Aspects of the fish ecology in the Heathcote River; Colombo Street to Opawa Road

Prepared for Christchurch City Council

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Contents

Executive Summary

An aquatic survey of the Heathcote River was undertaken between Colombo Street and Opawa Road during March and April 2004. The main objective was to assess the biodiversity and quality of the instream ecology, and compare its status with that from previous studies. Updated information would also provide ecological information that could be integrated into a river management plan for the reach.

Eleven fish habitats were electric-fished, supplemented by overnight fyke-net sets at eight deep-water locations. The catch comprised eight fish species. In order of abundance these were common bully, shortfin eel, longfin eel, bluegill bully, yellow eye mullet, upland bully, giant bully, and inanga. Of these the bluegill bully had not been recorded from the study area previously.

A bank treatment study, using a similar technique to that used in an Avon River survey, indicated that the highest fish densities in the Heathcote River were associated with banks with overhanging flaxes. Banks with other bank treatments, including overhanging toetoe, grasses, and quarried rock, had lower fish densities.

The riparian habitat along the study reach could be improved for fish values by the inclusion of more varied bank vegetation and the reduction of bank angles. The provision of more vegetated terraces to accommodate flood flows would also provide refugia for fish during high flows. Inanga spawning habitat, at the downstream limit of the study area, has undergone plant community succession. The restoration and maintenance of this habitat is detailed in a separate report.

Given the ongoing residential development in the upstream catchment, it is recommended that the physical substrate of silt-sensitive habitats be monitored for sediment build-up. This included both trout spawning and bluegill bully rearing habitats.

1 Introduction

The study area was the reach of the Heathcote River mainstem from Colombo Street downstream to Opawa Road. The first comprehensive fisheries survey of the Heathcote River included this reach (Eldon *et al.* 1989), at a time when the Woolston Diversion was in effect. Inanga spawning activity was also monitored during the late 1980s to late 1990s (Taylor 1999), and two trout spawning surveys were conducted in the winters of 1996 and 2003, with trout redds recorded in the study area in the later survey (Taylor 1996; Taylor 2003b). An update of inanga spawning in the study area was undertaken in autumn 2004 (Taylor & McMurtrie 2004).

Recent studies upstream of the study area, but with ecological links to it, include the surface water management study for South-West Christchurch (McMurtrie *et al.* 2004). Several species found in this study form part of the estuarine fauna found further downstream of the study area (Nairn 1998; Webb 1972).

2 Objectives

The purpose of this study is to provide information on the fish ecology of the study reach, specifically the Heathcote River between Colombo Street and Opawa Road. Recommendations could be considered for integration into the appropriate Area Management Plan, including considerations relating to surface water management, and works related to subdivision development, roading, bridging, and river banks.

The objectives for this study can be summarised into three categories:

1. To ecologically assess the Heathcote River's fish habitat between Colombo Street and Opawa Road. This will include a comparison, where possible, with ecological studies conducted in the 1980s.

2. To investigate the relationship between fish communities and bank treatment, and to discuss bank management options in respect to enhancing the habitat for fish.

3. To discuss impacts on the fish fauna from land-use practices, including bank management and subdivision development.

3 Study Area

The Heathcote River follows a serpentine course for approximately 7.8 km between Colombo Street and Opawa Road. The river forms three tight loops, which for the purpose of this report, are termed the Beckenham loop, the St Martins loop, and the Hansens Park loop (Fig. 1).

The downstream limit of the surveyed reach, Opawa Road, is nine kilometres from the sea, and is the upstream limit of seawater intrusion (Robb & Cooper 1994). Despite the study reach being comprised of fresh water, approximately 60% of the study area length is tidally influenced, with some spring-tide water level fluctuations discernable at Buxton Terrace, upstream of the Tennyson Street Bridge (J. Walter, CCC, pers. comm.).

Most (93%) of the study reach flows as a sluggish run, with a number of discrete sections of fast run, predominantly within the Beckenham loop. The fast runs have a combined length of approximately 560 m, or 7 % of the study area length. There were no fast shallow flows downstream of Wilsons Road. A long run/riffle sequence extends downstream of Colombo Street (near Site 1), with another fast run downstream of the Malcolm Avenue Bridge, (near Sites 2 and 3), and downstream of the Tennyson Street bridge (near Site 9).

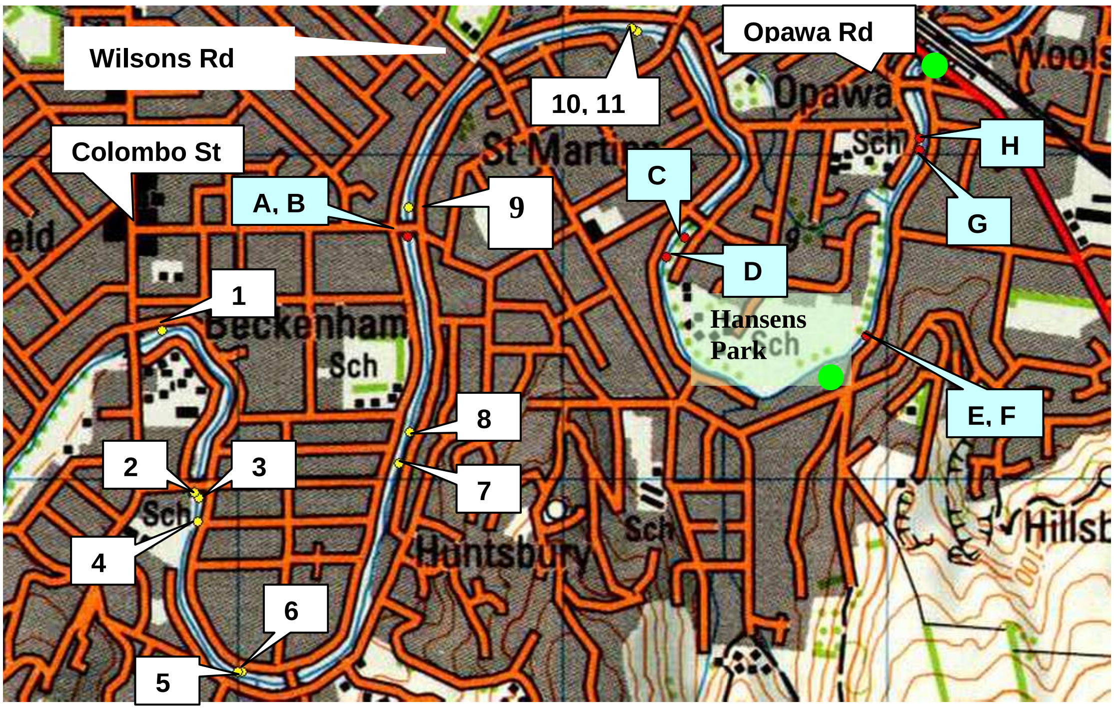

Figure 1. The study area. Yellow dots = Invertebrate sampling and electric fishing sites (Sites 1 to 11). Red dots = fyke net locations (Sites A-H). Large green dots indicate inanga spawning habitat detailed in Taylor and McMurtrie, 2004. Blue grid squares represent 1 km.

