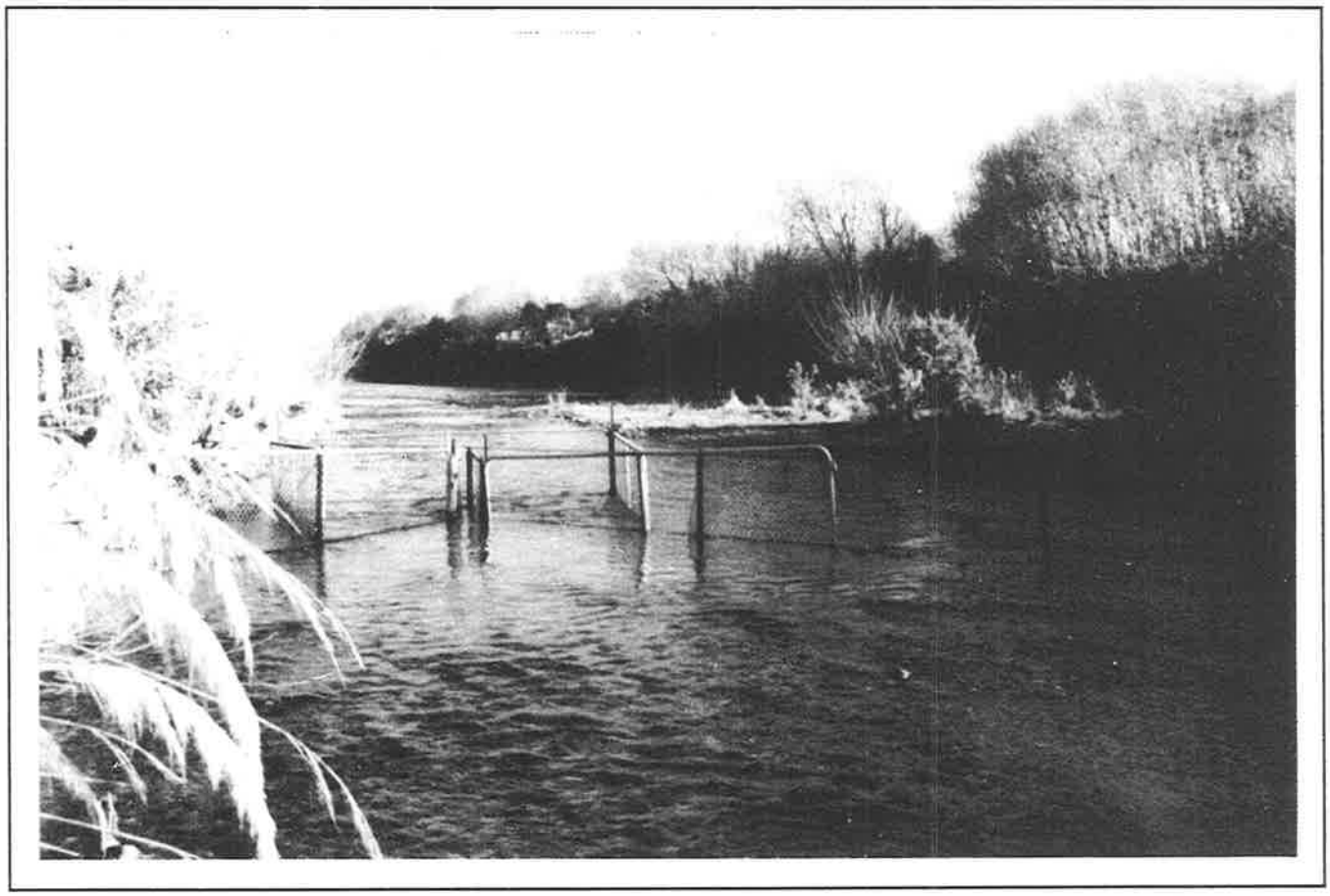

FIGURE 2. The Welcome Stream trap site, June 1982. (Photo: K. Deverall)

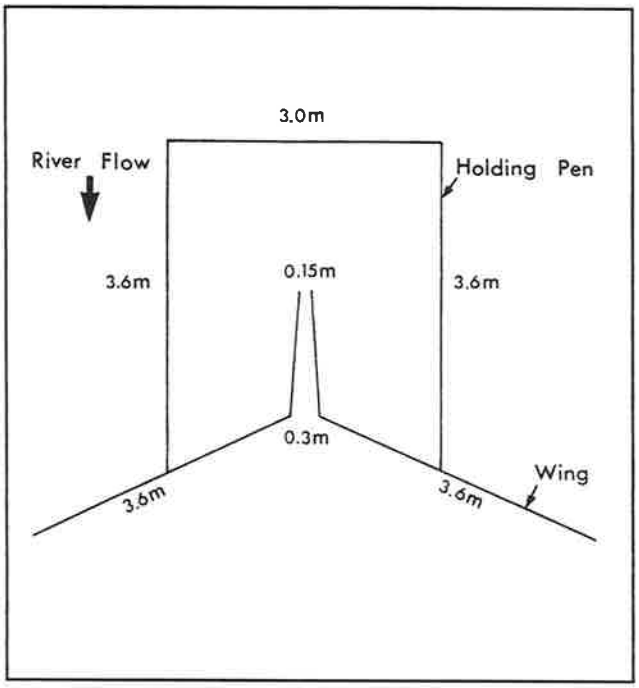

FIGURE 3. Plan of wire mesh fish trap.

The traps generally were positioned in a run below a riffle. The holding pen was placed in a slow, deep area close to the bank, so that the fish could rest until they were processed. Sites with gently sloping banks were chosen, so that high flows would spread, rather than submerge the trap (Fig. 2). Even so, the wings of the trap often were washed out during freshes and holding pens were destroyed during large floods.

During the main spawning run, traps were checked daily between 0900 h and 1100 h, and on alternate days at other times.

Trout and salmon were removed from the trap with a hand net, measured (fork length in mm), weighed (to the nearest 20 g), tagged with a plastic dart tag, and released upstream. Sexual maturity of males was determined by applying gentle pressure to the abdomen. This resulted in a show of milt at the vent in ripe individuals. Females were held by the tail to observe the shape of the vent and the adjacent abdominal wall. Ripe females had extruded urogenital papillae, pinching of the skin to form a line extending from the vent towards the pelvic fin, and bulging of the abdomen towards the head caused by loose eggs.

Total egg counts were performed on 12 rainbow trout and four brown trout, which ranged in length from 350 mm to 531 mm. These were dead females found on the upstream side of the Hakataramea trap on the day after tagging in the 1981 and 1982 seasons.

Condition factors (K) were calculated using the formula $K = (W * 10^7/L^3)$, where W = weight in grams and L = length in mm.

