Native fish and minimum flows in the Kakanui River

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prepared for Department of Conservation

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CONTENTS

EXECUTIVE SUMMARY

The purpose of this study was to determine the distribution of native fish in the Kakanui River, their importance, and to assess low flows for maintenance of native fish habitat.

The mainstem of the river was electrofished at 13 locations from near the estuary to the headwaters 54 km upstream. Eleven native fish species were found. Eight of these were reasonably abundant and their requirements have been considered in this report.

Habitat suitability curves were developed for native fish species from data collected in 32 North and South Island rivers. The suitability curves were then combined with instream habitat survey data from 5 reaches to predict how the area of habitat suitable for each native fish species varied for flows of 0.1-1. 5 m^3/s. The relationships between habitat and flow were used to select a minimum acceptable flow for maintenance of habitat. The selection criterion was either the optimum or the point of inflection, that is, the point on the curve where the quality of habitat begins to decline more rapidly with flow.

The habitat/flow relationships reflected the habitat preferences of the fish species. Higher flows provided more habitat for fast water species, whereas low flows provided more habitat for edge-dwelling species. Most relationships showed poorly defined points of inflection, and few showed clearly defined optima. Available habitat for the fast-water dwelling bluegill bully and torrentfish varied linearly with flow from 0.1 to 1.5 m^3/s. Longfin and shortfin eel habitat generally showed little variation with flow. Habitat/flow relationships for the edge-dwelling species (upland bully, common river galaxias, and redfin bully) showed that flow reductions would usually have little effect on their habitat. Common bully habitat was optimal at a flow of 0.5 m^3/s, with a point of inflection at 0.3 m^3/s. An increase in the minimum flow will improve habitat for common bullies, eels, torrentfish and bluegill bullies, but have little effect on the amount of habitat available for the other species. A minimum flow of 0.3 m^3/s in the lower reaches of the Kakanui River would maintain acceptable habitat for native fish.

INTRODUCTION

Small rivers and streams, particularly those close to the coast, are prime habitat for many native fish species, and information on their within stream habitat preferences is only now becoming available. In the past it has been difficult for water managers to make ecologically sound decisions about acceptable flows for the maintenance of native fish habitat.

In 1991, the Otago Regional Council set an interim minimum flow in the Kakanui River at Clark's Mill Dam of 0.25 m^3/s. This effectively prevents irrigation when flows fall below this level. Studies of water requirements and the fishery were initiated because of the conflict between instream and out of stream water use.

The Department of Conservation requested that NIWA

- describe the distribution and relative abundance of native fish in the Kakanui River
- compare the relative density of fish and fishery values in the Kakanui River with other South Island rivers
- use IFIM data to define minimum flows that provide appropriate levels of protection for native fish.

Site description

The Kakanui River is a small river in North Otago. From its source in the Kakanui Mountains, it flows north-east for about 40 km through partially developed tussock grassland before emerging onto plains at Clifton Falls. It then flows south-eastwards at a gentler gradient through highly developed pastures for a further 30 km to the sea. The river has a mean flow of 4.9 m^3/s near the mouth. The coefficient of variation of flow is 2.07, which classifies the flow variability as medium to high in comparison with other New Zealand rivers (Jowett and Duncan 1990).

The river can be divided into three sections of different character. The lower 9 km of river is low gradient (1.2 m/km) and willow-lined on at least one bank, with long pools and short cobble riffles. Many of the pools contain large macrophyte beds. The gradient increases to 3.6 m/km in the 19 km middle reach and there is generally less willow, macrophytes and pools than in the lower river, with correspondingly more run and riffle habitat. The upper 32 km of river is generally steep (10 m/km), confined by steep hillsides, and contains well-developed pool-riffle sequences.

Jowett (1990) classified the river as a brown trout river containing moderate numbers of trout in the lower section and low numbers in the upper section. Rainbow trout are found in low numbers, and the occasional salmon is also present in the river.

Continuous water temperature records maintained by the Otago Regional Council showed that maximum summer daily mean water temperatures at a site 3 km upstream of the estuary were about 18°C. Winter temperatures averaged 5°C in the lower reaches and reached a minimum of 3°C.

Minimum and mean temperatures were generally about 1°C lower 20 km further upstream at Clifton Falls, but maximum temperatures were about the same.

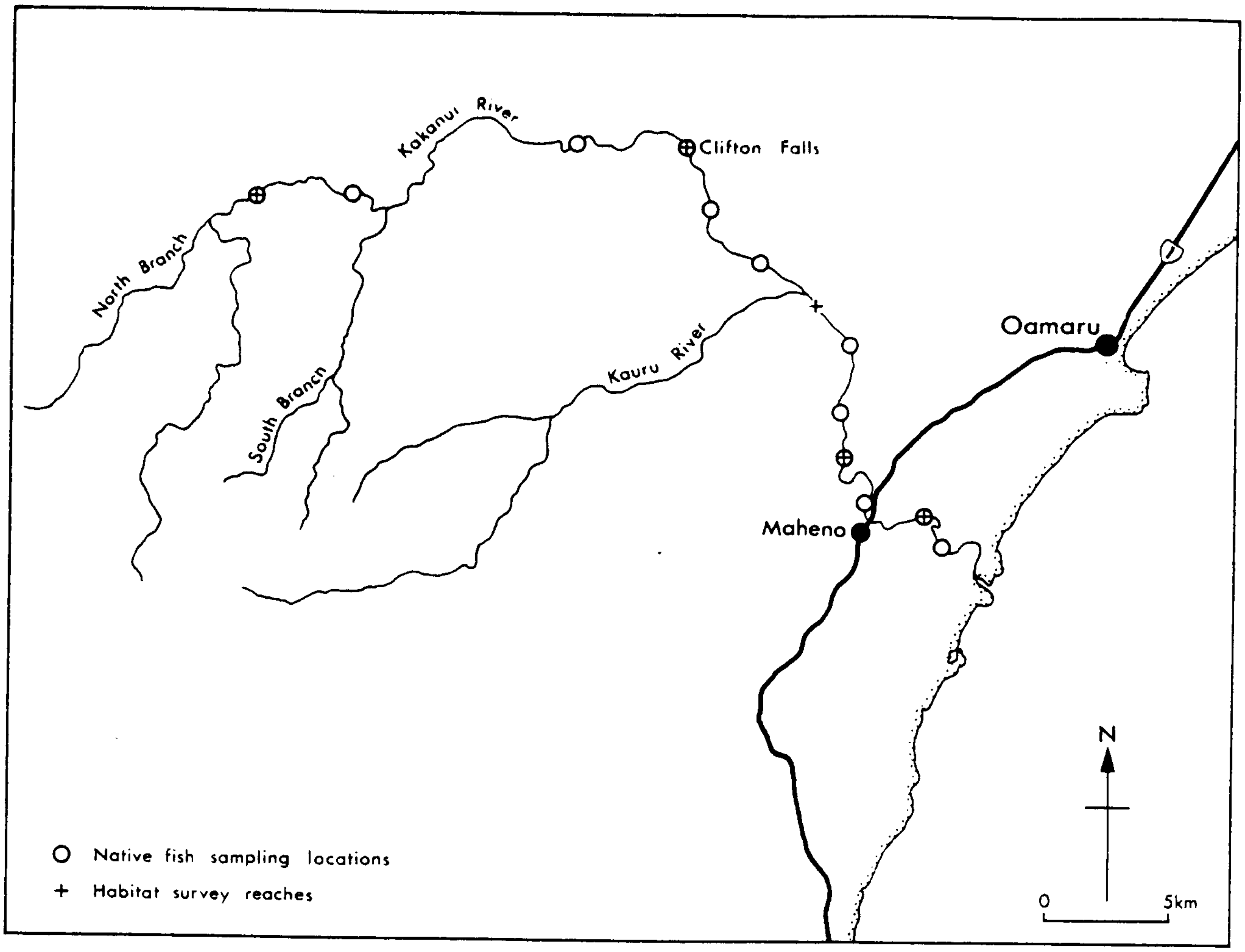

Figure 1. Location map, Kakanui River, showing the electrofishing locations and the habitat survey reaches.