Substrate composition was predominantly silt, with coarser particles (gravels) present in the fast-flowing section within the Beckenham Loop (i.e. downstream of Colombo Street).

Most of the banks in the study reach were steep, as the river is entrenched for most of the distance, but is setback from the road by only several metres. Variation in bank treatment was rather low, most banks were vegetated in steep mown grass, with little visible cladding. Over the last 15 years, some of the banks have been revegetated in native plants, the most extensive planting being at King George V reserve opposite Hansens Park.

4 Methods

4.1 Fishing techniques

A Kainga EFM 300 packset was used for electric fishing, the conventional and appropriate fishing technique for fishing the relatively shallow sites (i.e. depth < 0.7 m). A setting of 200 Volts was normally used, the minimum level required to achieve an effective electric field for small fish with a current of 300-400mA. Electric fishing serves only to briefly (approx. 3 seconds) render fish unconscious to facilitate their capture in nets for identification. Overall conditions for fish capture using electric fishing were adequate, owing to the reasonable water conductivity and clarity. The machine incorporates a timer, allowing the effective fishing time to be recorded.

Fyke nets were used to fish the deeper sections of the study area that were not possible to electric-fish safely or effectively. Netted habitats extended from Tennyson Street downstream to Opawa Road, with intermediate fished locations depicted in Fig. 1. Eight baited fyke nets were set in pairs overnight (21-22/4/04) at four deep-water locations. Fyke nets were single-ended, conventional in design (20 mm stretched mesh), and set with the leader adjacent and perpendicular to the bank. The fishing efficiency of nets A and B may have been jeopardised by leaf litter fouling their entrances overnight.

4.2 Bank Treatment Fish Survey

The procedure described below was used to estimate fish populations within enclosed bank sections. It is a similar technique to that used during the Avon River study (McMurtrie & Taylor 2003). Fish population estimates for the enclosed area were based on a multiple fish-pass method. This enables a statistical estimation of fish numbers based on the exponential decline in captured fish numbers from successive electric fishing passes (Carle & Strub 1978)

Nine riverbank sites were isolated from the main channel using knotless mesh nets (‘Rochelle’, mesh size *ca.* 5 mm), supported by steel posts (Waratah® Star® Posts) (Fig. 2). Enclosed sections were approximately 9 m in length and 1.2 m in wetted width. The bottom edge of the net was weighted with a pliable ‘lead line’ that conformed to the substrate contours, preventing the escape of net-enclosed fish. The net was tensioned and supported by adjustable hooks that were attached to the steel posts.

Figure 2. Netted bank treatment at Site 2, downstream of Malcolm Avenue.

Each netted section was electric-fished at last twice, with the captured fish from each fishing event retained in live boxes away from the fished area. All captured fish were anaesthetised with 2-phenoxyethanol before being identified and measured. Upon recovery from anaesthesia, fish were released back into their resident habitat.

Populations estimates were obtained for the four well-distributed species: shortfin eel, longfin eel, common bully, and upland bully. Usually fish numbers for most species fell steeply with successive fishing 'passes' suggesting high fishing efficiency, probably due to the relatively small enclosed area compared to the effective fishing operation of the electric-fishing machine. This efficiency meant that a third pass was necessary at only three of the heavily vegetated sites, where escapement was expected to be higher. At Site 10 the netted reach was inundated by the tide during fishing, and water depth increased to 91 cm. It is probable that fishing pressure was insufficient at this site to obtain an accurate population estimate.

After fishing, the dimensions of each site were recorded, together with water depth, and the extent that the vegetation overhung the water (vegetated overhang), the bank overhung the water (bank overhang), or the bank undercut. These bank characteristics were measured at the endpoints and midpoint of each site (i.e. three measurement sets), as depicted in Figure 3. Bank undercuts and overhangs were not all present at every site, and were measured or estimated at baseflow water level. Silt depth was measured with a metre-rule, and the degree of substrate embeddedness was visually estimated.

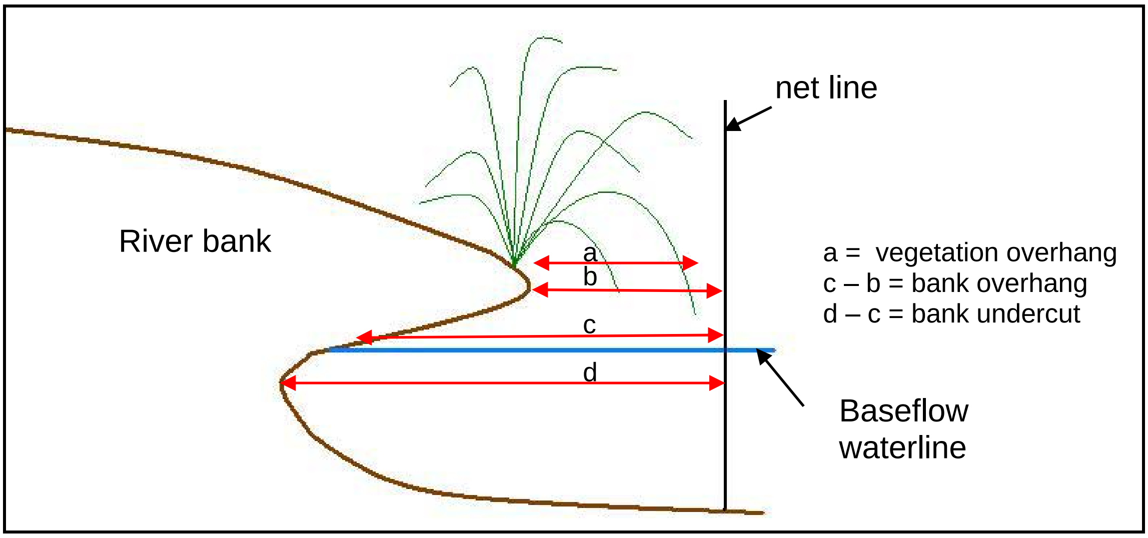

Figure 3. Bank profile depicting field measurements of vegetation overhang, bank overhang, and bank undercut.