Flow records were obtained from the (then) Ministry of Works and Development for the Hakataramea and Maerewhenua Rivers. Maximum/minimum thermometers were installed at each trap and provided approximately daily records of water temperature.

4. RESULTS

4.1 Size of the Annual Spawning Runs

On average, about 220 brown trout and 150 rainbow trout were trapped each year in the Hakataramea River. Only a proportion of the spawning run was caught because floods washed out the traps (especially during the brown trout spawning migration), and because of the late installation of the traps in 1981 and 1982 (Table 1). Estimates of the annual spawning runs of both species were made by assuming that there was no

TABLE 1. Factors influencing the number of brown and rainbow trout trapped in the Hakataramea and Maerewhenua Rivers and Welcome Stream from 1981-1983, and estimated size of runs.

River	Year	Floods	Droughts	Trap location	Late installation	Est. size
Brown trout						
Hakataramea	1981	**			**	350
	1982	*			*	300
	1983	**				500
Maerewhenua	1981	**		*		230
	1982		*	*		310
Welcome Stream	1981					140
	1982	*				160
Rainbow trout						
Hakataramea	1981	*				90
	1982					260
	1983	*				200
Maerewhenua	1981			*		60
	1982		*	*		120
Welcome Stream	1981				*	1
	1982				*	0

** = major influence on the numbers trapped.
* = moderate influence on the numbers trapped.

TABLE 2. Number of brown and rainbow trout trapped in the Hakataramea and Maerewhenua Rivers and Welcome Stream, 1981-1983.

River	Year	Brown trout M	F	Total	% male	Rainbow trout M	F	Total	% male	Both species
Hakataramea	1981	73	83	156	47	27	25	52	52	
	1982	97	92	189	51	118	121	239	49	
	1983	143	169	312	46	73	92	165	44	
	Total	313	344	657	48	218	238	456	48	1113
	Mean	104	115	219	-	73	79	152	-	371
Maerewhenua	1981	55	46	101	54	21	18	39	54	
	1982	92	122	214	43	40	38	78	51	
	Total	147	168	315	47	61	56	117	52	432
	Mean	73	34	158	-	30	28	59	-	216
Welcome Stream	1981	70	64	134	52	0	1	1	0	
	1982	32	31	63	51	0	0	0	0	
	Total	102	95	197	52	0	1	1	1	198
	Mean	51	47	99	-	0	0	1	-	99
Grand total				1169				574		1743

significant change in daily migration rates during floods, and by estimating the size of the run prior to installation of the traps, using information on the timing of migrations in other years. The mean annual run of brown and rainbow trout was estimated at about 390 per annum (95% confidence limits (C.L.) = 130 - 640) and 170 per annum (95% C.L. = 0 - 400), respectively. If migration rates doubled during floods, these estimates would increase to 480 and 180, respectively.

In the Maerewhenua River, about 160 brown trout and 60 rainbow trout were trapped per annum (Table 2). The annual runs were, however, larger than this, as floods, droughts, and the upstream placement of the trap probably reduced catches (Table 1). Spawning surveys by K.R. Deverall (pers. comm.) indicated that between 25% and 50% of the trout spawned below the lowest trap site. The mean annual run of brown and rainbow trout in the Maerewhenua was estimated at 270 (95% C.L. = 0 - 770) and 90 (95% C.L. = 0 - 400), respectively, and increased only slightly to 310 and 100 if migration rates doubled during floods.

Welcome Stream supported a small run, estimated at about 150 brown trout per annum (Tables 1 and 2).

Substantial annual variations in trap catches occurred (Table 2). A four-fold increase in rainbow trout catches in the Hakataramea River between 1981 and 1982 (Table 2) was a natural variation in stock numbers and was not caused by inadequate trapping (Table 1).

The capture of four quinnat salmon (three males and one female) in the Maerewhenua River trap during 1982 confirmed the presence of this species in the river for the first time in a number of years.

4.2 Timing of the Brown Trout Spawning Migration

The brown trout spawning migration usually commenced in April or May, peaked in late May and early June, and tapered off in July and August. In 1981, two traps were installed in mid May and therefore the first part of the spawning run was not trapped (Figs. 4 and 5). The main migration lasted for up to 40 days and included 60-70% of the fish.

In general, male trout entered the traps about three to 10 days earlier than the females (FFC unpublished data), a result similar to that found by Munro and