Habitat suitability and the instream flow incremental methodology

The concept of habitat suitability is all around us. All life, except perhaps the simplest, has adapted to a particular range of habitats. The concept of "good" habitat is familiar to most people. It is commonly used by anglers and hunters seeking their prey. In the aquatic environment, instream habitat usually refers to the physical habitat - water velocity, depth, substrate, and perhaps cover. Usually, animals are most abundant where the habitat quality is best, in lesser numbers where the habitat is poor, and absent from totally unsuitable habitat. If the characteristics of the habitats occupied by many animals are surveyed, it is possible to determine the relative quality of the different habitats from the abundance of animals in them. Habitat suitability curves provide a means of describing what is considered to be "good" habitat. If the range of suitable habitat for a species or life stage of a species can be determined, it is possible to quantify the area of suitable habitat available within a river. This area is termed the weighted usable area. Habitat suitability can vary from zero (unsuitable) to one (optimum).

Once habitat suitability curves or criteria are defined, they can be applied to hydraulic data (Fig. 2) and the amount of suitable habitat or weighted usable area (WUA) calculated.

This is the basis of the instream flow incremental methodology (IFIM) (Bovee 1982). In the USA, the power station licensing authority requires that this method be used for the assessment of minimum flow requirements for all hydroelectric power schemes.

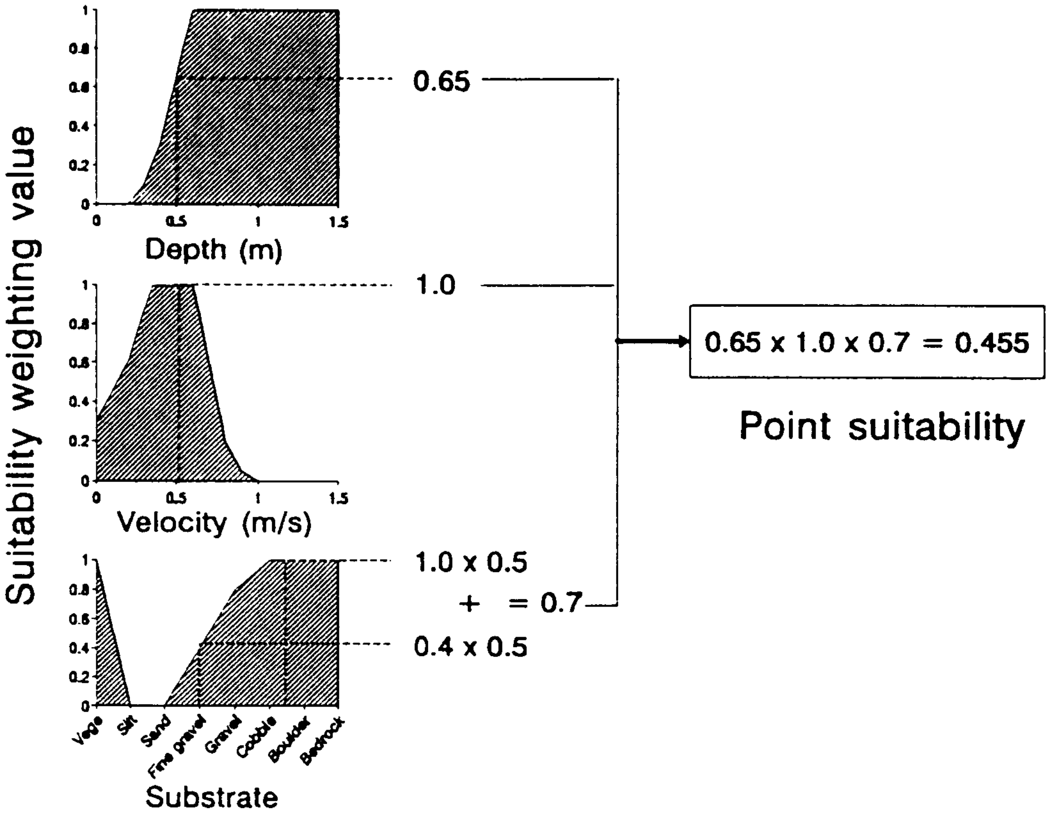

Figure 2. Calculation of point suitability for a point with 0.5 m/s velocity, 0.5 m depth, and a substrate of 50% boulders and 50% fine gravel

METHODS

Native fish survey

As an adjunct to the Kakanui River trout surveys, 12 reaches, from the headwaters to near the estuary, were electroshocked (Fig. 1) and the native fish species recorded. Each reach surveyed contained run and riffle habitat. The average area fished in each reach was 1860 m^2. Native fish densities were also surveyed in the lower reaches as part of the " 100 rivers" native fish study (Fig. 1). These data are directly comparable with native fish surveys carried out in other rivers in the North and South Islands.

Habitat Preferences of Fish

The habitat preferences of fish were determined by depth stratified sampling in run and riffle habitats. Two runs and two riffles were sampled by single pass electroshocking in 32 North Island and South Island rivers. All fish caught were identified, counted, and measured. Within each depth-stratified lane, 12 depth and velocity measures were taken and the mean values calculated. Substrate composition was assessed for each habitat type by the Wolman walk method (Wolman 1954). Habitat preferences curves for depth, velocity, and substrate were developed for all common fish species. A preference was determined by comparing the habitat in which fish were found (habitat used) with the habitat that was sampled (habitat available). Curves for the frequency of habitat use and availability were generated from kernel smoothed density distributions (Johnson and Kotz 1971; Silverman 1986; Aptech Systems Inc. 1991) of water depth and velocity. Preference curves were derived by dividing the frequency of use by the frequency of available habitat (Bovee 1986). The curves were scaled to a maximum preference value of 1 by dividing by the maximum ordinate.

Habitat hydraulic modelling and prediction of habitat suitability

Representative reaches of rivers were selected at five locations on the river. Two reaches represented the lower reaches, two the middle reaches, and one the upper reaches. Each reach was surveyed in the normal IFIM manner and hydraulic modelling techniques used to predict water levels at other flows.

Between 14 and 20 transects were selected to represent the habitat within each reach. Water velocities, depths, and substrate composition were recorded at an average of 0.7 metre intervals across each transect. Bench marks were established at each downstream transect on a reach and the water level at each transect surveyed to those benchmarks. In order to establish the relationship between flow and water level, the downstream transects were revisited and water levels resurveyed at one flow higher and at one flow lower than the initial survey.

