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DISTRIBUTION OF SMALL MIGRATORY FISH AND SHRIMPS IN THE WAIKATO RIVER AT NGARUAWAHIA

by

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Report to: Electricorp Production (Northern Thermal Group)

Confidential to client

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SUMMARY

To determine the effect of the Huntly Thermal Power Station discharges on the migration of small fish and shrimps into catchments above Huntly, fish migration was monitored by trapping at Ngaruawahia, below the confluence of the Waipa River, from October 1988 to March 1989. Inanga (Galaxias maculatus) was the most commonly caught species followed by shrimps (Paratya curvirostris), common bullies (Gobiomorphus cotidianus, elvers (Anguilla australis and A. dieffenbachii), and kokopu species (Galaxias fasciatus), G. argenteus, and G. postvectis). Inanga tended to avoid the left bank (which receives water from the Waipa River), but all the other species were attracted to it. Avoidance of the left bank by inanga was strongest during periods of high river levels when the Waipa River is most turbid. Catch-release experiments using stained fish revealed that most species are adept at crossing the river channel. It was concluded that the distribution of fish and shrimps at Ngaruawahia was not affected by the Huntly Thermal Power Station but that the water quality of the Waipa River influenced migrations.

1. INTRODUCTION

Every year, juveniles of at least 10 native fish species (inanga (Galaxias maculatus), banded kokopu (G. fasciatus), giant kokopu (G. argenteus), short-jawed kokopu (G. postvectis), koaro (G. brevipinnis), smelt (Retropinna retropinna), common bullies (Gobiomorphus cotidianus), shortfinned eels (Anguilla australis), longfinned eels (A. dieffenbachii), and the freshwater shrimp (Paratya curvirostris)) migrate from the sea or estuary up the Waikato River (Boubee et. al. 1986).

Inanga is regarded as a lowland species which occurs mostly in pools, backwaters, and swamps (McDowall 1980). Typical adult habitats of the kokopu species include swamps and swampy creeks (giant kokopu), small bush streams (banded kokopu and shortjawed kokopu), and tumbling rocky streams in native forest (koaro) (McDowall 1978). Smelt remain largely within river channels and lowland lakes but can move some distance into tributaries. Shrimps exploit the bottom and margins of rivers and streams while common bullies are found in most water bodies. Jellyman (1977) noted that shortfinned eels prefer low-lying swamps, streams and lakes, while longfinned eels penetrate further upstream to inhabit swift flowing, stony rivers.

In the Waikato catchment, streams and wetlands which were formerly suitable for fish have been affected by drainage, stopbanks, and floodgates. Access to upstream adult habitats also has been restricted by the construction of hydro-electric dams, water supply dams, weirs, and culverts. Prior to development, waterfalls and stretches of fast turbulent water prevented upstream migration of most species (e.g. Horahora rapids which were submerged by the Karapiro dam). Apart from these obvious migration blocks, point-source pollutant discharges (including thermal outfalls), which cause a deterioration in water quality, can disrupt access to upstream habitats.

At Huntly, the site of New Zealand's largest thermal power station, fish migrate mainly along the river margins where water velocities are lowest (Stancliff et al. 1988a; Schicker et al. 1989). The power station discharges up to 38 m^3s^{-1} of heated effluent on the true left bank of the Waikato River. This discharge can curtail fish and shrimp migration along the left margin (Stancliff et al. 1989) and could potentially affect recruitment to populations upstream. Particularly at risk is Lake Waahi and its catchment, as access is via Waahi Stream which enters the river just upstream of the power station (Fig. 1). Recruitment to populations in the more extensive habitat of the Waipa River system, which joins the Waikato River 15 km upstream of Huntly, also could be affected.

The migration of small fish and shrimps was monitored just downstream of the Waipa River confluence to determine whether the changes in their in-river distribution at Huntly affects recruitment to populations in the Waipa catchment.

2. METHODS

2.1 Trapping

The upstream migration of small fish and shrimps was monitored, at approximately weekly intervals, from 2 stands located on the Waikato River about 2 km below the confluence of the Waipa River, between 5 October 1988 and 7 March 1989.