4.3 Mid-channel electric fishing

Two mid-channel habitats were fished quantitatively using the same repeat-fishing technique outlined for the bank treatment sites. One site was a section of the fast riffle downstream of Colombo Street (Site 1), while a second site was a shallow reach downstream of Tennyson Street (Site 9). A hand-held whitebait mesh (ca. 3 mm) stopnet was used at both sites, although due to the faster flows, an additional downstream stopnet was deployed at the Colombo Street site.

5 Results

5.1 Electric-fished habitats

Photographs of all 11 electric-fished sites are provided in Appendix I. A total of eight species of fish were identified from electric-fished habitats (Table 1). The most frequently identified fish species were the common bully (*Gobiomorphus cotidianus*) (n=161), and the shortfin eel (*Anguilla australis*) (n =115), with both species found at all sites. Giant bullies, while uncommon, were well distributed and found at six sites, as were longfin eels. Two juvenile giant bullies were recorded, with a length of 27 mm. Upland bullies were found at five sites, inanga at three, and unidentified elvers recorded from two. Yellow eye mullet were frequently observed shoaling within the study area, but were only successfully captured at Site 9. Bluegill bullies were caught in both mid-channel sites (Sites 1 and 9).

5.2 Fish density by bank treatment

Unclad grassy banks were predominant in the study area, but varied widely in the degree of bank undercut (below the baseflow waterline), and bank overhang (above the baseflow waterline)(Table 2). There was a relatively limited proportion of bank length vegetated with native vegetation. However, short sections were vegetated in flaxes, toetoe, and *Carex* grasses.

As with the Avon study (McMurtrie & Taylor 2003), fish densities in this study were calculated for the same predominant species group (i.e. shortfin eel, common bully, longfin eel, and upland bully) (Fig. 4).

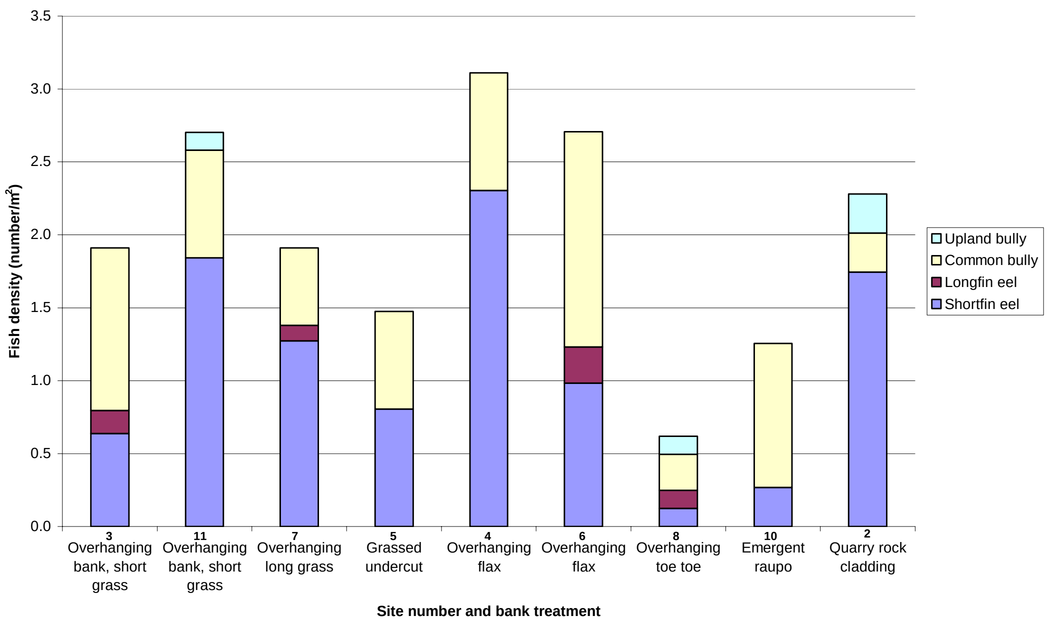

Figure 4. Total fish densities from nine bank treatments on the Heathcote River.

Table 1. Fish catch and fish lengths of the commonly encountered species in the Heathcote River caught by electric fishing. Unshaded columns present data from net-enclosed bank treatment sites. Shaded columns represent sites that were fished across the channel width.

		Site No.											Total
Fish species	Length (mm)	1	2	3	4	5	6	7	8	9	10	11	
Elver	n					1		1					2
	Mean					75.0		68.0					71.5
	Max					75		68					75
	Min					75		68					68
Longfin eel	n	2		1			2	1	1	6			13
	Mean	142.0		317.0			416.5	441.0	805.0	236.7			315.4
	Max	154		317			424	441	805	615.0			805
	Min	130		317			409	441	805	68.0			68
Shortfin eel	n	10	11	4	18	6	8	11	1	27	3	16	115
	Mean	211.8	124.1	317.8	255.2	174.3	364.6	145.0	193.0	196.7	232.3	207.8	212.5
	Max	388	280	609	720	235	586	415	193	455.0	280	409	720
	Min	73	64	134	122	132	168	68	193	68.0	171	32	32
Inanga	n		1							1	1		3
	Mean		46.0							49.0	60.0		51.7
	Max		46							49.0	60		60
	Min		46							49.0	60		46
Yellow-eye mullet	n									15			15
	Mean									275.0			275.0
	Max									300.0			300
	Min									250.0			250
Bluegill bully	n	11								2			13
	Mean	46.2								37.0			44.8
	Max	52								37.0			52
	Min	41								37.0			37
Common bully	n	19	2	7	7	5	11	5	2	88	10	5	161
	Mean	73.6	65.0	71.0	70.9	88.0	75.5	61.8	87.0	62.7	84.9	77.2	68.5
	Max	98	80	103	115	98	105	85	91	133.0	116	103	133
	Min	33	50	48	48	77	42	43	83	29.0	53	44	29
Giant bully	n	2		1		1	1		1			1	7
	Mean	57.5		146.0		139.0	27.0		141.0			27.0	85.0
	Max	70		146		139	27		141			27	146
	Min	45		146		139	27		141			27	27
Upland bully	n	4	2						1	15		1	23
	Mean	47.3	51.5						56.0	46.4		48.0	47.5
	Max	54	53						56	61.0		48	61
	Min	35	50						56	29.0		48	29
	Total n	**48**	**16**	**13**	**25**	**13**	**22**	**18**	**6**	**154**	**14**	**23**	**352**
	Fished area (m^2)	**60.0**	**7.5**	**6.3**	**8.7**	**7.5**	**8.1**	**9.4**	**8.1**	**146.1**	**11.2**	**8.1**	**280.9**
	Density (No./100 m^2)	**80**	**213**	**206**	**287**	**173**	**272**	**191**	**74**	**105**	**125**	**284**	**125**

Table 2. Habitat statistics from electric-fished habitats on the Heathcote River, with site locations depicted in Fig. 1.