The habitat analysis was carried out in the following steps:

1. Flows were computed from the measurements at each transect. These were used to make an estimate the flow in the reach.

2. A stage-discharge relationship was developed for the downstream transect.

Recently developed computer software was used to compare and select an appropriate stage-discharge curve. The basic methods were:

a) a least squares fit to the logarithms of the measured flow and stage (water level) and an estimated stage at zero flow
b) a relationship calculated from Mannings equation which allows the variation in roughness to be estimated from the measured flow and stage.
The best relationship was selected and used to compute water levels for a range of flows.

3. Water depths and velocities were computed at each measurement point across the transect for each flow, and the habitat suitability evaluated taking substrate composition into consideration.

4. The weighted usable area (WUA) for each flow was calculated for each transect and summed over the reach.

5. Weighted usable area was plotted against flow and the resulting curves were examined to determine the flows which provide optimum habitat and flows below which WUA declines sharply (points of inflection).

Table 1 Native fish distribution in the Kakanui catchment

Sampling location	Distance from sea (km)	Bluegill bullies	Torrentfish	Redfin bullies	Common bullies	Upland bullies	Longfin eels	Shortfin eels	Common river galaxias	Inanga	Smelt	Lamprey
Ford	54	-	-	-	-	-	-	-	4	-	-	-
Stoneyards	49	-	-	-	-	-	1	-	-	-	-	-
Tapui	34	-	-	-	-	1	1	-	1	-	-	-
Clifton	29	-	-	-	-	2	1	-	-	-	-	-
5 Forks	25	-	-	-	-	2	2	1	-	-	-	-
Johnsons	21	-	1	-	-	3	2	-	-	-	-	-
Perniskis	16	-	-	-	-	3	3	1	1	-	-	-
Gemmels	13	1	-	-	-	3	1	-	1	-	-	1
Riverside	11	2	-	-	-	3	2	-	1	-	1	-
Mill dam	8	1	1	2	2	1	1	1	-	-	-	-
Pringles	4	3	-	-	-	-	-	3	-	-	1	-
100 river	3.5	4	1	1	3	-	2	1	-	-	-	-
Raynes	0.5	4	-	1	4	-	1	1	-	2	2	-

1 = rare < 5, 2 = occasional 5-20, 3 = common 20-50, 4 = abundant >50

TABLE 2. Relative fish densities (no/1000 m²) in 18 South Island rivers .

River	Distance from sea (km)	Longfin eel	Shortfin eel	Torrentfish	Upland bully	Brown trout	Redfin bully	Bluegill bully	Common river galaxias	Common bully	Total
Opihi	9	2	93	176	82	0	0	1808	4	357	2522
Kakanui	4	109	18	33	0	0	3	2041	0	196	2400
Waipara (lower)	2	0	6	335	557	0	0	678	6	0	1582
Rai	24	9	8	3	746	2	0	2	0	0	770
Selwyn	80	5	0	0	448	20	0	0	284	0	757
Maerewhenua	55	0	0	0	457	11	0	0	236	0	704
Waipara (middle)	14	50	14	50	579	0	0	5	0	0	698
Orari	43	0	0	0	256	4	0	0	382	0	642
Wairoa	14	221	0	45	36	5	5	0	0	0	312
Hakataramea	66	0	0	0	158	13	0	0	2	13	186
Motueka	39	61	11	16	44	7	0	0	0	0	139
Baton	41	19	4	12	50	30	1	17	0	0	133
Mangles	115	25	0	0	81	18	0	0	0	0	124
Grey	62	46	0	5	0	7	16	46	0	0	120
Pelorus	22	9	1	0	102	6	0	0	0	0	118
Riwaka	8	84	2	5	0	13	1	0	0	0	105
Takaka	34	32	1	0	37	26	0	0	0	0	96
Inangahua	91	27	0	1	52	11	0	0	0	0	91
Taipo	43	2	0	6	0	36	0	0	0	0	44

RESULTS

Kakanui River fishery values

The survey found 1 1 native species in the main stem of the river; longfn eels, shortfin eels, lamprey, torrentfish, bluegill bully, common bully, upland bully, redfin bully, common river galaxias, inanga, and smelt (Table 1). In the headwaters, the fish population was dominated by common river galaxias, which live their entire lives in freshwater. The middle reaches of the river were dominated by upland bullies and longfin eels. Nearer the sea, the diadromous species, mainly bluegill bullies and common bullies, began to dominate. Torrentfish were relatively rare in the lower reaches compared to similar rivers on the east coast (Table 2). Eels were widespread, although shortfin eels tended to be more common closer to the estuary. The eels found in the survey were generally less than 350 mm in length. This is because the fishing method and habitats surveyed favour smaller eels which live amongst the substrate. Smelt and inanga were confined to the lower reaches near the estuary. Black flounder and giant bullies are known to be in the estuary but their presence has not been recorded further upstream. The Kakanui River fish community was typical of that in most of the larger Canterbury and North Otago foothill rivers draining to the east coast (Table 2, Richardson and Jowett 1994), with native fish densities comparable with those in other rivers in the region (Table 2).

Habitat preferences

Bluegill bullies and torrentfish were found in very swift deeper water, whereas upland bullies, common bullies, and common river galaxias were edge-dwelling fish that were most abundant along the margins of riffles. The habitat preferences of eels were less well defined than those of the other species. Eels tended to be found in a wide variety of water depths and velocities. Their main habitat requirement was suitable cover, usually either substrate or vegetation. Figure 3 shows the habitat preference curves for torrentfish, bluegill bullies, common bullies, upland bullies, redfin bullies, common river galaxias, longfin eels, and shortfin eels.

Habitat survey and habitat evaluation

The Kakanui River exhibited the characteristics expected in a well confined river. The average width of the river increased from 15 m in the upper reaches to 28 m in the lower reaches (Table 3). There was also relatively little change in average depth and velocity along the river with depth increasing from 0.3 to 0.5 m and velocity from 0.14 to 0.2 m/s. The substrate became finer in the downstream reaches, with 20% boulders (>264 mm dia.) in the headwaters, 11 % in the middle reaches, and only 1 % in the lower reaches. There was less change in the finer substrates, but generally the proportion of cobbles (64-264 mm) and gravel (8-64 mm) increased with distance downstream (Table 3).