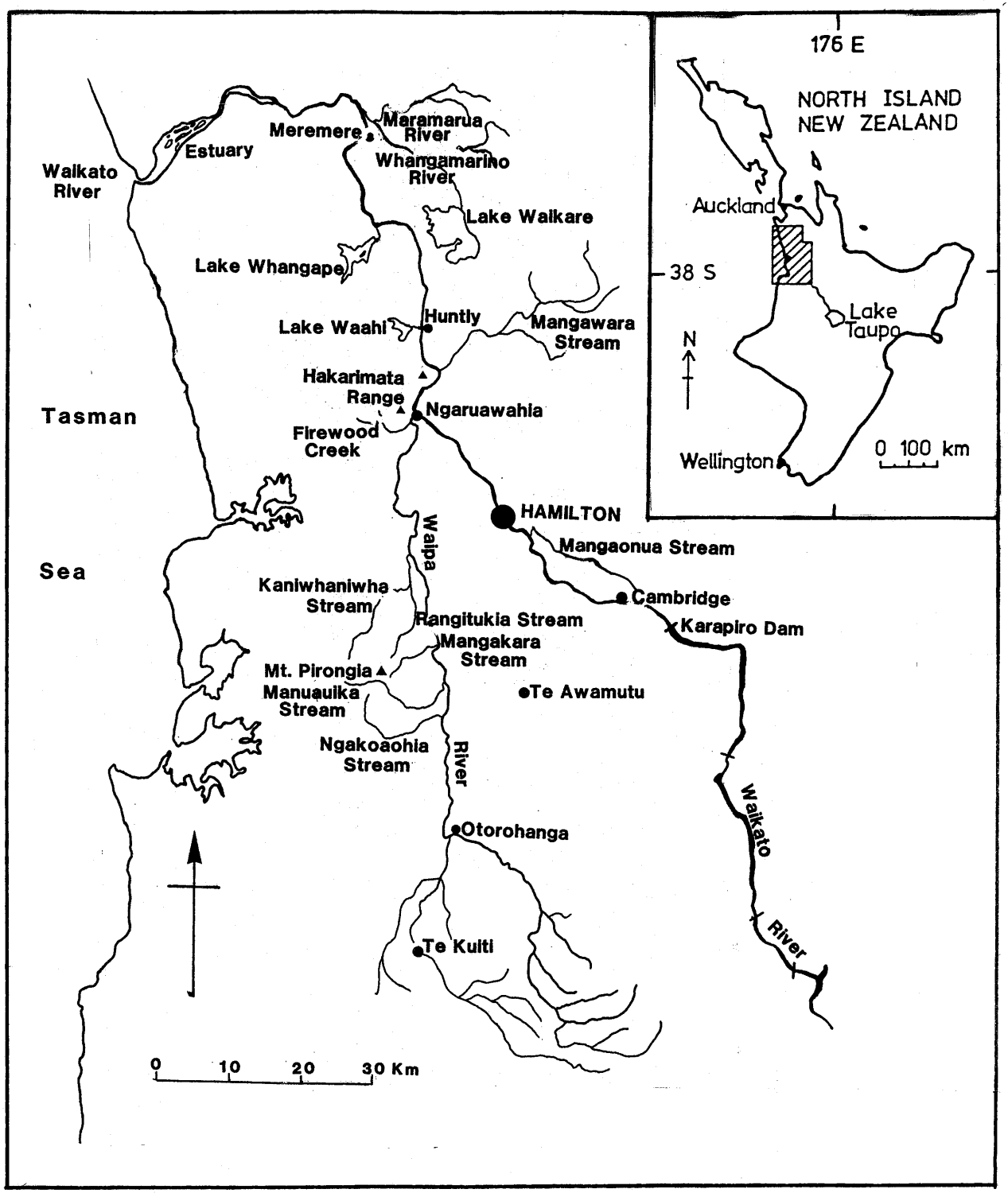

FIGURE 1. Map of the Lower Waikato River and Waipa River Systems.

Transverse mixing of Waipa and Waikato waters occurs only slowly below the Waipa confluence, and the more turbid Waipa water is confined to the true left bank for several kilometres downstream of the confluence (pers. obs.). One stand located on the left bank (NZMS260 S14/998929) was situated in a zone of substantially unmixed Waipa water, whereas the right bank stand (NZMS260 S14/999928) sampled Waikato water. Consequently, the left and right bank stands are hereafter referred to as the "Waipa" and "Waikato" stands, respectively.

Fish and shrimps were caught in 2-mm-mesh traps, set from solid wooden stands which blocked off the entire river margin. Each trap sampled the uppermost metre of the water column. All traps were set in the morning and lifted in the early evening. Traps were then reset and left in position overnight. The entrances were screened at night with 10 mm plastic mesh to prevent eels from entering and feeding in the traps.