Site No.	Bank treatment	Length (m)	Mean Width (m)	Bank over-hang (m)	Vege. over-hang (m)	Total over-hang (m)	Under-cut (m)	Mean depth (cm)
3	Overhanging bank, short grass	6.30	1.00	0.15	0.27	0.42	0.11	42. 0
11	Overhanging bank, short grass	6.60	1.23	0.11	0.25	0.36	0.00	25.3
7	Overhanging grass	7.10	1.33	0.14	0.40	0.54	0.09	28.3
5	Grassed undercut	5.20	1.43	0.15	0.20	0.35	0.40	41.3
4	Overhanging flax	6.20	1.40	0.08	0.81	0.89	0.12	33.3
6	Overhanging flax	5.30	1.53	0.03	1.17	1.20	0.20	61.7
8	Overhanging toe toe	6.13	1.32	0.00	1.67	1.67	0.10	48.7
10	Emergent raupo	6.20	1.80	0.00	1.80	1.80	0.00	90.7
2	Quarry rock cladding	7.90	0.94	0.06	0.00	0.06	0.00	20.3
9	mid-channel	19.40	7.53	0.43	0.30	0.73	0.12	28.7
1	mid-channel	12.00	5.00	0.00	0.25	0.25	0.05	21.0

The fish fauna near the banks comprised mainly shortfin eels and common bullies, with longfin eels present where overhanging vegetation was more prevalent. Upland bullies were recorded where large stone cladding was present, and in lower densities at some sites with overhanging banks or overhanging toetoe. The highest total fish densities were recorded from the two sampled reaches which were vegetated with overhanging flaxes, with a mean density of approximately 2.9 fish/m^2 (Sites 4 and 6)(Fig. 4). Fish densities associated with flax-clad banks with overhanging vegetation crowns, but little bank overhang, where significantly higher than other bank treatments. The flax-clad banks supported higher fish densities, compared to fish numbers associated with grassy banks with overhangs and undercuts, and banks with toetoe or emergent raupo ($p < 0.05$, Kruskal-Wallis). Fish densities associated with the overhanging toetoe, and the emergent raupo bank treatment, were low compared to other treatments.

5.3 Mid-channel catch and fauna (Sites 1 and 9)

Species diversity was higher from the whole-channel sites compared to the bank treatment sites, but the mean fish density was lower than that within the netted bank sites (Table 1). Six species were recorded from Site 1 near the upstream boundary of the study reach; common bully, bluegill bully, shortfin eel, upland bully, longfin eel, and the giant bully, and seven species from Site 9 near Tennyson Street. The mean whole-channel bank-to-bank fish density was 92.5 fish/100m^2, compared to a mean of 203 fish/100m^2 for the netted banks. Bluegill bullies were identified from the two shallow mid-channel habitats.

5.4 Fyke net catch

A total of 104 fish were captured overnight from eight fyke-nets (Table 3). In order of abundance these were shortfin eel, common bully, yellow eye mullet, longfin eel, and giant bully. The mean sizes of captured fish were greater than those obtained by electric fishing owing to the size selectivity of the fyke net mesh. The most productive catches, in terms of fish numbers, were in the reach bordering Hansens Park (Fig. 1, Sites E, F, and G). The most upstream location where yellow eye mullet were recorded was at fyke net location C, immediately downstream of the Beckford Road bridge at Hansens Park. The largest fish caught during the survey was a shortfin eel at 822 mm in length, from the fyke net catch at location E.

Table 3. Statistics of fish caught by fyke net in the Heathcote River between Colombo Street and Opawa Road. Locations of fyke net sets are depicted in Figure 1.

		Fyke Net Site								
Species	**Length (mm)**	**Fyke A**	**Fyke B**	**Fyke C**	**Fyke D**	**Fyke E**	**Fyke F**	**Fyke G**	**Fyke H**	**Total**
Common bully	n			3	5	2	13	2	2	27
	Mean			96.7	96.6	96.5	101.7	94.0	108.5	99.7
	Min			95	90	91	94	92	106	90
	Max			98	111	102	123	96	111	123
Giant bully	n						4	1	1	6.0
	Mean						124.8	131.0	40.0	111.7
	Min						100	131	40	40
	Max						149	131	40	149
Longfin eel	n	1	1	1		1	1	1		6
	Mean	550.0	438.0	780.0		563.0	486.0	676.0		582.2
	Min	550	438	780		563	486	676		438
	Max	550	438	780		563	486	676		780
Shortfin eel	n		1	3		21	8	15	3	51
	Mean		593.0	501.0		501.7	493.6	444.3	477.3	483.8
	Min		593	480		362	365	252	350	252
	Max		593	532		**822**	640	562	622	822
Yellow eye mullet	n			1		1		9	3	14
	Mean			271.0		267.0		247.1	216.0	243.6
	Min			271		267		214	176	176
	Max			271		267		283	250	283
Total n		1	2	8	5	25	26	28	9	**104**
Total Mean length		550.0	515.5	355.5	96.6	462.3	240.6	353.0	259.7	336.0
Total Min length		550	438	95	90	91	94	92	40	40
Total Max length		550	593	780	111	822	640	676	622	822

6 Discussion

6.1 Fauna and comparisons with past studies

Compared to lowland waters elsewhere in New Zealand, the fish fauna in the Heathcote River was regarded as of low diversity (Eldon *et al.* 1989), and the recent survey indicates that this still is the case, as even fewer species were recorded. In January 1989, 10 fish species were recorded from three sites in the study reach. In order of abundance these were the shortfin eel, common bully, inanga, longfin eel, upland bully, giant bully, common smelt, black flounder, yellow eye mullet, and yellow belly flounder. Of these, the common smelt, black flounder and yellow belly flounder were not recorded during the March/April 2004 survey. Seasonal longitudinal changes in the fish fauna between the 1989 and 2004 surveys were regarded to only affect inanga distribution, when adult fish would be concentrated in the lower reaches for spawning.

None of the fish species recorded in the Heathcote River would be regarded as rare or endangered at a national level, although until recently the bluegill bully has been rare in urban reaches of the City.