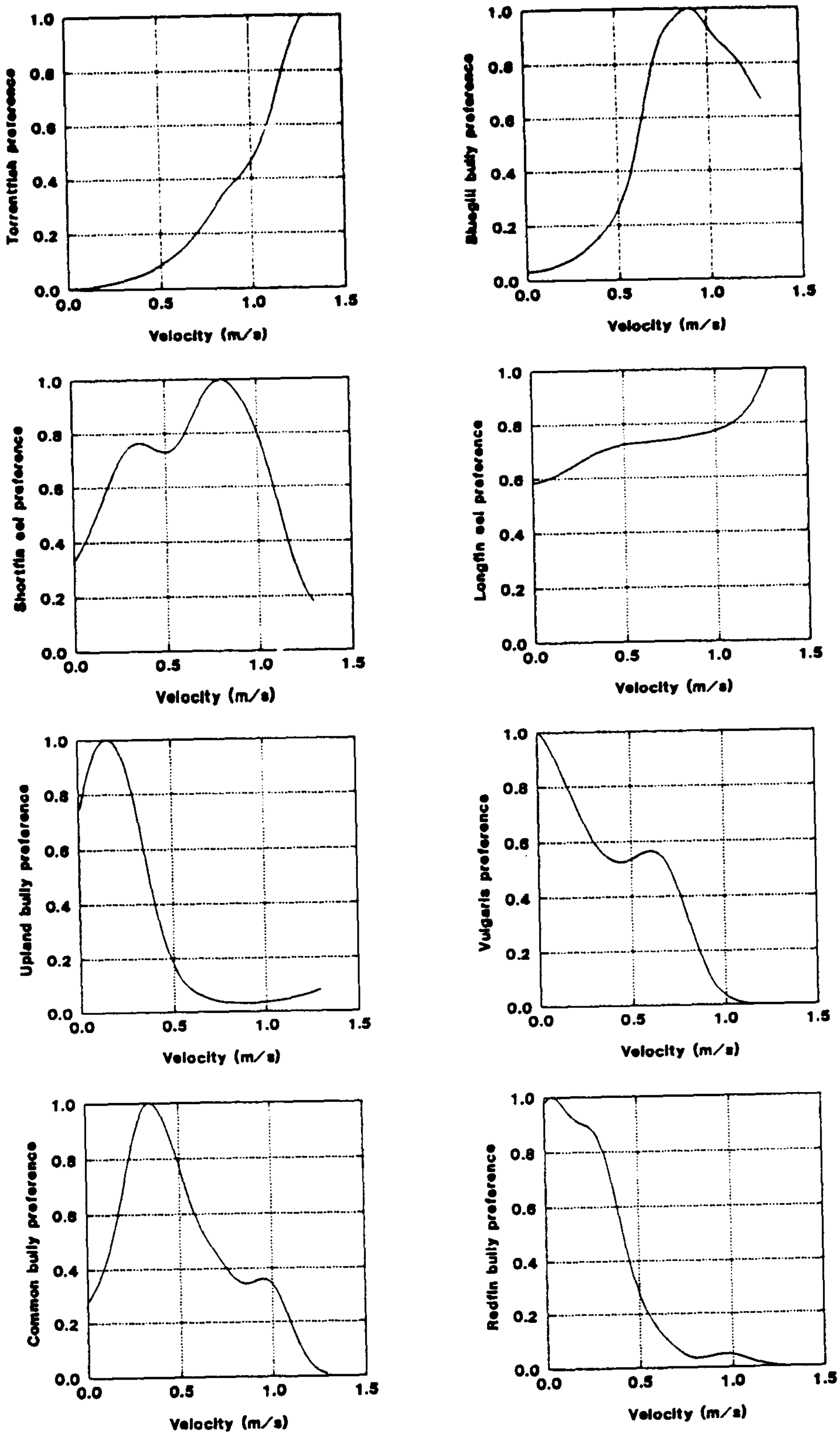

Figure 3. Generalised velocity preference curves for torrentfish, blue-ill bully, shortfin eel, longfin eel, upland bully, common river galaxias, common bully, and redfin bully derived from data collected in 32 New Zealand rivers.

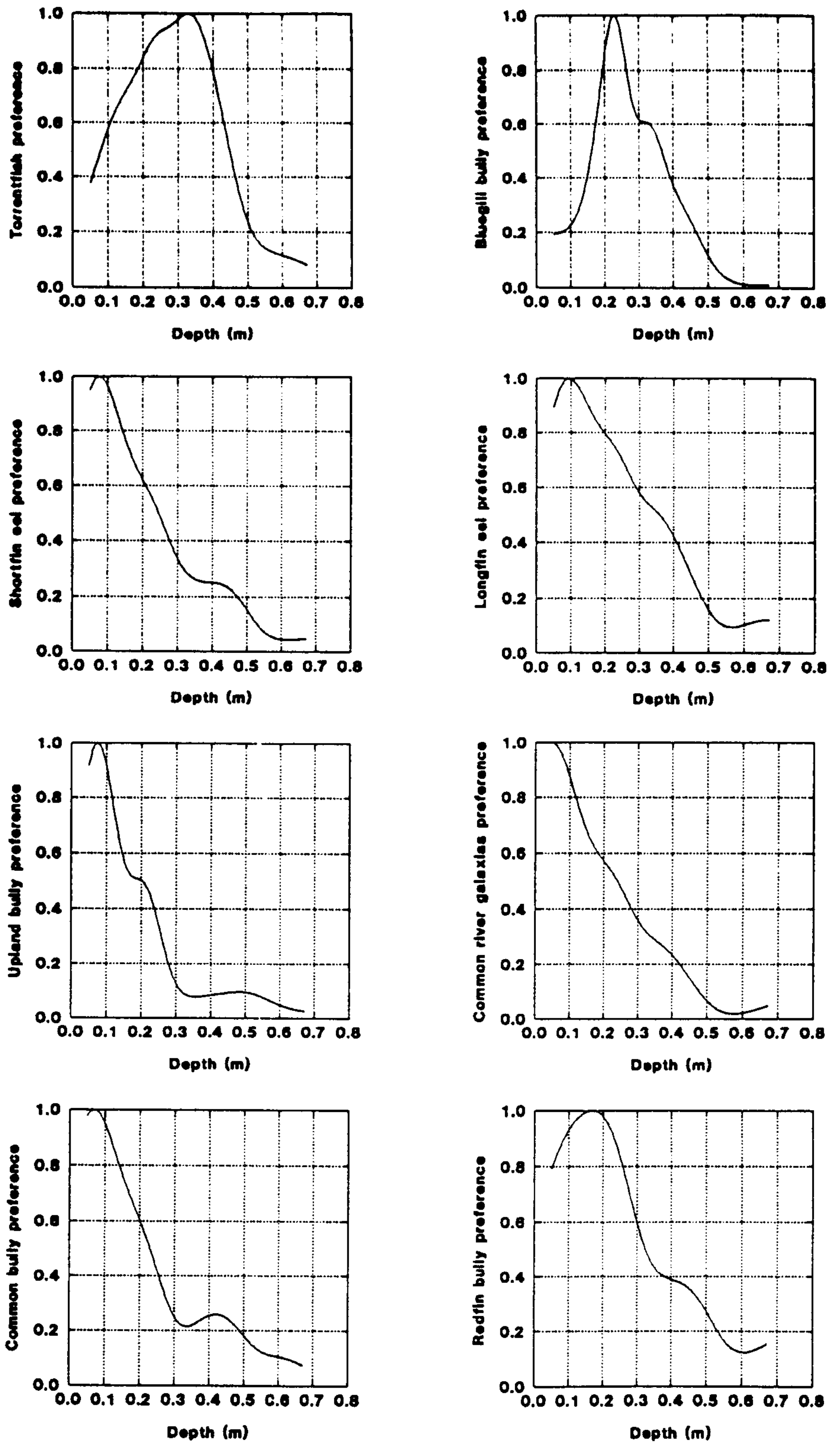

Figure 3 (contd). Generalised depth preference curves for torrentfish, bluegill bully, shortfin eel, longfin eel, upland bully, common river galaxias, common bully, and redfin bully derived from data collected in 32 New Zealand rivers.