When catches were small, the number of each species was counted. When more than 200 fish were caught, a representative subsample was taken and the rest of the catch was weighed to the nearest 10 g and released upstream. The proportion (% by weight) of each fish species in the subsample and the mean weight of each species were then used to back-calculate the number of each species in the total catch. Shrimps were weighed to the nearest 5 g.

2.2 Mark-recapture experiments

To determine cross-channel movement at the sampling sites juveniles of inanga and kokopu species (banded, giant, and shortjawed) were batch-marked by immersion in dye, as described by Stancliff *et al.* (1989). Marked fish were then released about 200 m below the trapping sites which were monitored for at least 24 hours after each release. Recaptured individuals were counted and released about 20 m upstream of the recapture site.

2.3 Additional sampling

To further monitor the upstream migration of kokopu species into the Waipa River, traps were set overnight at 2 additional locations. On 4 occasions, traps were set along the true right bank in Firewood Creek (NZMS260 S14/978888), a tributary of the Waipa River which supports a population of banded kokopu (Fig. 1). On 8 November 1988, a trap was set from the end of a natural promontory on the left bank of the Waikato River 2 km upstream of the Waipa confluence (NZMS260 S14/009899).

3. RESULTS

3.1 Inanga

Catches of inanga were significantly higher at the Waikato stand than at the stand on the opposite bank (Wilcoxon Matched-pairs Signed-ranks test, 2-tailed $P = 0.0000$). Nevertheless, catches at the two stands were similar for the first seven sampling dates and, up to the 22 November 53.8% of the total catch of 2127 inanga were trapped at the Waipa stand (Table 1). Thereafter, and until the end of February, catches were much lower at the Waipa stand, particularly on the 3 occasions when the river was high and laden with silt (Table 1). A seasonal plot of the Waipa River flow and of the proportion of the inanga catch at the Waipa stand shows an inverse relationship between river flow and catch ratio (Fig. 2).

TABLE 1. Number of juvenile inanga caught in traps set in the Waikato River downstream of the Waipa River confluence.

Date	Left bank (Waipa side)	Right bank (Waikato side)
5.10.88	0	2
25.10.88	84	2
27.10.88	60	0
2.11.88	207	283
7.11.88	320	178
16.11.88	50	11
22.11.88	424	506
30.11.88	58*	1298
7.12.88	438	2656
15.12.88	2240	5517
18.12.88	1728	5887
23.12.88	1746	2400
27.12.88	6064	11915
4.01.89	9675	14745
8.01.89	281	833
11.01.89	145*	3532
31.01.89	418	1115
5.02.89	55*	151
13.02.89	501	935
19.02.89	28	47
27.02.89	25	20
7.03.89	1284	1396
15.03.89	155	159
21.03.89	9	8
30.03.89	8	2
7.04.89	7	3
19.04.89	0	0
Total	26010	53601
% of total catch	32.7	67.3