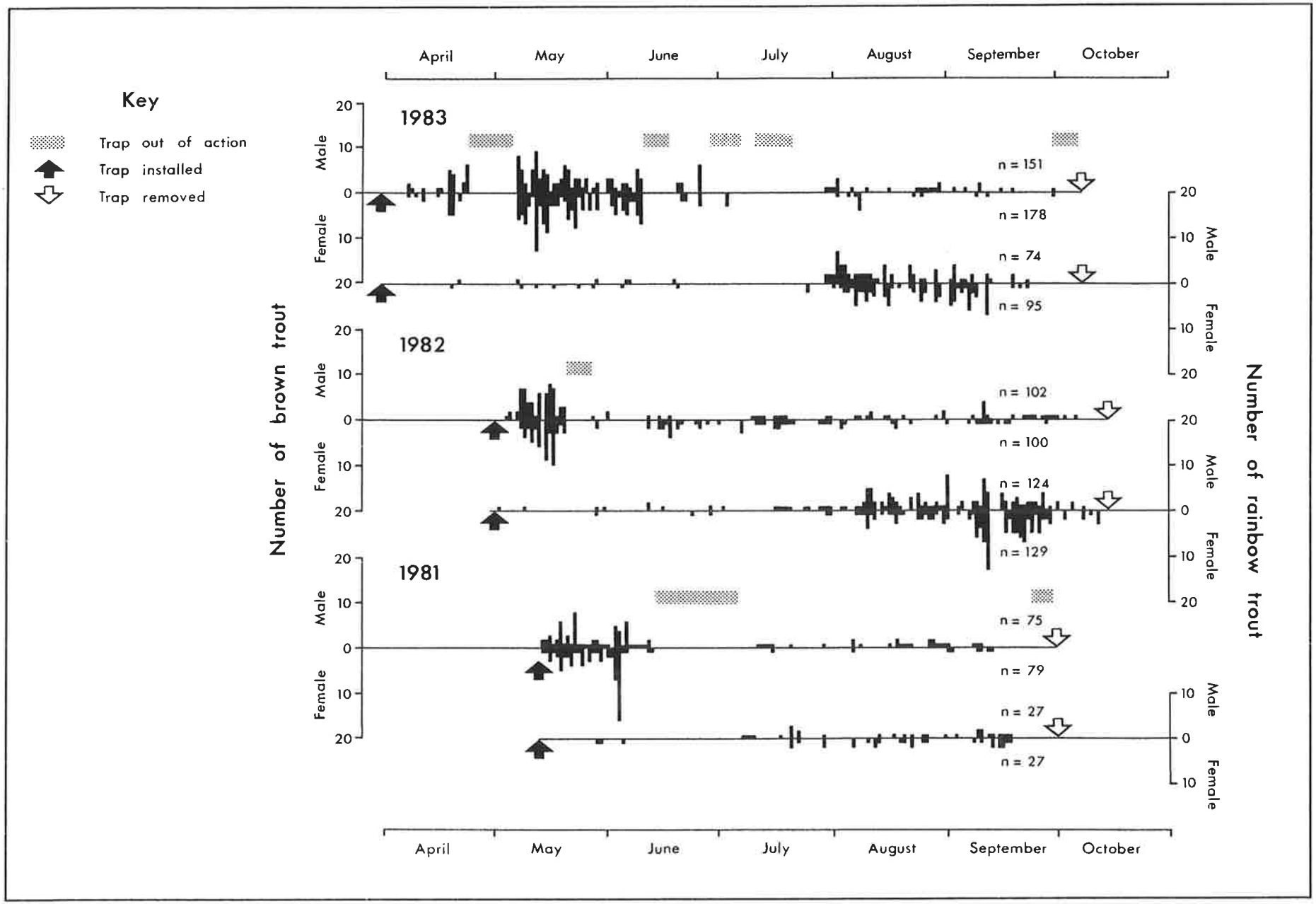

FIGURE 4. Number of brown and rainbow trout captured per day in the Hakataramea River trap, 1981-1983.

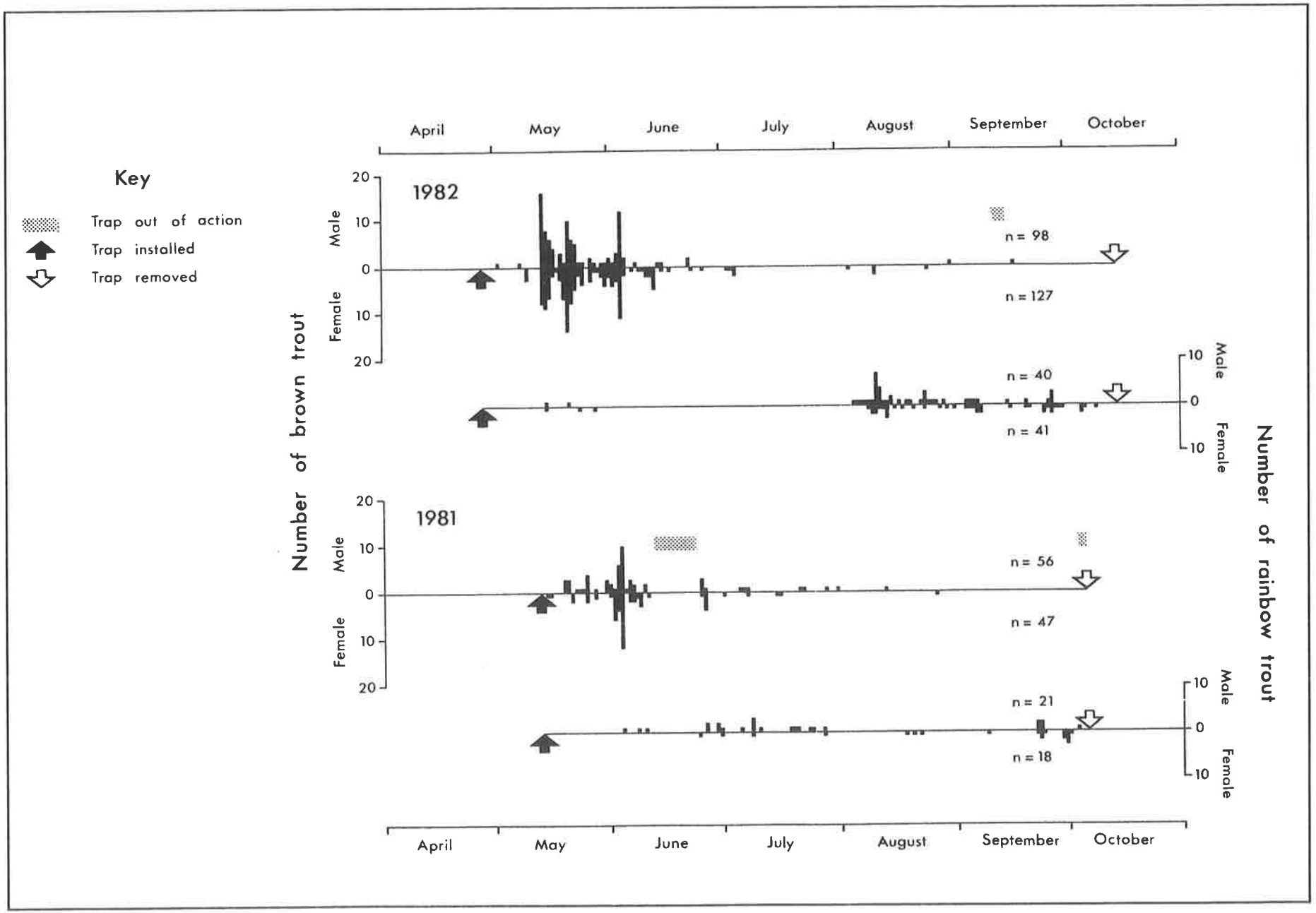

FIGURE 5. Number of brown and rainbow trout captured per day in the Maerewhenua River trap, 1981 and 1982.

Balmain (1956) in Scotland, and Gustafson (1951) in Norway.

There are indications that the brown trout spawning migration started earlier and lasted longer in the upstream tributary, the Hakataramea, than in the tributaries further downstream (Figs. 4, 5, and 6).

4.3 Timing of the Rainbow Trout Spawning Migration

A few rainbow trout entered the tributaries from April to July, but the migration peaked in August and September and finished in October (Figs. 4, 5, and 6). About 80% of the total rainbow run was trapped during the 50 days of the main migration. The main male rainbow trout spawning migration occurred 10 to 20 days earlier than the female migration in the Hakataramea River (Fig. 4 and FFC unpublished data).

The migrations in the Maerewhenua probably were delayed by droughts. In 1981, mainly males entered in late June and July. Flows then dropped and the main migration of females occurred only after the flows increased in mid September. Also, during June and July 1982, a prolonged drought reduced flows in the Maerewhenua River to less than 0.6 m^3/s. Flows increased on 7 and 14 August to 2.6 m^3/s, which probably induced the main migration.