Table 3. Average characteristics of the Kakanui River at survey flows

Reach	Survey flow (m^3/s)	Width (m)	Depth (m)	Velocity (m/s)	Boulder (%)	Cobble (%)	Gravel (%)	Fine gravel (%)
Upper	0.41	15.4	0.31	0.14	20	29	33	9
Middle	0.61	15.8	0.40	0.14	11	32	46	5
Lower	0.61	12.3	0.24	0.22	1	43	53	2
Lower	2.81	27.7	0.55	0.22	1	25	48	8

The area of usable habitat within a river can be expressed in two ways. The first is in terms of area. This can be thought of as either metres of usable width (m) or area/unit length of river (m^2/m). The other method is to express usable habitat as a percentage of the river width. This takes into account the change in water area with flow and is like a measure of "efficiency" or "utilisation", showing the proportion of the water area which is useful habitat. Curves using both methods are presented in this report.

Figures 4-6 show the habitat/flow variation, expressed as a percentage, for the common native fish species present in each area of the river. Generally, three groups of fish species have similarly shaped curves. Torrentfish and bluegill bully habitat declines linearly with flow. Longfin eel and shortfin eel habitat shows little variation with flow, whereas common river galaxias, redfin bully, and upland bully curves show an increase in the proportion of available habitat as the flow declines. Common bully habitat shows an optima at a flow of about 0.5 m^3/s and begins to decline at flows of less than 0.3 m^3/s.

Figures 7-9 show the habitat/flow variation, expressed as area, for the common native fish species present. Curves for the upper reaches (Fig. 9) are markedly different from those for the middle and lower reaches. The following comments apply only to habitat/flow relationships for the middle and lower reaches (Figs 7&8). Habitat for the two fast water species, torrentfish and bluegill bullies shows a linear decrease with decreasing flow. The three edge-dwelling species, upland bully, redfin bully, and common river galaxias, show generally increasing habitat with decreasing flow, whereas the other 3 species, longfin eel, shortfin eel, and common bully, show a decline in habitat with a decline in flow below about 0.7 m^3/s. Common bully habitat shows a point of inflection at about 0.3 m^3/s.

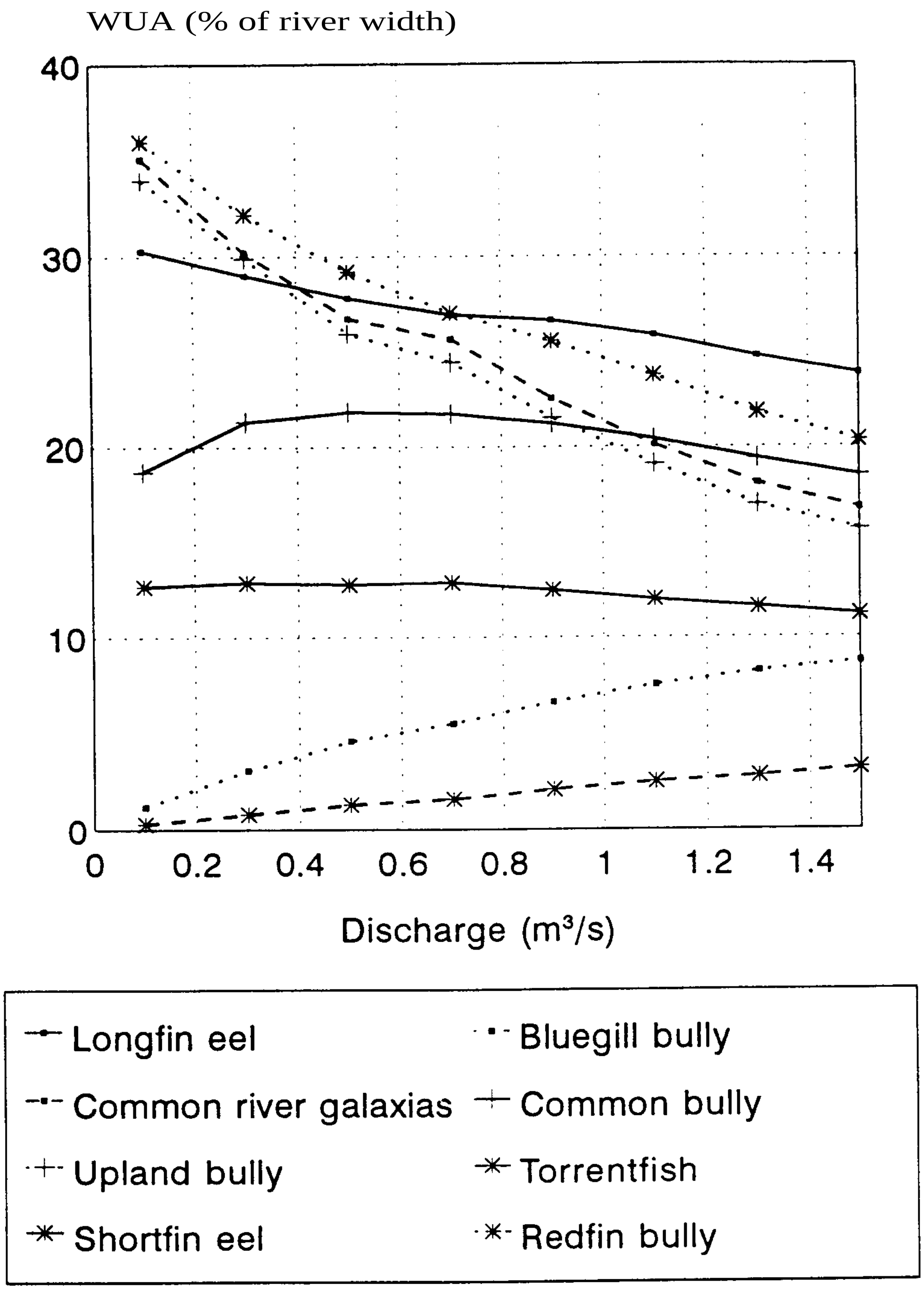

Figure 4. Variation of instream habitat in the lower reaches with flow (WUA expressed as a percentage of river width) for torrentfish, bluegill bully, shortfin eel, longfin eel, upland bully, common river galaxias, common bully, and redfin bully.