* = high silt load

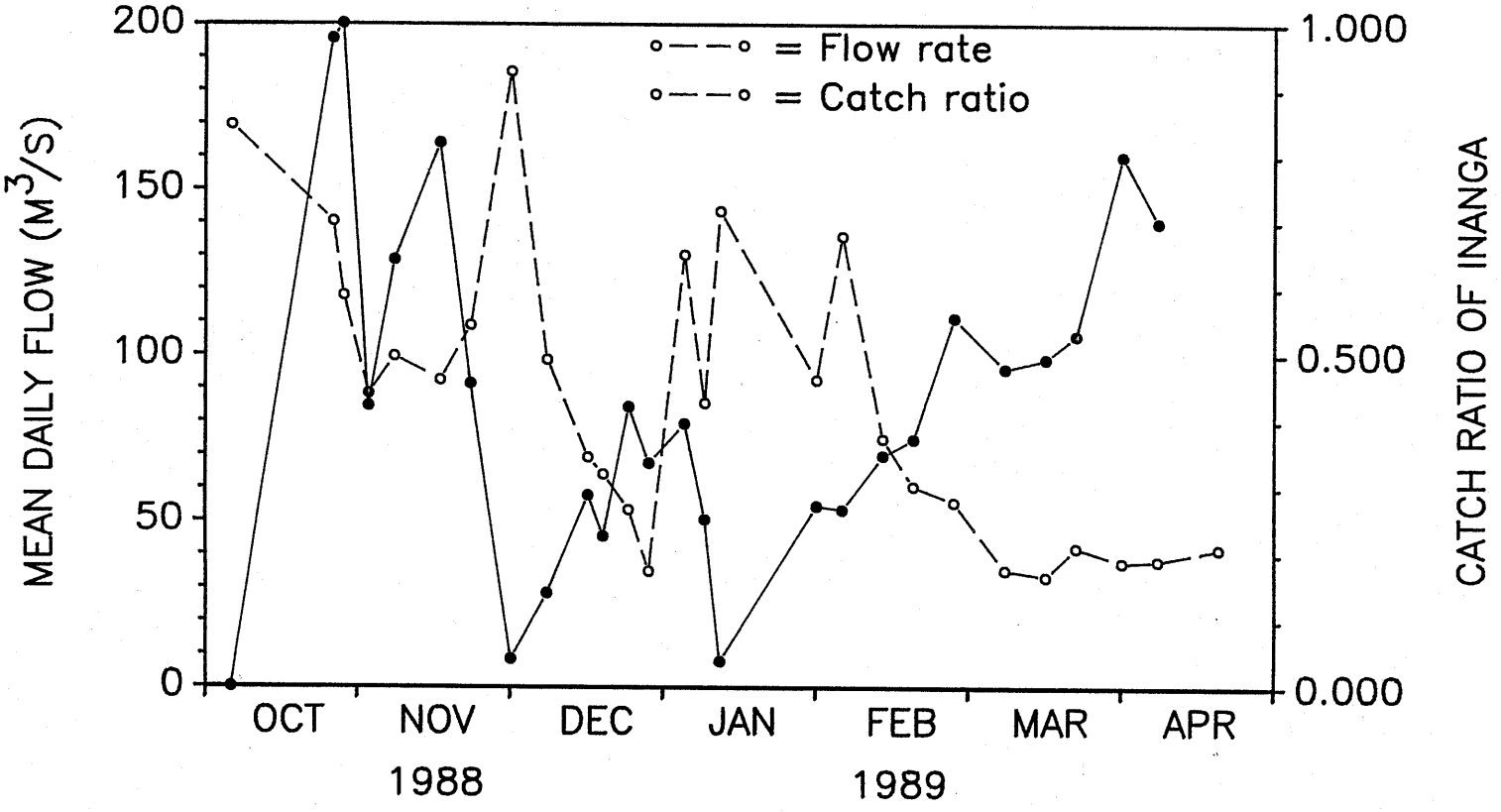

FIGURE 2. Seasonal plot of the mean daily flow of the Waipa River at Whatawhata and of the ratio of inanga caught on the left bank (Waipa side) to the total catch (left + right bank). (Flow data courtesy of the Waikato Regional Council).

Marked inanga usually were recaptured directly upstream of their release sites. However, on 2 occasions, when low recaptures of Waikato-released fish were made, a large proportion was caught at the opposite (Waipa) stand (Table 2). Overall, fewer inanga crossed from the Waipa to the Waikato side of the river than vice versa.

Table 2: Percent recaptures of marked juvenile inanga released approximately 200 m downstream of two stands on the Waikato River below the Waipa River confluence.

Releases			% Recaptured		% of recaptures crossing the river
Site	Date	n	Waipa side	Waikato side	
Waipa	2.11.88	159	6.29	0.00	0.00
	1.02.89	768	62.76	1.56	2.43
Waikato	2.11.88	244	6.97	0.41	94.40
	8.11.88	123	8.94	14.63	37.90
	1.02.89	492	2.03	46.54	4.20

3.2 Kokopu species

Juvenile kokopu (largely banded kokopu) were caught only between 25 October and 22 November in 1988. Most were caught at the Waipa stand (Table 3).

On the 2 occasions when juvenile kokopu species were marked, only a small percentage were recaptured. A relatively large number of the recaptures was made at the stand opposite the release site (Table 4), indicating high cross channel movement.

During additional sampling on 8 November 1988 (see section 2.3), six marked kokopu (out of 139 released) were recaptured in the trap set on the true left bank of the Waikato River within the Ngaruawahia township. This site was 4 km upstream from the release site and on the opposite margin. Such a high recapture rate, given the distance of travel, the need to cross the river channel, and the likely low efficiency of the trap, suggests that kokopu prefer to continue their migration up the Waikato River rather than enter the Waipa system. Nevertheless, a small number of kokopu species were caught on all occasions when traps were set in Firewood Creek (Table 5).