6.1.1 Bluegill bully

Moderate numbers of bluegill bullies were found during this survey in suitably fast shallow waters, yet Eldon *et al.* (1989) did not record them from the Heathcote River in 1989. Bluegill bullies were first identified from the Heathcote Catchment in Cashmere Stream in February 2004 (McMurtrie *et al.* 2004), so it was pleasing to find them in also in this study area. Their presence in this study, over a reasonable size range, indicates that this attractive native species has established itself in the Heathcote River. This is consistent with our findings in the Avon River where bluegill bullies are much more common than recorded previously in the central city (McMurtrie & Taylor 2003).

It is unknown why bluegill bullies are now present in habitats where they were clearly absent or rare fifteen years ago. Predation by brown trout, while possible, may not be significant, as bluegill bully habitat is amongst the substrate in shallow riffles, seemingly secure from predatory adult brown trout. Competition for space and food between young trout and bluegill bullies may be more likely, but the ecological relationships between these two species is unclear in Christchurch Rivers.

There may be links with invertebrate prey sources for both species. Invertebrate biomass, as a food source, has been shown to account for 45% of the variation in large brown trout numbers in New Zealand Rivers (Jowett 1992). Yet the dependence of native fish populations on invertebrate production appears to be much weaker, despite also being solely dependant on invertebrates for food (McIntosh 2000). Thus, in the Heathcote River mainstem, only native fish can be supported on the limited invertebrate biomass. The same principal may be occurring in the Avon River, where trout and invertebrate diversity appear to be decreasing in the central city, yet bluegill bullies numbers have recently been reported to be increasing (McMurtrie & Taylor 2003).

6.1.2 Brown trout

Brown trout were not recorded from the study reach in 2004, nor in the 1989 survey, although they were present in Cashmere Stream (McMurtrie *et al.* 2004). It was surmised by earlier workers that the absence of brown trout in the Heathcote River was due to the scarcity of adequate spawning gravel (Eldon *et al.* 1989). However, later studies revealed that some brown trout spawning was taking place in the Heathcote River, with gravels utilised in the Heathcote mainstem (Taylor 1996; Taylor 2003b). Within the study area, several trout redds were found in the fast-water section downstream of the Colombo Street bridge, and a number of defined reaches extending a distance of 3 km downstream from this point around the "Beckenham loop" (Fig. 5).

Possibly, the trout population in the middle reaches of Heathcote River is low and transitory, for reasons mentioned in the previous section (i.e. low invertebrate numbers), and the spawning gravels service only fish from the lower reaches and Cashmere Stream. Conversely, Cashmere Stream can support both trout and native fish, possibly because invertebrate numbers and diversity are likely to be higher here, and support more EPT taxa which trout prefer. Pending analysis of invertebrates collected in the study reach will allow comparison of its composition with Cashmere Stream.

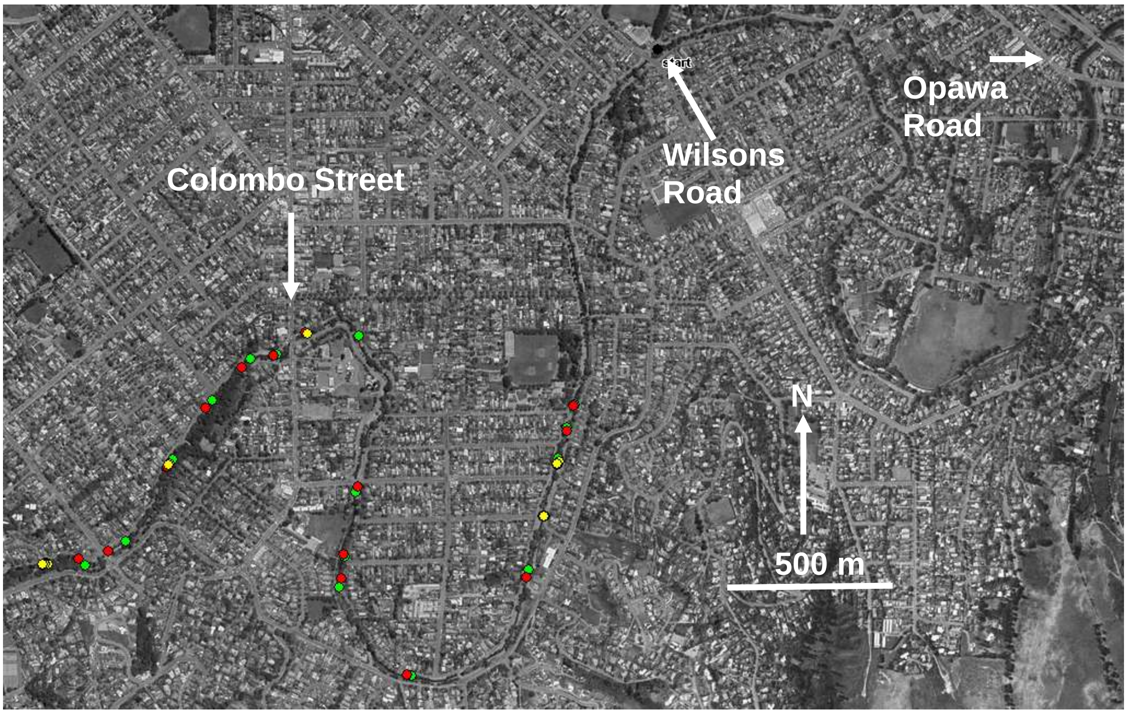

Figure 5. Brown trout redd distribution in the study area (GPS data from (Taylor 2003b)). Trout redds (yellow), upstream limit of suitable spawning gravel (red), downstream limit of suitable spawning gravel (green).

6.1.3 Longitudinal changes in fish distribution

In 1986, the Woolston Diversion was commissioned by the Christchurch Drainage Board as a flood control measure (Robb & Cooper 1994). The Woolston Diversion is a straight artificial channel which rerouted flow from a sinuous section of the lower river, increasing the drainage efficiency of the river during flood flows. The diversion effectively shortened the main river channel by 2.8 km, which allowed estuarine saltwater to penetrate upstream to Armstrong Avenue, well into the survey area. Associated problems with bank instability and the death of riparian trees led to the decommissioning of the Woolston Diversion for non-flood flows in April 1993.

The earlier fisheries study took place in 1989, when the Woolston Diversion was in permanent operation for all river flows. Thus, some of the faunal differences between the 1989 study and that in 2004 are probably attributable to the consequent contraction of the saltwater intrusion after the Woolston Diversion was decommissioned in 1993. This shift would represent a reversion in the ecology to the original state of affairs.