A number of the early-migrating rainbows were observed feeding on quinnat salmon eggs washed downstream during spawning. Because very few of these rainbows were in spawning condition, they were probably opportunistic feeders rather than early migrants.

The daily catches of brown and rainbow trout in the Hakataramea River trap in 1982 and 1983 were compared to environmental variables such as the phase of the moon, mean daily flows of the Waitaki and Hakataramea Rivers, and daily water temperatures (Figs. 7 and 8). No obvious relationships were apparent, although time-series analyses were not attempted.

4.4 Length of Brown and Rainbow Trout

Length frequency distributions of male and female brown and rainbow trout caught in the Hakataramea trap in 1982 and 1983 are shown in Figure 9. Most trout ranged in length from 30 cm to 60 cm. Fish smaller than 21 cm may have squeezed through the trap mesh. The largest trout caught in the various traps was 77 cm.

Mean lengths ranged from 40 cm to 52 cm and declined over the study period (Fig. 10). On average, male trout were longer than females, and brown trout were longer than rainbow trout. Hakataramea trout generally were larger than trout caught in the other traps.

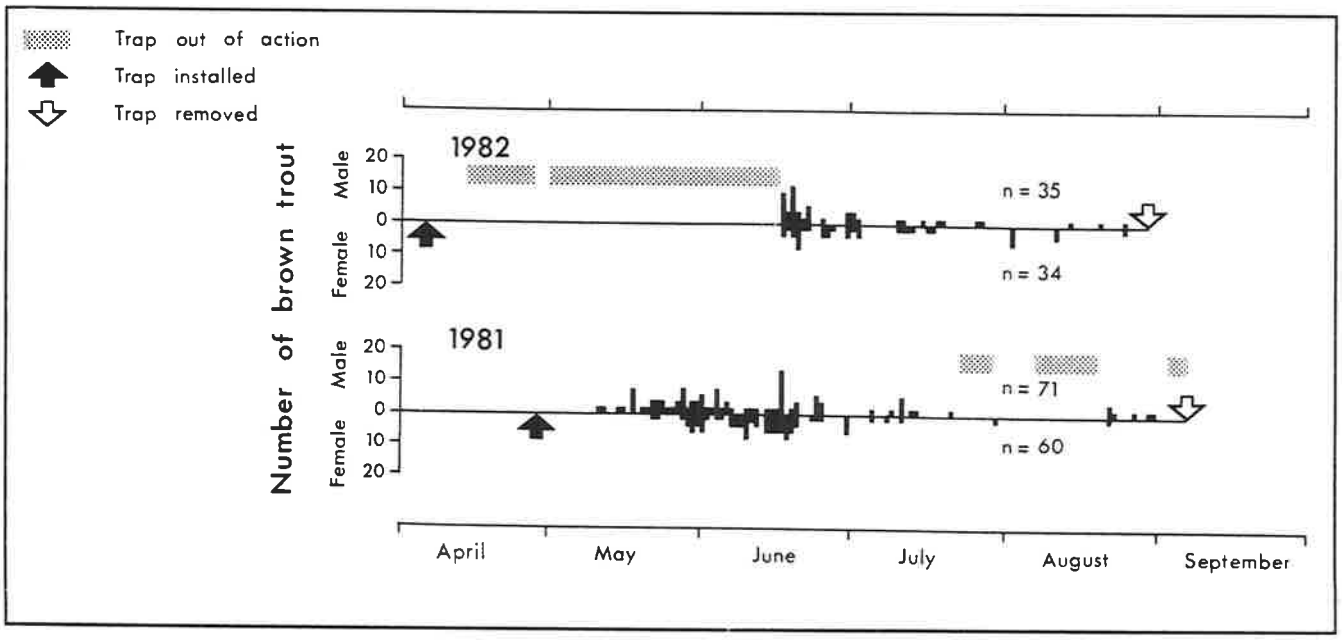

FIGURE 6. Number of brown trout captured per day in Welcome Stream trap, 1981 and 1982. (Note: one female rainbow trout was captured on 28.05.81.)