3.3 Common bullies

Common bullies were recorded throughout the sampling period, with slightly higher catches (57.0%) at the Waipa stand (Table 6).

3.4 Shrimps

Shrimps were caught mostly during the night. Catches generally were higher along the left bank, with 63.7% trapped at the Waipa stand (Table 7). The difference between the 2 sides was particularly marked in November.

3.5 Elvers

Like shrimps, most elvers were caught at night, with the majority trapped at the Waipa stand (Table 8).

TABLE 3: Numbers of juvenile kokopu caught in traps set in the Waikato River downstream of the Waipa River confluence.

Date	Left bank (Waipa side)	Right bank (Waikato side)
5.10.88	0	0
25.10.88	70	4
27.10.88	137	4
2.11.88	94	34
7.11.88	183	49
16.11.88	50	15
22.11.88	17	3
30.11.88	0	0
7.12.88	0	0
15.12.88	0	0
18.12.88	0	0
23.12.88	0	0
27.12.88	0	0
4.01.89	0	0
8.01.89	0	0
11.01.89	0	0
31.01.89	0	0
5.02.89	0	0
13.02.89	0	0
19.02.89	0	0
27.02.89	0	0
7.03.89	0	0
15.03.89	0	0
21.03.89	0	0
30.03.89	0	0
7.04.89	0	0
19.04.89	0	0
Total	551	109
% of total catch	83.5	16.5

TABLE 4: Percent recaptures of marked kokopu species released downstream of the two stands on the Waikato River below the Waipa River confluence.

Releases			% Recaptured		% of recaptures crossing the river
Site	Date	n	Waipa side	Waikato side	
Waipa	2.11.88	25	8.00	4.00	33.3
Waikato	2.11.88	18	5.56	16.67	25.0
	8.11.88	139	3.60	3.60	50.0

TABLE 5: Numbers of kokopu species and inanga captured in traps set in Firewood Creek and along the left bank of the Waikato River at Ngaruawahia.

Sites	Firewood Creek		Ngaruawahia Township	
Date	Kokopu	Inanga	Kokopu	Inanga
26.10.88	2	3	-	-
28.10.88	3	0	-	-
2.11.88	2	0	-	-
7.11.88	2	1	-	-
8.11.88	-	-	21*	6

- = trap not set
* = includes 6 marked kokopu

TABLE 6: Number of common bullies caught in traps set in the Waikato River downstream of the Waipa River confluence.

Date	Left bank (Waipa side)	Right bank (Waikato side)
5.10.88	4	1
25.10.88	1	2
27.10.88	2	12
2.11.88	11	10
7.11.88	3	17
16.11.88	6	2
22.11.88	19	12
30.11.88	14	8
7.12.88	63	9
15.12.88	0	5
18.12.88	52	24
23.12.88	37	0
27.12.88	62	29
4.01.89	267	30
8.01.89	134	133
11.01.89	99	113
31.01.89	41	30
5.02.89	150	151
13.02.89	83	173
19.02.89	80	85
27.02.89	47	33
7.03.89	319	260
15.03.89	309	217
21.03.89	94	63
30.03.89	5	4
7.04.89	0	9
19.04.89	0	0
Total	1902	1432
% of total catch	57.0	43.0

TABLE 7: Weight of shrimps in grams caught in traps set in the Waikato River downstream of the Waipa River confluence.

Date	Left bank (Waipa side)	Right bank (Waikato side)
5.10.88	-	-
25.10.88	-	-
27.10.88	-	-
2.11.88	305	15
7.11.88	250	5
16.11.88	150	5
22.11.88	240	5
30.11.88	50	0
7.12.88	350	105
15.12.88	280	125
18.12.88	70	85
23.12.88	80	75
27.12.88	70	45
4.01.89	240	30
8.01.89	395	710
11.01.89	155	50
31.01.89	300	160
5.02.89	80	30
13.02.89	90	40
19.02.89	150	15
27.02.89	120	80
7.03.89	230	95
15.03.89	180	260
21.03.89	40	65
30.03.89	120	170
7.04.89	10	75
19.04.89	5	10
Total	3960	2255
% of total catch	63.7	36.3

- = traps not set overnight.