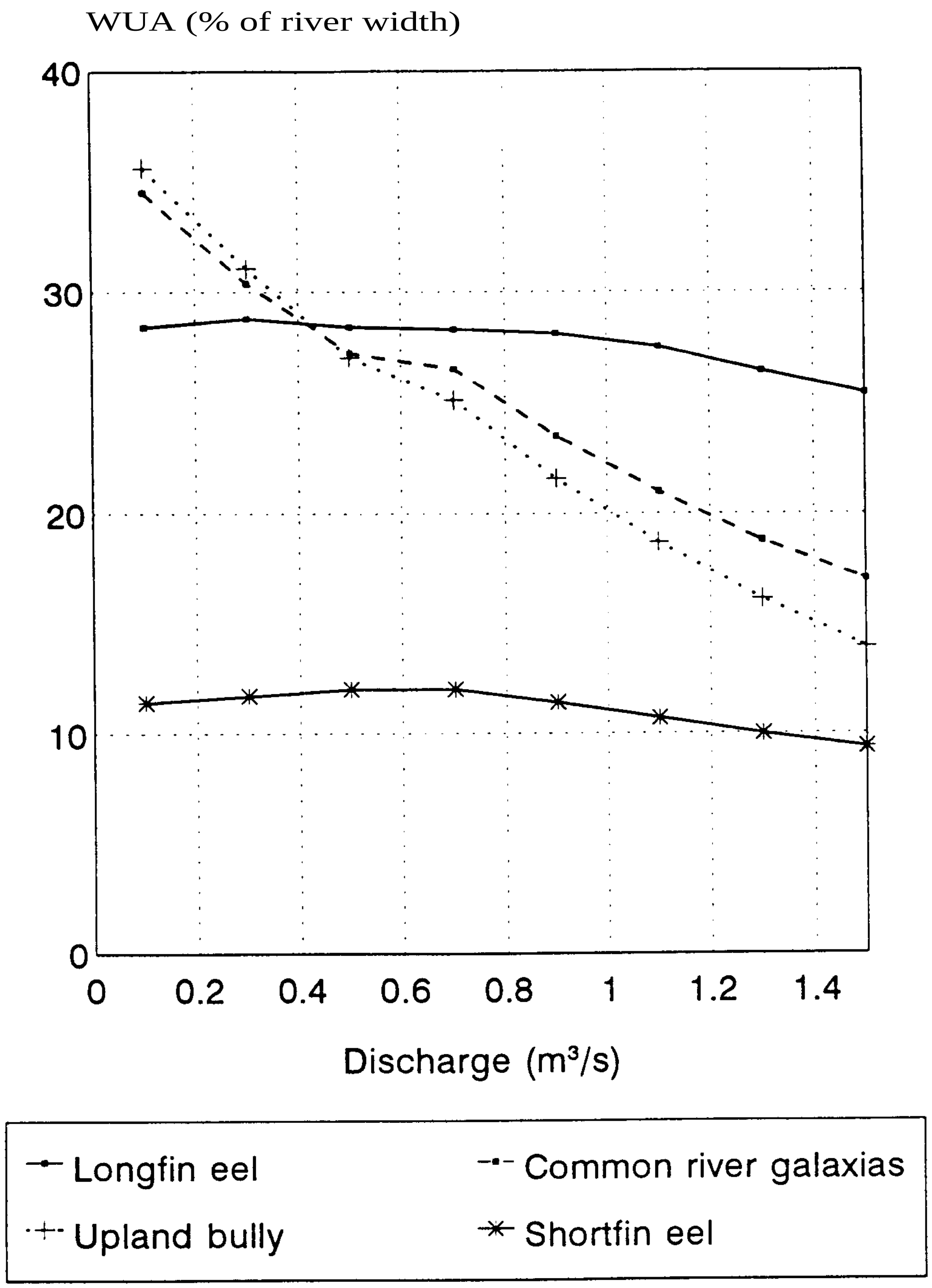

Figure 5. Variation of instream habitat in the middle reaches with flow (WUA expressed as a percentage of river width) for torrentfish, bluegill bully, shortfin eel, longfin eel, upland bully, common river galaxias, common bully, and redfin bully.

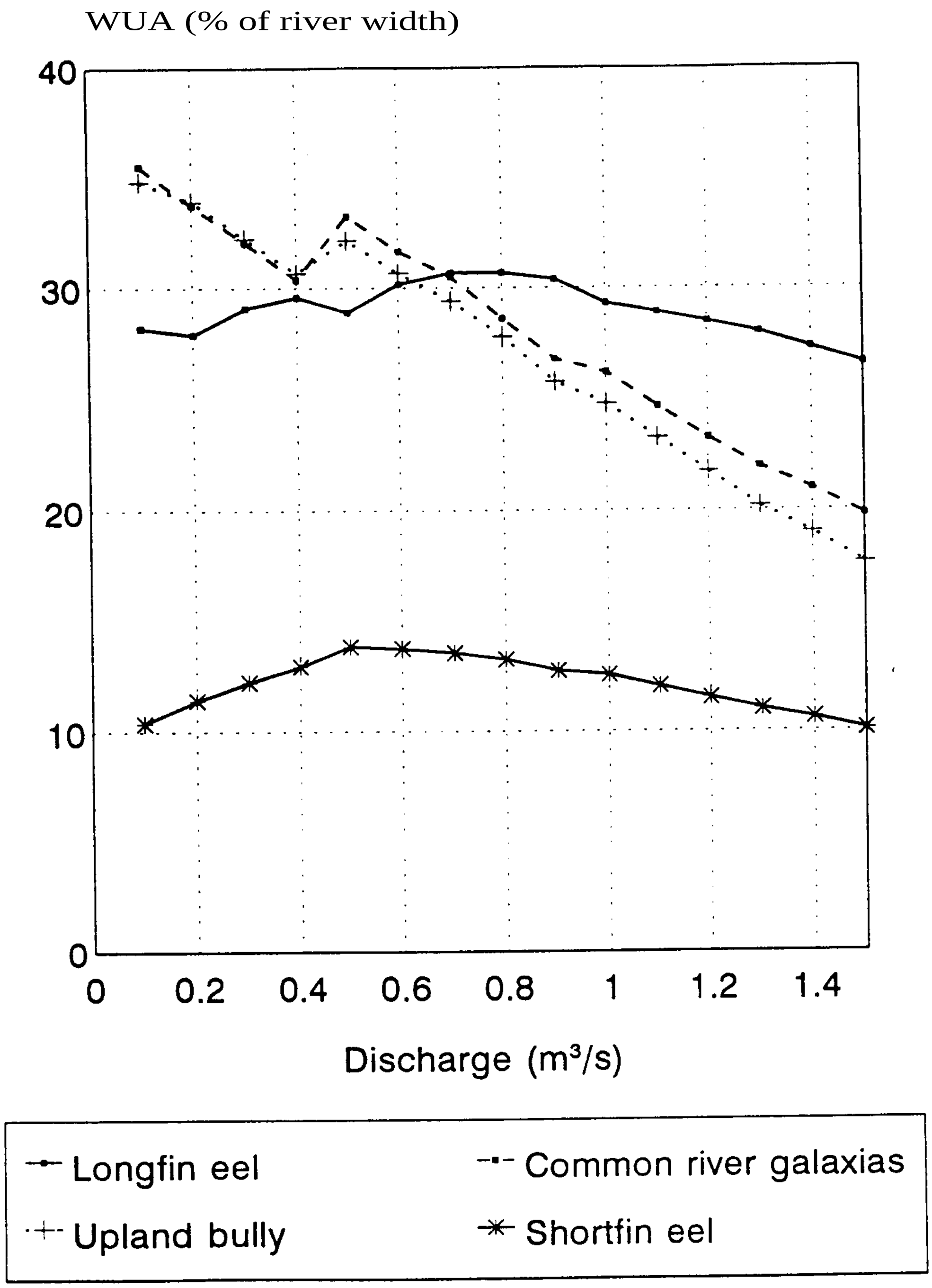

Figure 6. Variation of instream habitat in the upper reaches with flow (WUA expressed as a percentage of river width) for longfin eel, common river galaxias, upland bully, and shortfin eel.