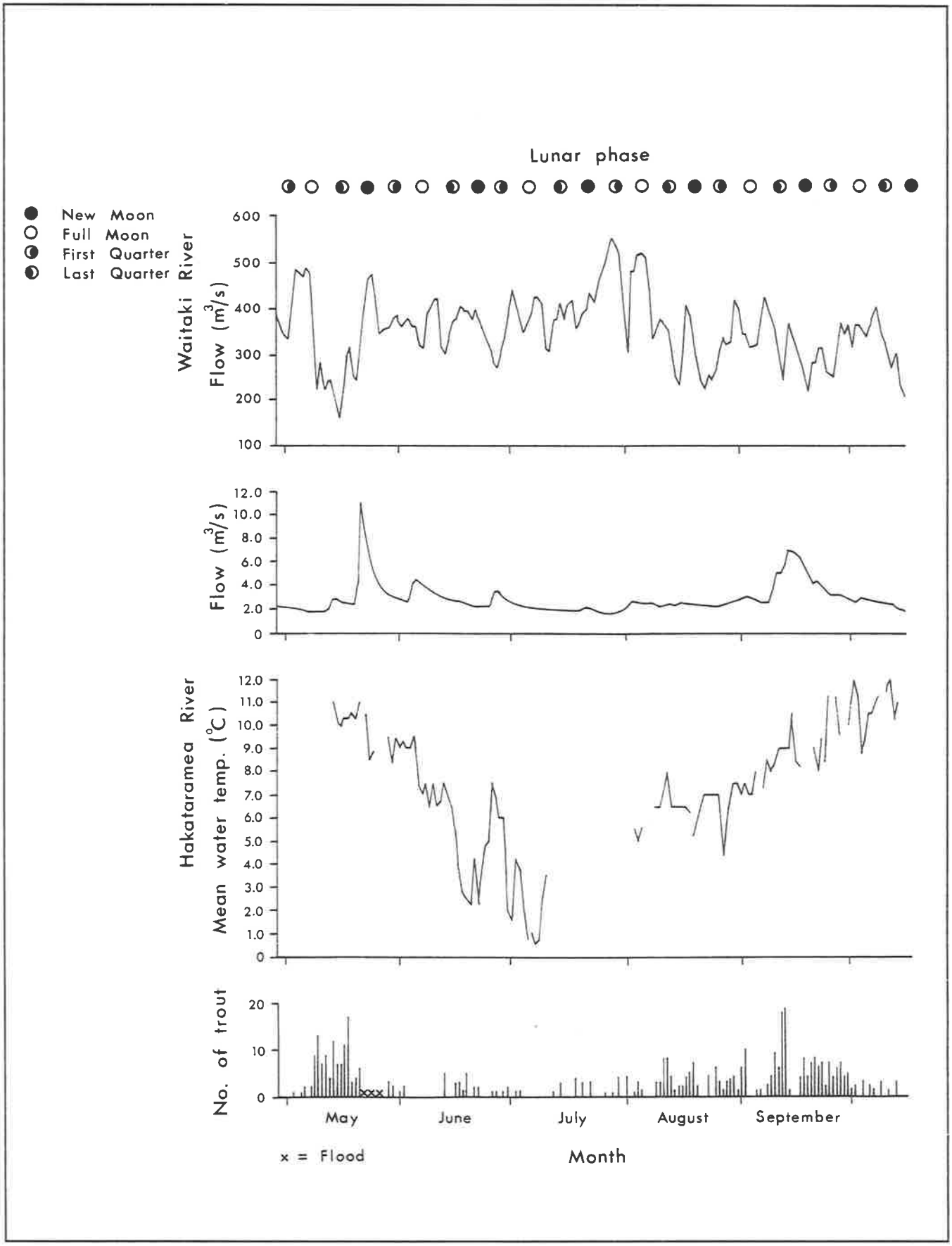

FIGURE 7. Number of trout captured per day, mean water temperature, and mean daily flow during the 1982 spawning run in the Hakataramea River. Mean daily flow in the Waitaki River and lunar phases also are shown.

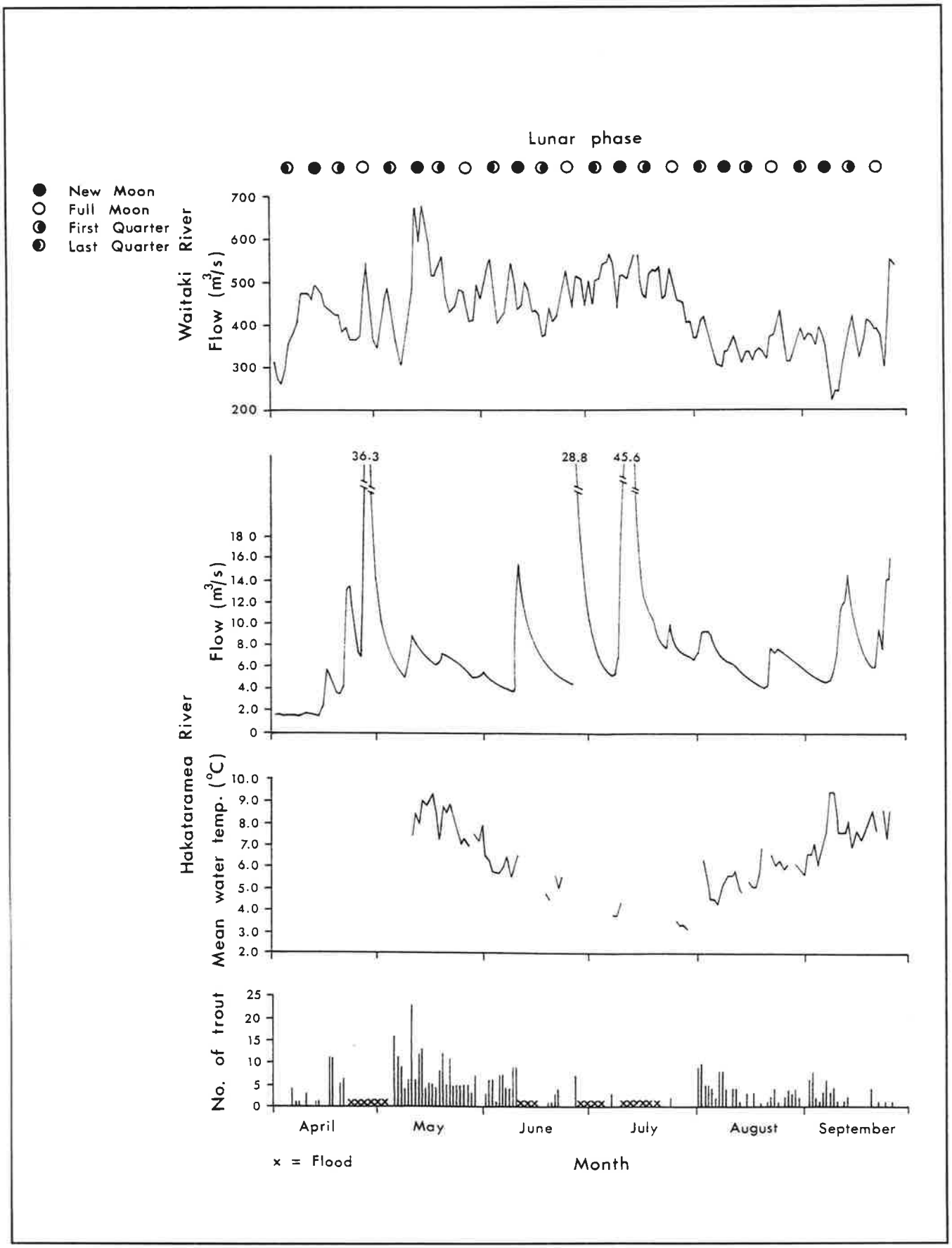

FIGURE 8. Number of trout captured per day, mean water temperature, and mean daily flow during the 1983 spawning run in the Hakataramea River. Mean daily flow in the Waitaki River and lunar phases also are shown.