TABLE 8: Number of elvers caught in traps set in the Waikato River downstream of the Waipa River confluence.

Date	Left bank (Waipa side)	Right bank (Waikato side
5.10.88	-	-
25.10.88	-	-
27.10.88	-	-
2.11.88	37	3
7.11.88	58	0
16.11.88	85	14
22.11.88	2	3
30.11.88	125	30
7.12.88	13	46
15.12.88	0	0
18.12.88	0	16
23.12.88	0	0
27.12.88	12	0
4.01.89	102	0
8.01.89	66	0
11.01.89	76	0
31.01.89	12	0
5.02.89	12	5
13.02.89	4	0
19.02.89	0	0
27.02.89	7	0
7.03.89	0	0
15.03.89	0	0
21.03.89	0	0
30.03.89	0	0
7.04.89	0	0
19.04.89	0	0
Total	611	117
% of total catch	83.9	16.1

- = traps not set overnight.

4. DISCUSSION

It is likely that the catch efficiency of traps used in this survey varied according to species, features of the site, river flow, and water depth. If there is in addition an attraction/repellant effect of Waipa waters (we suspect this from the variation in the number of marked fish crossing to the opposite bank), then there is no effective means of determining the efficiency of the traps. In comparing catches therefore, we have had to assume that trap efficiency was the same on both stands and that the number of fish caught was representative of the migration along each river margin.

4.1 Inanga

Stancliff et al. (1988b) noted that a significant proportion of inanga which migrated past Meremere power station utilised habitats upstream of Huntly. Thus, although inanga are regarded as a lowland species (McDowall 1978), the low gradient of the lower Waikato River system allows inanga to move upstream as far as the Karapiro dam on the Waikato River, the Otorohanga weir on the Waipa River, and to Te Kuiti, via Waipa River tributaries (Stancliff et al. 1988b). Indeed, surveys by the Waikato Catchment Board (WCB) of streams in the eastern Pirongia catchment, which drains into the Waipa River, revealed that inanga were the most commonly occurring galaxiid (WCB 1989). Disruption of the inanga migration at Huntly could therefore affect a significant proportion of the inanga population of the Waikato.

Numbers of inanga migrating upstream in the Waikato River below the Waipa confluence in October and November appeared to be similar on both banks. However, at the peak of the migration in December and January, most inanga were captured along the right bank. This could have been caused by fish avoiding the thermal plume and crossing to the right bank at Huntly to continue their migration upstream. However, during part of this period (23/12/88 - 06/01/89), the power station was shut down and migrations at Huntly could not have been disrupted by thermal discharges.

Mitchell (1989) gave the mean sustainable swimming speed of inanga as 0.19 ms^{-1}. Inanga, therefore could have covered the distance between Huntly and the stands at Ngaruawahia (a distance of 13 km) in 1 or 2 days. A chance recapture at Ngaruawahia of a marked inanga released at Huntly confirms this. The Huntly power station therefore is unlikely to have influenced the distribution of inanga below the confluence of the Waipa and Waikato rivers.

Examination of catch records reveals that the proportion of inanga caught on the left bank was particularly low during flood discharges from the Waipa River. In a survey of water quality of the Waipa River (WVA 1987), it was noted that all sites became more turbid after periods of heavy rain. At high flows there can be marked increases in suspended solids (Fig. 3), which cause a significant discolouration of the Waikato River below Ngaruawahia. Therefore inanga may be showing an avoidance to silt or to some other factor associated with the water quality of the Waipa River.

4.2 Kokopu species

Juvenile kokopu species and koaro undoubtedly enter tributaries downstream of Huntly during migration, but a substantial proportion of the population utilises habitats upstream of Huntly. In this study, we recorded juvenile kokopu migrating upstream both in Firewood Creek and in the Waikato River (Ngaruawahia township). Hanchet (1989) found banded kokopu adults to be widely distributed