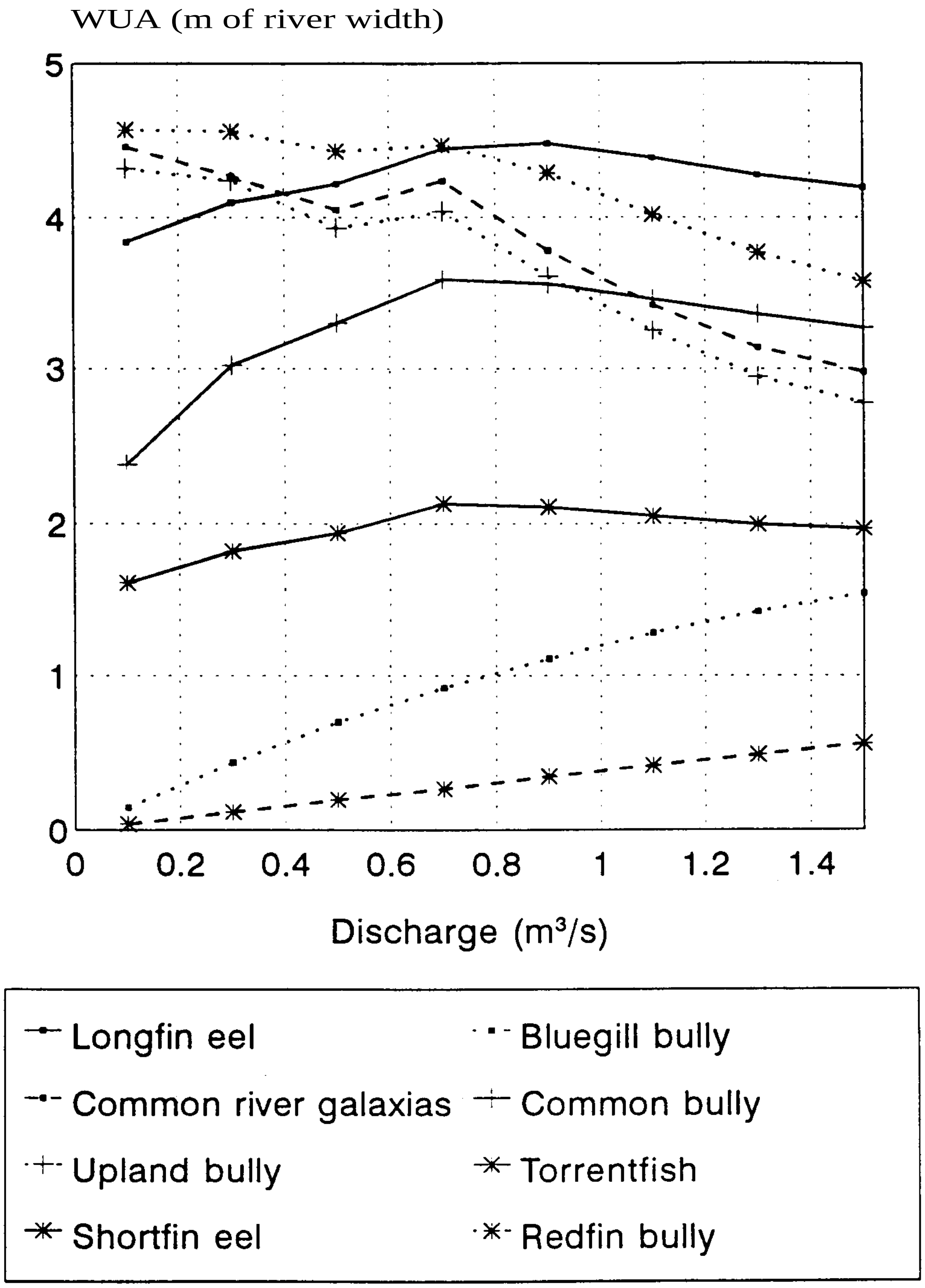

Figure 7. Variation of instream habitat in the lower reaches with flow (WUA expressed in metres of river width) for Ion-fin eel, common river galaxias, upland bully, shortfin eel, bluegill bully, common bully, redfin bully, and torrentfish.

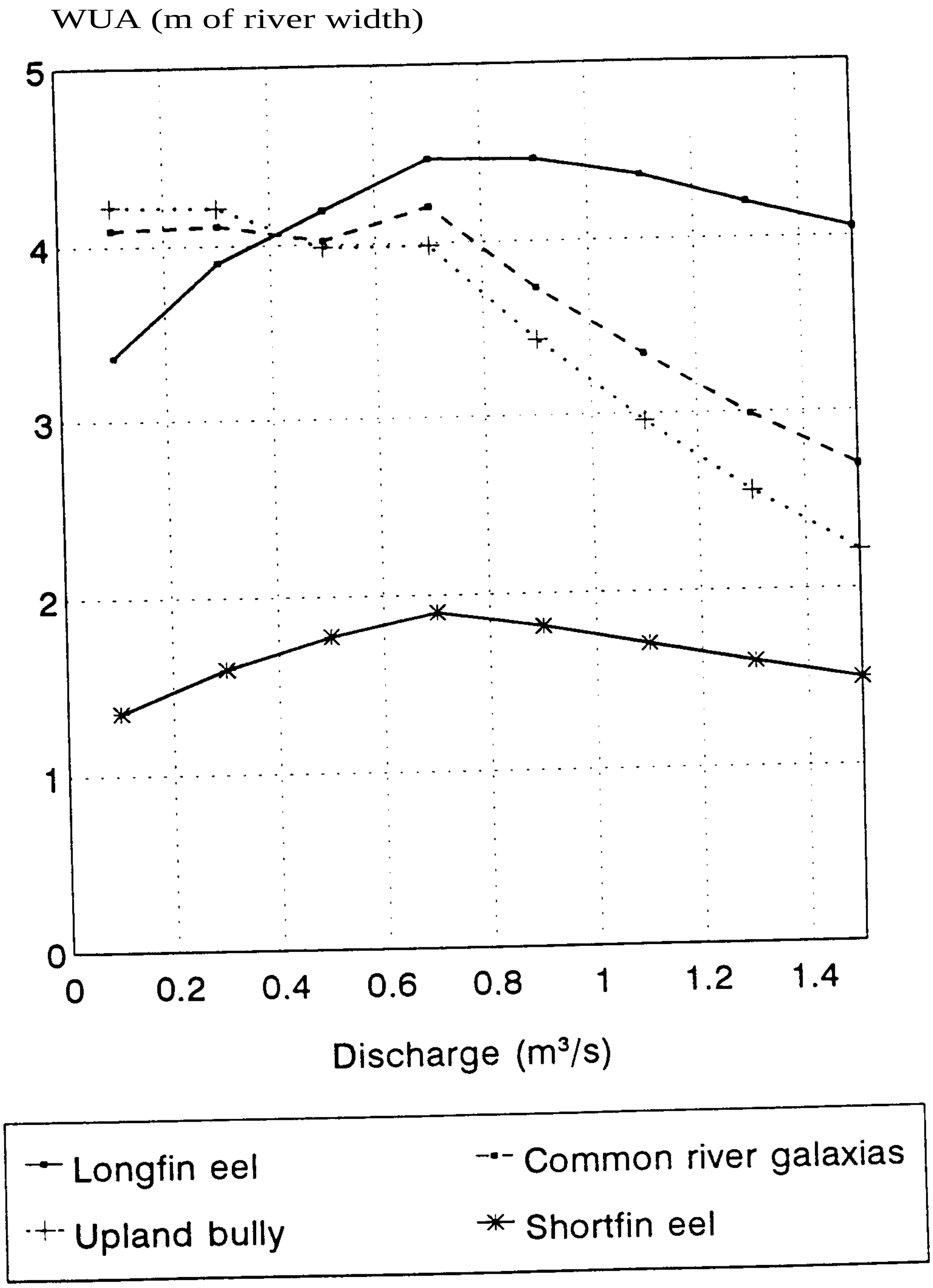

Figure 8. Variation of instream habitat in the middle reaches with flow (WUA expressed in metres of river width) for longfin eel, common river galaxias, upland bully, and shortfin eel.