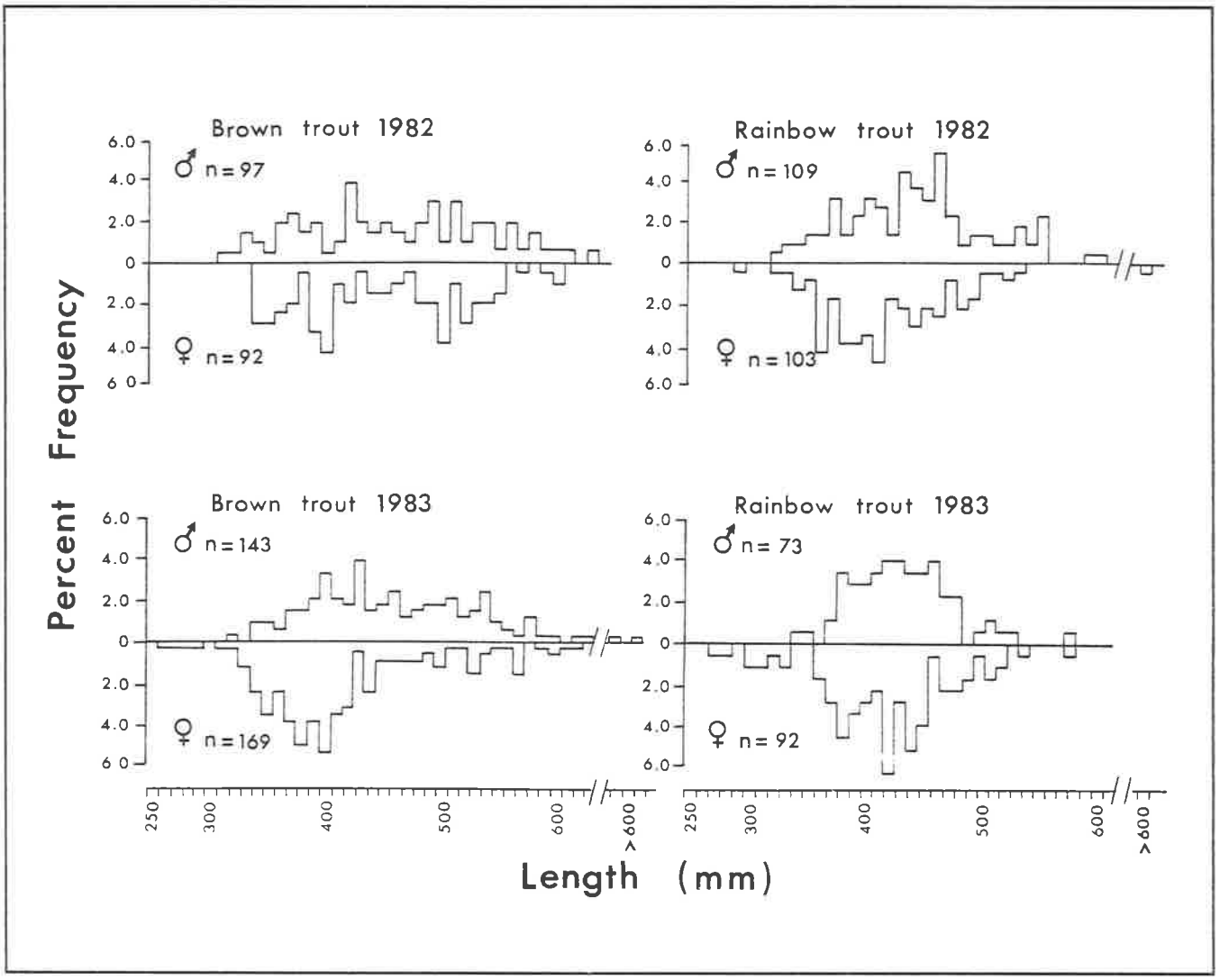

FIGURE 9. Length frequency of male and female brown and rainbow trout captured in the Hakataramea trap, 1982 and 1983.

4.5 Condition Factor

The condition factor of the trout was inversely proportional to their mean length, and generally increased during the study period (Fig. 11). Females had higher condition factors than males, and rainbow trout had higher condition factors than brown trout.

4.6 Sex Ratios, Maturity, Fecundity, and Number of Ova Deposited

For both species, the sexes usually were present in approximately equal numbers (Table 2). Sex ratio could have been influenced by floods and timing of the installation of the traps. Most of the fish captured in the traps were ripe, although between 10% and 20% of the total catch (mostly brown trout) were either maturing or spent.

From August onwards, a steady stream of spent brown trout was caught migrating upstream during the rainbow trout run. Most were large males, in below average condition. In the Hakataramea River in 1982, condition factors for 27 of these spent males and 18 females averaged 97 and 106, respectively.

For rainbow trout, fecundity averaged 2771 eggs per female and was equal to $9.26 \times 10^{-6} \times L^{3.23}$, where L = length in mm ($r = 0.78$, $n = 12$). For brown trout, the average number of eggs per female was 2070 (with $n = 4$, no meaningful equation for fecundity could be written). Therefore, an average of approximately 1.1 million trout eggs could be deposited per annum in the Hakataramea and Maerewhenua Rivers (Table 3). The number of fry produced is unknown and would depend upon the severity of floods, predation, and other mortality factors.

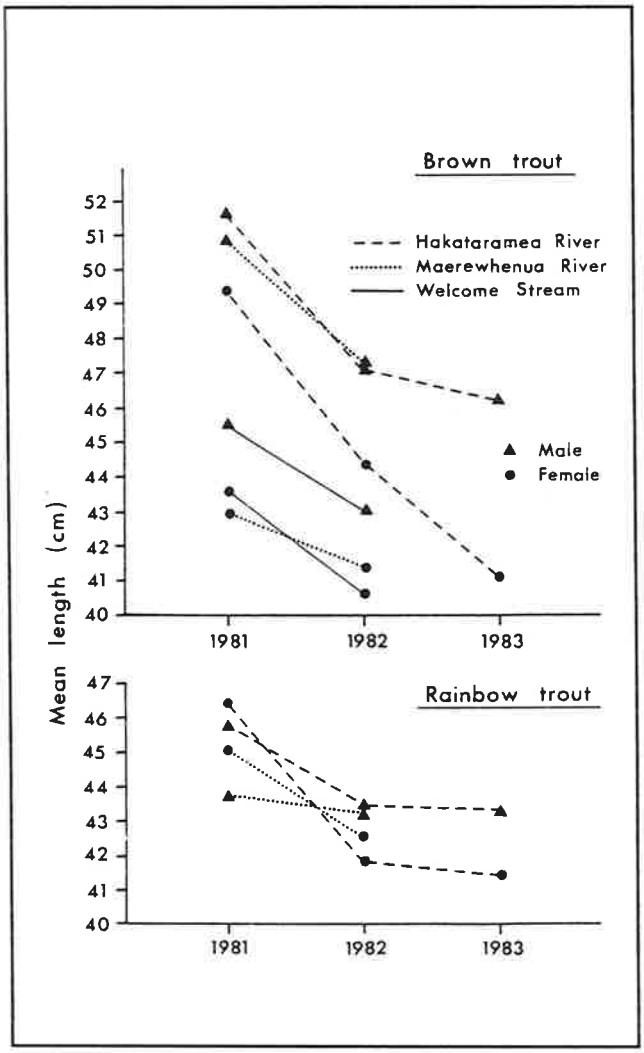

FIGURE 10. Changes in mean length of brown and rainbow trout trapped in the Hakataramea and Maerewhenua Rivers and Welcome Stream, 1981-1983. (See Table 1 for sample sizes.)