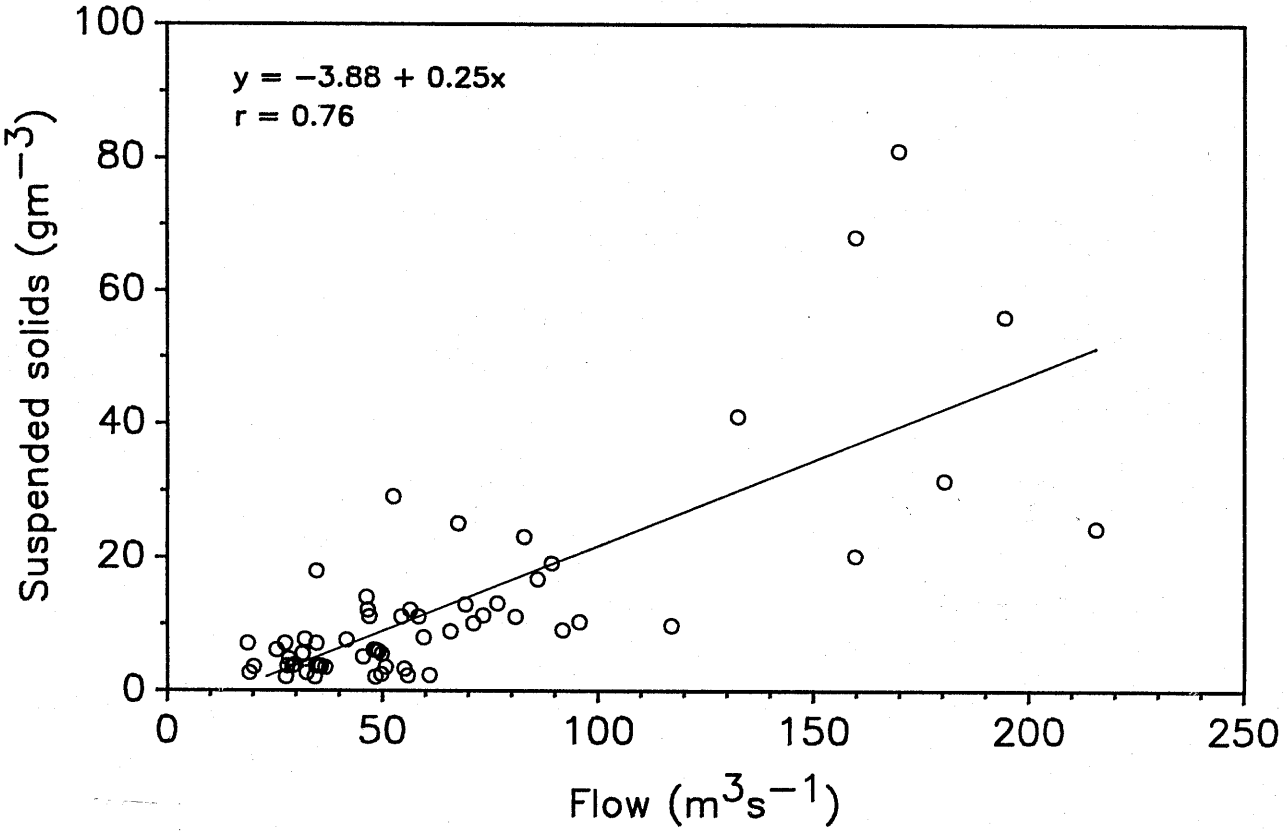

FIGURE 3. Plot of mean daily flow of the Waipa River at Whatawhata versus suspended solids of the Waipa River at Ngaruawahia, 1982-1988. (Flow data courtesy of Waikato Regional Council).

throughout headwater streams which drain the Hakarimata Range between Huntly and Ngaruawahia. Adult giant and shortjawed kokopu also were found in bush streams draining these hills. West (1989) captured shortjawed kokopu in the Mangakara Stream (Pirongia) and in an unnamed Hakarimata stream. No juveniles were caught in these streams.

A recent study by Stancliff et al. (1988b) found that juveniles of koaro, banded kokopu, and giant kokopu move upstream rapidly, and are present in the Waikato River below Huntly from mid-August to late November. During this time, ambient river temperatures are low (<18 ^{0}C), and plume temperatures do not appear to be high enough to curtail the migration of these species along the left bank of the river. Nevertheless, migration past the power station was still impeded, and the high water velocity at the outfall was identified as an additional problem (Stancliff et al. 1989).