The contraction in the saltwater intrusion has led to a retreat of marine and 'down-river' species from the study reach, with up-river species (e.g. the upland bully) adopting vacated habitats. An example of the faunal changes was noted at Tennyson Street (Site 9, Appendix I), where one of the 1989 survey sites (CDB 139) was re-surveyed using similar fishing methods in 2004. Total fish density at this site was markedly higher during this survey; 105 fish/100m^2 compared to 34.4 fish/100m^2, (Eldon *et al.* 1989), largely due to an 11-fold increase in bully density over that recorded in 1989 (71.9 c.f. 6.4 fish/100 m^2). The largest increase was in common bully numbers, but upland bully, absent from this site in 1989, was also common in 2004. The yellow belly flounder was identified from this site in 1989, but this and other marine fish were absent in 2004. Yellow belly flounder do not penetrate far from saltwater (McDowall 1990). The 'down-river' species, common smelt, found in low numbers in 1989, were not present in 2004. Further downstream, near Hansens Park, the fauna shift since 1989 was also apparent, with an absence of yellow belly flounder and common smelt when this site was repeat-fished with fyke nets.

Changes in the spawning grounds of inanga have been attributed to the decommissioning of the Woolston Diversion in 1993. Inanga are considered to use the saltwater intrusion limit as an approximate guide for locating suitable riparian areas to spawn, but are sensitive to the suitability of the riparian vegetation (Richardson & Taylor 2002). In 1989, inanga spawning was recorded 3.5 km further upstream at Wilsons Road (Eldon *et al.* 1989). However, the known main inanga spawning grounds are now found at the downstream margin of this study area (see Fig. 1 and (Taylor & McMurtrie 2004)). This downstream shift in inanga spawning habitat is broadly consistent with the reported 2.8 km downstream shift in saltwater intrusion due to the 1993 decommissioning of the Woolston Diversion (Robb & Cooper 1994).

Upstream of Tennyson Street, longitudinal changes in fish distribution were less apparent. The fish catch from electric fishing upstream of the Malcolm Avenue bridge in 1989 (CDB site 130) was similar to our results from two of the bank treatment sites (Sites 2 and 3) downstream of the bridge. Upland bullies were present in both surveys, as were common bullies, inanga, both eel species, and the giant bully. While differences in fish densities were apparent between the two surveys, these were consistent with fishing different habitats (i.e. mainstem vs. banks only), rather than temporal changes.

6.2 Mid-channel habitats

Most mid-channel habitats in the Heathcote River were composed of deep slow-flowing runs, but some shallower mid-channel habitats were present, especially in the upstream section of the study area around the Beckenham loop (Fig. 1). Some of these faster reaches provided trout spawning habitat in the winter months (Taylor 2003a), but they also provide hydraulic conditions suitable for native bluegill bully habitat. Bluegill bully has a velocity preference optimum near 0.9 m/s, and a depth optimum of 0.25 m (Jowett & Richardson 1995). The mean depth of the two fished riffles (0.249 m, raw data) was therefore close to the optimal depth for bluegill bullies. However, water velocities, while unmeasured, were probably less than 0.9 m/s during our survey and during summer baseflows. In contrast, the bluegill bully habitat in Cashmere Stream had both optimal velocity, and optimal depth (0.25 m) (McMurtrie *et al.* 2004). High water velocities are probably necessary to ensure that interstitial spaces between cobbles remain free of fine silt. It is these spaces which provide important refuge for the bluegill bully. Levels of interstitial silt and/or substrate embeddedness should be monitored at bluegill bully sites, because the absence of silt is critical for this species.

6.3 Effect of bank treatment on Heathcote River fish communities

A focus of this and other recent studies has been the effect of different bank treatments on local fish communities. An Avon River survey in the CBD (Central Business District) indicated that bank treatment has a significant effect on local fish community structure (McMurtrie & Taylor 2003). Notably, the naturalisation of banks was demonstrated to benefit both fish and aquatic invertebrate communities.

It was anticipated that bank treatment effects on fish communities could be less in the Heathcote River than in the Avon River. This was because Heathcote River banks were more entrenched, and uniform in nature than in the Avon CBD study. Water depths were greater in the Heathcote River, and could offer alternative cover for some fish species (e.g. large trout and bullies) where banks did not provide sufficient refuge. The water depth also restricted sampling options and prevented us from replicating some bank treatments. This study also lacked the degree of replication and experimental control found in the Avon study, mainly because only 11 bank treatment sites could be sample in the time, compared to 31 in the Avon study.

However, despite these limitations, the results indicated that fish density and diversity increased under banks with heavy vegetation, especially flaxes. The success of the flax banks is probably due to substantial amount of cover created underneath their overhanging crowns, which extended approximately 0.9 m out over the water. However, less vegetative overhang may be sufficient to enhance fish values, and this is discussed further in the following section. Much of the overhanging flax foliage was only just above the water surface, which provide a habitat for a varied insect community, including caterpillars of the flax looper moth, and the flax notcher moth (Millar 1971). These insects and other invertebrates would become food for all fish species when they fall into the water. For this, and other reasons, overhanging vegetation close to the water surface is more beneficial to fish values than plants with a higher crown, or overhanging trees.

Fish density under the toetoe crowns along the Heathcote River, was substantially less than under the flax, despite an even greater extent of overhang (see Table 2). However, only one section of riparian toetoe was sampled, and further replication of this treatment would certainly be desirable to confirm this preliminary finding. The relative insect-harbouring ability of toetoe compared to flax is unknown, but could well be inferior to flax. Should toetoe be considered as riparian vegetation, then further investigations would be warranted as to whether flax plantings would offer a better alternative.

Quarried volcanic rock cladding provided refuge for eels and bullies at one site, but there was insufficient data to demonstrate its relative merits against grassed banks. However, the rocky bank harboured a lower fish density than flax-lined banks.

6.4 Comparison with the Avon River bank treatment study

Bank treatments were considered to be particularly important in the Avon CDB environment because fish cover away from the banks was particularly sparse due to shallow water, a scarcity of aquatic macrophyte cover, and little coarse substrate.

There was no direct equivalent in the Avon CDB of the flax banks sampled on the Heathcote River. The nearest approximation would have been the luxuriant riparian native plantings around Little Hagley Park. The total predominant-fish (i.e. upland bully, common bully, shortfin eel, longfin eel) densities obtained there were approximately 2.5 fish/m^2, but these bank sites were not netted because of water depth and habitat roughness (see Fig. 4.10 (McMurtrie & Taylor 2003)). However, allowing for a degree of escapement along the Avon sites, this result is probably comparable with our mean density of 2.9 fish/m^2 from netted flax-lined banks on the Heathcote.