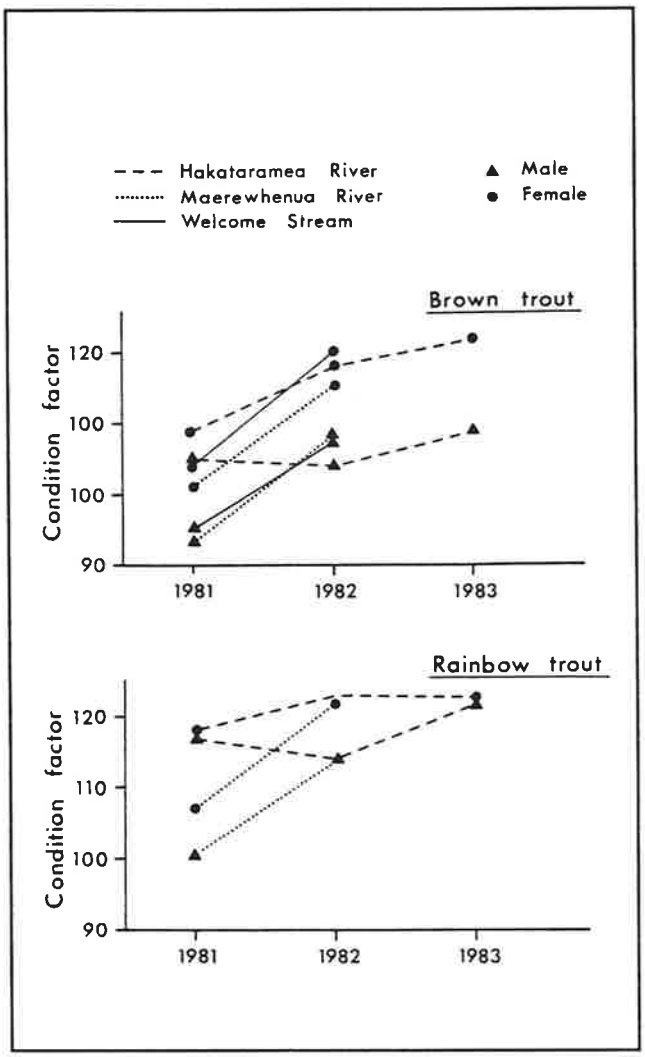

FIGURE 11. Changes in the condition factor of brown and rainbow trout trapped in the Hakataramea and Maerewhenua Rivers and Welcome Stream, 1981-1983.

TABLE 3. Potential number of eggs deposited by the estimated average run of brown and rainbow trout in the Hakataramea and Maerewhenua Rivers.

	Hakataramea		Maerewhenua	
	Brown trout	Rainbow trout	Brown trout	Rainbow trout
No. of females spawning	200	90	140	40
No. of eggs (average)	2 070	2 771	2 070	3 059
Potential egg deposition	410 000	250 000	290 000	120 000

TABLE 4. Mean length of repeat spawning trout at initial tagging, and growth rate per year (365 days) between tagging and recapture.

	Hakataramea River		Maerewhenua River
	BT	RT	BT
No. of trout	21	6	7
Mean length (mm)	515	452	495
Standard deviation	39	40	77
Growth (mm/yr)	25	41	32

BT = brown trout.
RT = rainbow trout.

4.7 Age and Growth

Information on growth was obtained from the recapture of tagged fish and from netting and scale reading of immature fish (Palmer 1986). The scales of old and sexually mature trout appeared to have absorbed edges and so were not used to determine age or growth.

Fish tagged at the traps and recaptured at the traps approximately one year later had mean growth increments of 25 mm to 41 mm (Table 4). Size-specific growth rates (annual increments versus length at the beginning of the year) were plotted for these tagged fish and for 179 brown trout caught in the demonstration channels (Palmer 1986). The data indicated that brown trout between three and eight years old averaged 363, 425, 474, 511, 537, and 554 mm in length, respectively.

4.8 Movement and Survival

Fifteen of the 1743 trout trapped in the tributary streams had been trapped and tagged originally in the demonstration channels, and two had been netted at the Waitaki River mouth. Of these, 12 rainbow trout had been trapped in the demonstration channels, presumably during their spawning migration, and were re-trapped 12 days later, on average (range 2-31 days) in the Hakataramea River, some 27 km upstream. None was caught in the nearby Maerewhenua trap. The remaining four brown trout and one rainbow trout remained at large for an average of 260 days (range 98-359 days).

Tagged trout sometimes were recaptured, either as spent fish on the upstream side of a trap, or by anglers in the spawning tributary during the next fishing season, or trapped as returning fish a year later. No tagged trout were caught by anglers in the mainstem Waitaki River.

A small percentage (1.9 - 2.9%) of the trapped trout were recaptured as dead spent fish on the upstream side of the traps. These fish had spent, on average, 59 days upstream. An additional 24 trout were caught by anglers in the spawning stream (Table 5), 113 days, on average, after tagging. Another 43 trout were trapped as sexually mature repeat spawners returning to the tributary in which they had been tagged originally (Table 5). Two brown trout spawned for three years in a row in the Hakataramea.

The fate of the remaining trout is unclear. No doubt some died after spawning within the tributaries, whilst most migrated downstream to the lower Waitaki during floods (Hobbs 1948) or after the traps had been removed.

5. DISCUSSION

5.1 Size of Spawning Runs

The spawning runs into the three tributaries studied were estimated to total 810 brown trout and 260 rainbow trout per annum (see Section 4.1). This is only a small fraction of the estimated stock of 20 000 trout (>20 cm in length) in a 55-km-long reach of the lower Waitaki River (Graybill *et al.* 1988). The reasons why relatively small numbers of trout spawn in these tributaries are not known and are being investigated. Although some trout spawn in other tributaries, such as the Awakino, and some brown trout spawn in the main river, many more trout would be expected to spawn in the tributaries which were trapped.

Spawning runs in the upper Waitaki catchment (Table 6) also appear to bear little relationship to the size of the waters in which the adult trout live. The runs in the Tekapo system seem low in comparison to the Haldon Arm of Lake Benmore (<0.5 adult trout per ha of lake surface) (McCarter 1987), and high in Scotts Creek, which feeds the small, but productive, Lake Alexandrina (approximately 4.5 adult trout per ha) (Hayes 1984).

5.2 Length and Condition Factor

Comparisons were made between the features of mature trout trapped in the lower Waitaki River system and those trapped in tributaries of lakes in the upper Waitaki catchment (Table 7). There were no significant differences between these two localities in the mean length of brown trout ($p = 0.16$, two-way analysis of variance, Wilkinson 1987) or in the condition factor of rainbow trout ($p = 0.63$). However, on average, brown trout were in poorer condition ($p = 0.02$) and rainbow trout were smaller ($p = 0.003$) in the lower Waitaki than their counterparts in the upper Waitaki. The reasons for these two differences are not known, as there is insufficient information available on comparative fish ages, growth rates, and diets in the two localities.