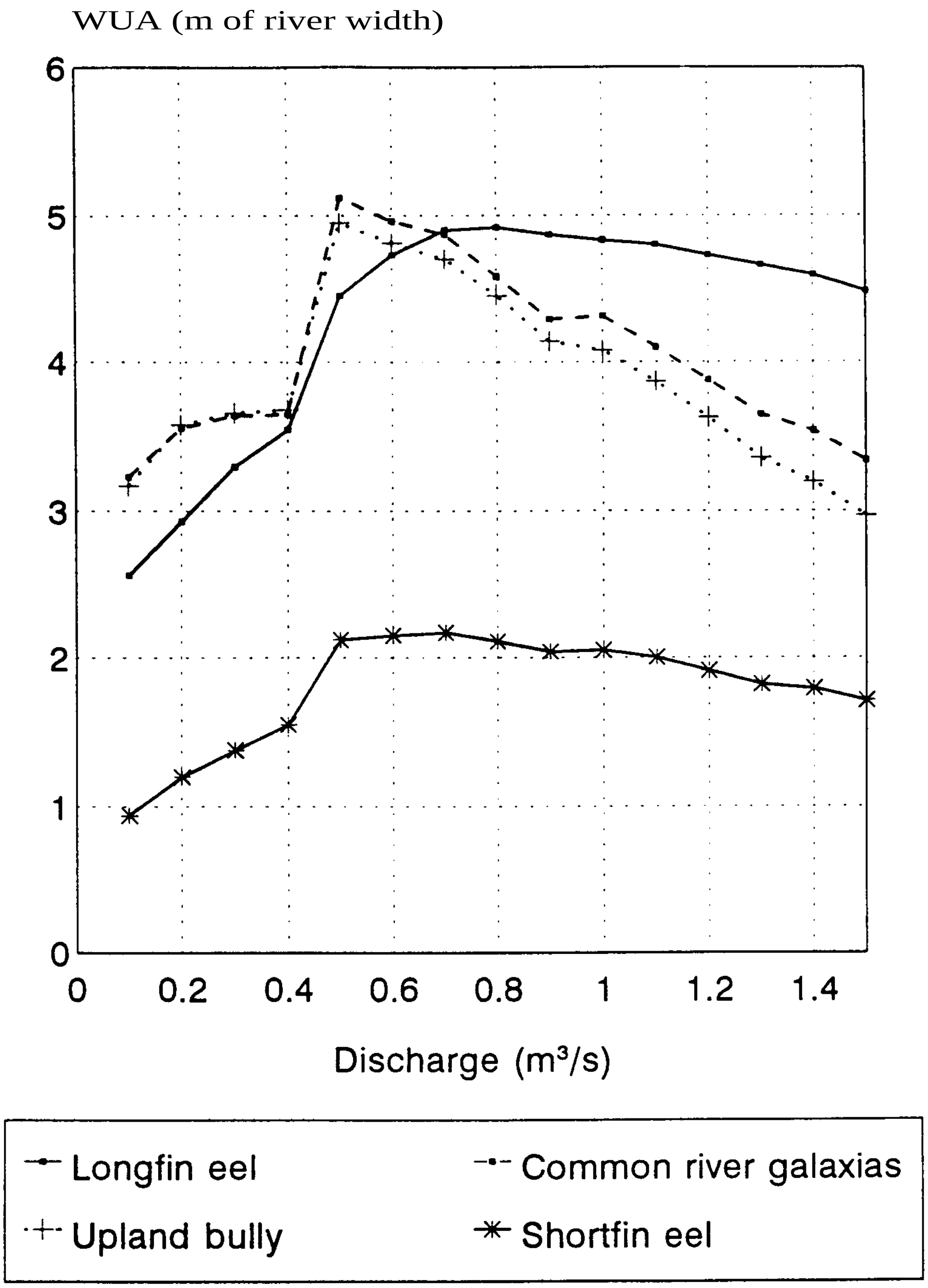

Figure 9. Variation of instream habitat in the upper reaches with flow (WUA expressed in metres of river width) for longfin eel, common river galaxias, upland bully, and shortfin eel.

Minimum flow assessment

The assessment of a minimum flow was based on the habitat requirements of common bullies, eels, and the two fast water species. Flows lower than the present minimum flow of 0.25 m^3/s have little impact on the habitat of common river galaxias, redfin bullies, and upland bullies, whereas habitat for the other species decreases. Common bully habitat shows a point of inflection at 0.3 m^3/s. Below this habitat begins to reduce more sharply with flow, although, even at 0.1 m^3/s, the available habitat has not been reduced by more than 5096 of the optimum.

Habitat for torrentfish, and bluegill bullies in the lower reaches declines sharply with any reduction in flow. Although there are no "rules" for setting habitat maintenance flows, an increase in minimum flow would result in a proportional increase in available habitat for bluegill bullies and torrentfish, a slight increase in available habitat for common bullies and eels. Above about 0.3 m^3/s, the increased flow is of less benefit to common bully habitat. Overall, I consider that a minimum flow of 0.3 m^3/s at the Mill Dam gauging site would maintain acceptable habitat for native fish.

ACKNOWLEDGMENTS

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REFERENCES

Aptech Systems Inc. 1991. The GAUSS system, version 2.1. Aptech Systems Inc., Kent, Washington, USA.

Bovee, K. D. 1982. A guide to stream habitat analysis using the instream flow incremental methodology. U.S. Fish and Wildlife Service Biological Services Program FWS/OBS-82/26, *Instream flow information paper 12.* 248 p.

Bovee, K.D. 1986. Development and evaluation of habitat suitability criteria for use in the instream flow incremental methodology. U.S. Fish and Wildlife Service Biological Report 86(7), *Instream flow information paper 21.*

Johnson, N. L., Kotz, S. 1971. Univariate continuous distributions: distributions in statistics Vol 1 and 2. Wiley, New York.

Jowett, I. G. 1990. Factors related to the distribution and abundance of brown and rainbow trout in Nev. Zealand clear-water rivers. *New Zealand Journal of Marine and Freshwater Research* 24:429-440.

Jowett, I. G.; Duncan M. J. 1990. Flow variability in New Zealand rivers and its relationship to in-stream habitat and biota. *New Zealand Journal of Marine and Freshwater Research* 24:305-317.

Richardson, J., Jowett l. G. 1994. Fisheries values of the Waipara River Catchment. NIWA Christchurch miscellaneous report 173.

Silverman, B. W. 1986. Density estimation for statistics and data analysis. Chapman and Hall, London.

Wolman, M.G. 1954. A method of sampling coarse river-bed material. *American Geophysical Union 36(6):* 951-956.