Overhung grassy banks on the Avon River along Park Terrace were more luxuriant than those along the Heathcote (McMurtrie & Taylor 2003). The grass overhanging the water on the sampled Avon River banks had a mean value of 0.42 m, compared to 0.31 m on the Heathcote, and the bank line on the Avon appeared superficially rougher with many small embayments created by the large outgrowths of *Festuca* grass. Probably owing to this roughness, fish densities associated with grassy banks on the Avon were substantially higher (with a mean of 4.2 fish/m^2), than their counterparts on the Heathcote River (mean of 2.0 fish/m^2).

Banks clad in quarried rock, while occasionally present along the central Avon River, where not sampled during the survey. Some bank sections were lined with close-fitting concrete blocks, which possessed a deep (0.15 m) continuous undercut below the waterline (McMurtrie & Taylor 2003). At these sites, fish densities were high, especially for bullies. However, interstitial gaps amongst the quarried rocks on the

Heathcote River were functionally different than the Avon River undercut, and possessed only occasional deep recesses to 0.15 m.

6.5 Siltation and fish habitat quality in the Heathcote River

Aside from the exception of the bluegill bully which is almost always found in fast-water habitats with coarse substrates, most of the other fish species in the Heathcote River are habitat generalists, with rather broad associations in respect to water depth, velocity and flowtype (Jowett & Richardson 1995). Thus, a slight increase of mean baseflow depth or velocity is unlikely to affect them, certainly within the range the low-gradient Heathcote River would provide.

Potential adverse impacts on the fish fauna are more likely to be associated with changes in the flow regime and increased siltation of the river bed. Trout spawning reaches are sensitive to silted substrates, and a recent resurvey of trout spawning habitat has indicated that this has deteriorated in recent years, with the worst apparent effects being in the upper catchment (Taylor 2003b). This places relatively more importance on remaining spawning gravels in the Heathcote mainstem, including this study reach. In addition to trout spawning, fast-flowing gravel reaches have an important ecological role for bluegill bullies, and the physical nature of these reaches (i.e. substrate composition and embeddedness, water depth and velocity) should be preserved. Upland bully density has also been demonstrated to decrease with increasing sediment embeddedness (Jowett & Boustead 2001), yet other Christchurch studies have shown that shortfin eel density increases with sediment depth (McMurtrie *et al.* 2004). In short, increasing bed sedimentation leads to a loss of fish diversity, with habitats becoming dominated by shortfin eels, the only species which clearly benefits from substrate sediment.

6.6 Bank profiles and plantings

The banks of the Heathcote River are steep in many locations, and have slumped upstream of the study reach where root mats on steep slopes have consisted only of grass (e.g. Ashgrove Terrace). Road narrowing would permit bank angles to be reduced to a shallower angle in some locations, and where bank angles cannot be reduced, banks could be consolidated with tree or shrub plantings. The role of bank treatments in supporting the fish fauna has been demonstrated in this study, especially in regard to flaxes with a generous vegetative overhang. Accordingly, flaxes planted near the bank toe would, as well as providing much-needed stability, enhance fish communities. Flaxes may not have to be the large species; the smaller varieties could also function adequately as cover, and yet retain sightlines of the river. Vegetative overhangs of 0.4 m may be adequate and achievable with a number of smaller and medium-sized flax varieties.

The natural spread of the sedge *Carex secta* along the bank toe of the Avon in the CBD has been demonstrated to benefit fish communities, and there is every reason to consider that they would also benefit Heathcote River fish values. The extent of vegetation overhang is important, and mature plants which possess an overhang width in excess of 0.3 m support higher fish densities. An increase in flood capacity could be accommodated by the provision of floodable terraces that do not increase channel width during normal flows. The use of floodable terraces to increase hydraulic capacity without increasing channel width at baseflow was also recommended in earlier works on the Heathcote River (Eldon *et al.* 1989).

An example of a short reach where terracing was used was found within the study area, although a broader riparian planting would be beneficial in that instance (Fig. 6). During natural flooding events, smaller and/or weaker-swimming fish would take refuge along the banks amongst flooded vegetation where the current is more subdued. Adult inanga and whitebait have been observed in flooded riparian grasses along rivers during high flows (Taylor & Main 1987), and other species are also likely to benefit with increased refuge from flood flows. During higher flows, grass-like plants would offer refuge, but also bend with the flood current, which would help reduce flow resistance and the risk of excessive flood stages.

Figure 6. An example of a floodable terrace which provides vegetative fish cover during base flow, but hydraulic capacity and fish refuge during flood flows. The vegetation cover along should be more continuous than depicted here to provide ecological value.

6.7 Subdivision development

The river between Colombo Street and Opawa Road receive largely untreated stormwater from surrounding residential land. It is unlikely contaminant loadings will increase in the foreseeable future from these mature subdivisions. However, additional subdivision development is taking place in the suburbs of Westlake, Halswell, and other areas in the upper Heathcote catchment. This will lead to the discharge of treated stormwater into the Cashmere Stream catchment, and possibly the upper Heathcote mainstem. New subdivisions have stormwater treatment systems which should provide a reasonable degree of contaminant removal, and the commissioning of the large-scale Hendersons Basin stormwater treatment and wetland system within the next five years should significantly mitigate effects of this new development. However, while interim stormwater treatment measures are in place to cope with expected subdivision development, the trapping and containment of fine particulates into and along natural waterways remain a major concern. Cashmere Stream, in particular, has suffered from bed sedimentation and turbid flows in recent decades, and its turbid discharge, even at baseflow, is visible a short distance upstream of the study area (McMurtrie *et al.* 2004; Taylor 2003b). The disruption of the upper catchment necessitates the continued monitoring of critical habitats in the study area.

Owing to the widespread concern about sediment transfer in the Cashmere Stream catchment, a water quality and ecological monitoring strategy has recently been mooted to provide a better understanding of stormwater treatment effectiveness in this waterway (Shelley McMurtrie pers. comm. EOS Ecology). If this is implemented, the data provided will demonstrate the effectiveness of stormwater treatment systems to mitigate the impacts of stormwater discharges.

7 Recommendations

In respect to the Heathcote River between Colombo Street and Opawa Road, the following recommendations are made.