By releasing marked banded kokopu, Stancliff et al. (1989) showed that this species could negotiate the station outfall by crossing the river to the ambient right margin. From mark-recapture experiments conducted at Ngaruawahia we found that kokopu can cross the river within a short distance of their release site. Therefore, if these fish were forced to avoid the station outfall at Huntly by crossing to the right margin, they have 15 km of river to return to the left margin before they reach the Waipa confluence. Indeed, most kokopu species caught at Ngaruawahia were captured along the Waipa side of the river which confirms that they were able to continue their migration past the power station by crossing the river. However, it appears that most kokopu continue upstream along the Waikato River past Ngaruawhahia and that few enter the Waipa River. As the largest area of suitable kokopu habitat remaining in the Waikato occurs in the Waipa catchment, this avoidance of the lower Waipa River has serious implication for the survival of the population.

4.3 Common bullies

Large numbers of juvenile common bullies migrate upstream past Huntly. Adults have been found in all habitats surveyed in the Waikato (MAF Fisheries unpub. data, WVA 1986b, WCB 1989).

Common bullies have a higher thermal tolerance than most fish species in the Waikato River (Simons 1984), but they too, at times will avoid the power station's discharge. Stancliff et al. (1989) suggested that common bullies move upstream along the river bottom to avoid the thermal plume. Therefore disruption to their upstream migration should be minimal. This is supported by the distribution that we found at Ngaruawahia, where similar numbers were caught on both sides of the river.

4.4 Shrimps

Stancliff et al. (1988a) found that shrimps migrate mostly at night and this observation was confirmed in our study. Shrimps have been described as being more temperature sensitive than either inanga or common bullies (Simons 1984), and have been found to die in summer when exposed to continuously high temperatures of 27.5 ^{0}C (Town 1982). They are therefore thought to be particularly vulnerable to thermal discharge.

To avoid high water temperature and velocity discharges at Huntly power station, Stancliff et al. (1988a) suggested that shrimps are able to walk and cling to the substrate in mid stream, in order to continue their upstream migrations. Shrimp distribution at

Ngaruawahia shows that a large number migrate along the Waipa margin, to which they appear to be attracted. Huntly power station therefore does not appear to seriously disrupt their migration and distribution.

4.5 Elvers

Hanchet (1989) recorded both species of eel in streams draining the Hakarimata Range, with longfinned eels occurring throughout the area and shortfinned eels found most often in slow moving, lowland, pastoral streams and swamps. West (1989) sampled streams draining Mt. Pirongia and found longfinned eels to be the most common fish in headwater streams, with shortfinned eels occurring mainly in the middle reaches of streams in pastoral land. Surveys by the Waikato Catchment Board of the eastern Pirongia catchment found juvenile and adult longfinned and shortfinned eels to be the most abundant fish species present in the catchment (WCB 1989). The larger waterways surveyed (Kaniwhaniwha, Ngakoaohia, Mangauika and Rangitukia) were fished periodically by commercial fishers. In the Mangaonua catchment, which enters the Waikato River above Ngaruawahia, the longfinned eel was found to be the most commonly recorded fish (WVA 1986). Large populations of longfinned eels populate Lake Karapiro (Boubee et al. 1989) and large numbers of elvers have been seen ascending the spillway of the dam (Cairns 1941, Jellyman 1977).

Since elvers can migrate across the river bottom (Schicker et al. 1989) and have a high thermal tolerance (Simons 1984), it is unlikely that their upstream migration will be impeded by the Huntly power station's thermal discharge. Elver distribution below the Waipa confluence showed that most moved upstream at night and that they appeared to be attracted to the Waipa River.

5. CONCLUSION

Juveniles of inanga, three kokopu species, common bullies, elvers, and shrimps migrate in large numbers up the Waikato system (Table 9). Catch records and catch-release experiments below the Waipa confluence (this study) and at Huntly (Stancliff et al. 1989) showed that all species were adept at crossing the river channel, and did so regularly. The discharge of heated effluent at Huntly does not appear to seriously disrupt fish migration into habitats upstream of Ngaruawahia. However, the water quality of the Waipa River appears to have a significant effect on the distribution of fish. Laboratory studies should be made to determine to what extent changes in water quality parameters such as silt loading, interfere with migration of fish and shrimps

Table 9: Relative abundance of migratory fish (numbers) and shrimps (g) captured in traps set in the Waikato River below the confluence of the Waipa River for 24 hours, at approximately weekly intervals from 5 October 1988 to 19 April 1989. (n = 27).

Species	Left bank (Waipa side)	Right bank (Waikato side)	Total
Inanga	26010	53601	79611
Shrimps	3960	2255	6215
Common bullies	1902	1432	3334
Elvers	611	117	728
Kokopu	551	109	660

6. ACKNOWLEDGEMENTS

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