The small differences in mean length and condition factor between trout in the lower Waitaki tributaries are not thought to have any ecological significance. The reasons for the comparatively large size of female brown trout entering the Hakataramea trap in 1981 are unknown.

TABLE 5. Tagged fish recaptured in traps one year later and caught by anglers in the season after release.

Sex	Trap	Year	No. tagged	Recaptures Trap	Recaptures Anglers	% recaptured Trap	% recaptured Anglers
Brown trout							
Male	Hakataramea	1981	73	6	0	8	0
	Hakataramea	1982	97	5	0	5	0
	Maerewhenua	1981	55	4	5	7	9
	Maerewhenua	1982	92	-	4	-	4
	Welcome	1981	70	1	2	1	3
	Total		387	16	11	5.4*	2.8
Female	Hakataramea	1981	83	6	0	7	0
	Hakataramea	1982	92	5	1	5	1
	Maerewhenua	1981	46	3	4	6	9
	Maerewhenua	1982	122	-	0	-	0
	Welcome	1981	64	4	2	6	3
	Total		407	18	7	6.3*	1.7
Rainbow trout							
Male	Hakataramea	1981	27	2	0	7	0
	Hakataramea	1982	118	1	0	1	0
	Maerewhenua	1981	21	0	0	0	0
	Maerewhenua	1982	40	-	0	-	0
	Total		206	3	0	1.8*	0
Female	Hakataramea	1981	25	1	1	4	4
	Hakataramea	1982	121	3	2	2	2
	Maerewhenua	1981	18	2	1	11	6
	Maerewhenua	1982	38	-	2	-	5
	Total		202	6	6	3.7*	3.0

* = excludes Maerewhenua 1982.

There was a marked decline in the size of brown and rainbow trout trapped in the lower Waitaki from 1981 to 1982. The reasons for this also are not known - it could be due to the influx of a strong year class of small fish in 1982 or a high mortality of larger fish between 1981 and 1982. Changes in environmental conditions and growth rates also could be responsible.

The larger size of male trout is not unusual (Munro and Balmain 1956, Stuart 1957), and may be due to differences in growth rate or kype length.

5.3 Sex Ratios

The equal sex ratios found in the lower Waitaki tributaries contrasts with the situation in the upper

TABLE 6. Estimated size of brown and rainbow trout spawning migrations in the Waitaki River system.

Location	Brown trout	Rainbow trout
Hakataramea River	390	170
Maerewhenua River	270	90
Welcome Stream	150	0
Demonstration channels (1)	80-300	0
Grays River (2)	90	10
Mary Burn (2)	280	100
Tekapo River (2)	320-1250	15-450
	1250	450
Scotts Creek (3)	60	2900

(1) = Palmer 1986.
(2) = FFC unpublished data.
(3) = Hayes 1984.

Waitaki (Table 7), where male trout usually were more abundant in tributaries of Lake Benmore and less abundant in the Ohau River and Scotts Creek. The reasons for these differences are unknown.

5.4 Survival Rates of Trapped Trout

A low percentage of trout was recaptured in the traps as repeat spawners. On average, 5.8% of the brown trout were repeat spawners (Table 5), which is less than the 19% recorded from Glenariffe Stream (Davis *et al.* 1983) and the 15% in a Scottish system (Munro and Balmain 1956). However, it exceeds the return rates of 3.9% observed in the Tekapo River system (FFC unpublished data) and 2.8% recorded from the lower Waitaki River demonstration channels (Palmer 1986). Only 2.7% of the rainbow trout were repeat spawners, and this is much lower than the return rates of 15% recorded in a Canadian lake tributary (Hartman *et al.* 1962), 8% in the Tekapo River system, and 7.7% in the demonstration channels.

TABLE 7. Mean length, condition factor (CF), and sex ratio for brown and rainbow trout trapped in the Waitaki system.

		Brown trout					Rainbow trout				
		Mean length (mm)		Mean CF			Mean length (mm)		Mean CF		
Location	No. of years trapped	M	F	M	F	% males	M	F	M	F	% males
Lower Waitaki system											
Hakataramea River	3	478	440	107	118	48	437	421	117	123	49
Maerewhenua River	2	485	418	103	111	48	435	434	110	117	52
Welcome Stream	2	447	425	100	110	51	-	-	-	-	-
Demonstration channels [a]	2	445	415	108	115	67	437	403	114	118	49
Tekapo system											
Grays River [b]	1	501	457	115	119	74	573	560	111	105	75
Mary Burn [b]	3	496	420	107	113	71	489	481	114	118	63
Tekapo River [b]	3	484	418	108	118	51	494	482	113	119	55
Ohau River [b]	1	445	399	121	130	31	459	441	112	128	33
Scotts Creek [c]	2	565	568	-	-	31	559	561	-	-	36

- = no data.
a = Palmer 1986.
b = FFC unpublished data.
c = Hayes 1984.

Survival rates after trapping and spawning are influenced by factors such as tagging and handling techniques (Hartman *et al.* 1962), water temperatures, and food supplies (Hobbs 1948). In some waters, such as Lake Hayes, brown trout are reported to spawn only every second year (R.T. Hutchinson, DOC, pers. comm.).

It is not known why such a relatively low percentage of repeat spawners was found in this study. Angling pressure was probably not important, as less than 3% of the tags from trapped fish were returned by anglers. It is presumed that most of the spent fish either died in the spawning streams or died in the lower Waitaki River, where there is believed to be a shortage of large food items suitable for large trout (Rutledge in press).

6. IMPLICATIONS FOR POWER DEVELOPMENT

Stocks of rainbow trout in the present lower Waitaki River probably depend upon recruitment from the tributaries. Spawning surveys also have revealed a scarcity of rainbow trout redds in the mainstem Waitaki River (K. Deverall pers. comm.). Extensive electric fishing has shown that, although brown trout fry are present throughout the lower Waitaki and the demonstration channels, rainbow trout fry are virtually absent. Since very few juvenile rainbow trout have been reported from the demonstration channels, rainbow trout in any future residual river will probably need access to both the Hakataramea and Maerewhenua tributaries.

As well as the tributaries, brown trout use the main braids and the side braids of the Waitaki mainstem, and the spring-fed streams, for spawning. Should the total area available for spawning decrease, the brown trout population may diminish.

It is also important that adequate flows are maintained in the tributaries during the spawning runs, otherwise fish may superimpose redds or spawn in marginal areas. The minimum flows necessary for upstream migrations to occur are believed, from personal observations and from Figures 7 and 8, to be about 1.2 - 1.6 m^3/s in the Hakataramea and 0.8 - 1.3 m^3/s in the Maerewhenua.

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