- Where road width allows, bank angles be reduced as much as possible, and where bank angles cannot be relieved, grassed banks should be consolidated with plantings of flaxes, sedges (e.g. *Carex secta*), and possibly other native species. Plantings of smaller flax varieties could be trialled to provide a balance between enhancing fish habitat and maintaining river views for passers-by.

- That floodable terraces be constructed to increase hydraulic capacity during high flows, and then planted to provide fish cover. This recommendation reiterates that of the 1989 study (Eldon *et al.*), but bears repeating here. Flaxes and *Carex* plants that overhang the water by approximately 0.4 m during normal river levels would be suitable for vegetating flood terraces. Such plants have the added benefit of lying flat and reducing their hydraulic roughness when overtopped by flood waters.

- Floodable terraces could also offer amenity values by including mown swards or footpaths further away from the waters edge to offer picnicking and access areas for pedestrians during normal river levels.

- That the physical nature of the substrate in known trout spawning and bluegill bully habitat be monitored for increases in siltation and weed cover. Especially important because of the extensive subdivision activity in the upper catchment.

8 Acknowledgements

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9 References

Carle, F. L.; Strub, M. R. 1978: A new method for estimating population size from removal data. *Biometrics 34*: 621-630.

Eldon, G. A.; Kelly, G. R.; Bonnett, M. L.; Taylor, M. J. 1989. Fisheries survey of the Heathcote River, January 1989. MAFFish, Christchurch. *New Zealand Fisheries Report No. 111*. 50 p.

Jowett, I. G. 1992: Models of the abundance of large brown trout in New Zealand rivers. *North American Journal of Fisheries Management 12*: 417-432.

Jowett, I. G.; Boustead, N. C. 2001: Effects of substrate and sedimentation on the abundance of upland bullies (*Gobiomorphus breviceps*). *New Zealand Journal of Marine and Freshwater Research 35*: 605-613.

Jowett, I. G.; Richardson, J. 1995: Habitat preferences of common, riverine New Zealand native fishes and implications for flow management. *New Zealand Journal of Marine and Freshwater Research 29*: 13-23.

McDowall, R. M. 1990: New Zealand Freshwater Fishes: A Natural History and Guide. Auckland, Heinemann Reed. 553 p.

McIntosh, A. R. 2000: Aquatic predator-prey interactions. *In:* Collier, K. J.; Winterbourn, M., J. *eds*: New Zealand Stream Invertebrates: Ecology and implications for management, New Zealand Limnological Society. Christchurch. 125-156 pp.

McMurtrie, S.; Taylor, M. J. 2003. Ecological assessment of the Avon River mainstem, from Fendalton Road to Fitzgerald Avenue. EOS Ecology, *EOS Ecology, report prepared for the Christchurch City Council No.* 61 p.

McMurtrie, S. A.; Taylor, M. J.; Kingett Mitchell Limited 2004. Aquatic values in South West Christchurch (Draft); prepared for Christchurch City Council. EOS Ecology, Aquatic Ecology Limited, Kingett Mitchell Limited, Christchurch. *No.* 79 p.

Millar, D. 1971: Common insects of New Zealand. Wellington, Reed. 178 p.

Nairn, H. J. 1998: Fish fauna of the Avon-Heathcote Estuary (M.Sc. Thesis, Zoology). University of Canterbury, Christchurch.

Richardson, J.; Taylor, M. J. 2002. A guide to restoring inanga habitat. National Institute of Water and Atmospheric Research, Wellington. *NIWA Science and Technology No. 50*. 29 p.

Robb, J. A.; Cooper, D. A. 1994. High-Tide Salinity Data Heathcote River September-November 1993. Christchurch City Council, Christchurch. *No.* 15 p.

Taylor, M. J. 1996. Brown trout redd survey of the upper Heathcote River, August 1996. National Institute of Water and Atmospheric Research, Christchurch. *NIWA Christchurch Consultancy Report No. CCC70501*. 10 p.

Taylor, M. J. 1999. Inanga spawning on the Avon and Heathcote Rivers, 1999. National Institute of Water and Atmospheric Research, Christchurch. *NIWA Client Report No. CHC99/27*. 9 p.

Taylor, M. J. 2003a. Brown trout redd distribution in the Avon River, and a comparison with the 1991 trout redd survey. Aquatic Ecology Limited, Christchurch. *AEL Report No. 14*. 24 p.

Taylor, M. J. 2003b. Trout spawning and suspended sediment sources in the upper Heathcote River. Aquatic Ecology Limited, Christchurch. *AEL Report No. 20*. 20 p.

Taylor, M. J.; Main, M. R. 1987. Distribution of freshwater fishes in the Whakapohai to Waita River area, South Westland. Fisheries Research Division, New Zealand Ministry of Agriculture and Fisheries, Christchurch. *Fisheries Environmental Report No. 77*. 85 p.

Taylor, M. J.; McMurtrie, S. A. 2004. Inanga spawning grounds on the Avon and Heathcote Rivers. Aquatic Ecology Limited, Christchurch. *AEL Report No. 22*. 34 p.

Webb, B. F. 1972: Fish populations of the Avon-Heathcote Estuary. 1. General ecology, distribution, and length-frequency. *New Zealand Journal of Marine and Freshwater Research 6* (*4*): 570-601.

10 Appendix I

Sampled habitats from the Heathcote River, between Colombo Street and Opawa Road. For the study reach as a whole, the predominant fish were considered to be the shortfin eel, longfin eel, common bully and upland bully**.**

Site 1. Mid-channel site, downstream of Colombo Street Bridge. Predominant fish density = 0.6 fish m^{-2}

Site 2. Downstream of Malcolm Avenue. Predominant fish density = 2.3 fish m^{-2}

Site 3. Downstream of Malcolm Avenue. Predominant fish density = 1.9 fish m^{-2}.

Site 4. Opposite Corson Avenue. Predominant fish density = 3.4 fish m^{-2}.

Site 5. Opposite 225 Waimea Terrace. Predominant fish density = 1.5 fish m^{-2}.

Site 6. Opposite 255 Waimea Terrace. Predominant fish density = 2.7 fish m^{-2}.

10 Appendix I (cotd.)

Site 7. Upstream of Martin Avenue. Predominant fish density = 1.9 fish m^{-2}.

Site 8. Opposite 40 Palentine Street. Predominant fish density = 0.6 fish m^{-2}.

Site 9. Mid-channel site downstream of Tennyson Street. Predominant fish density = 0.9 fish m^{-2}.

Site 10. Esher Place. Predominant fish density = 1.3 fish m^{-2}. Density probably underestimated due to water depth.

Site 11. Esher Place. Predominant fish density = 2.7 fish m^{-2}.