NIWA

Taihoro Nukurangi

Fish and invertebrate values of the Styx River catchment: a strategic review

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Fish and invertebrate values of the Styx River catchment: a strategic review

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prepared for

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Executive Summary

The fish and invertebrate values of the Styx River are reviewed, and compared with catchments of a similar nature, both regionally and nationally. A number of study topics are outlined to improve fish and invertebrate values in the catchment, and preliminary cost estimates are provided.

1 INTRODUCTION

The following physical description of the Styx River catchment is quoted from the CDB (1989). The catchment had an area of 54.8 km^2.

"The Styx River ... traverses the northern suburbs of the Board's district and is the main outlet for the Papanui, Belfast, and Northcote areas. It is 21km long and roughly parallels the Waimakariri River which it joins near its mouth in Brooklands Lagoon. Two natural tributaries service this river - Smacks Creek (approximately 2 km long) and the Kaputone Stream (11 km). All three branches are spring-fed and maintain reasonably constant flows through predominantly rural areas. The tide-gates just below Harbour Road have a major influence on the hydrology of the lower reaches of the Styx River. Not only is seawater prevented from penetrating much above site 41 but the impedance offered to the river water during each flooding tide ensures that a (freshwater) tidal regime is maintained almost up to Marshlands Road where low-flows average between 1.5 and 2.0 m^3/s*"*

2 FISH VALUES

2.1 Species richness

Currently (15/6/99), NIWA's Freshwater Fish Database lists 10 freshwater fish species in the Styx catchment, the same number recorded in 1990 when a major fisheries survey was conducted (Eldon and Taylor 1990, Fig. 1). Recorded species are, in approximate order of general abundance: shortfin eel, longfin eel, brown trout, common bully, lamprey (ammocoetes), common smelt, inanga, giant bully, upland bully and black flounder. In addition, the yelloweyed mullet (a marine itinerant species), may be seen shoaling in the lower reaches below Marshlands Road. Life histories and general biology of these species may be found in McDowall (1990). A further four marine species are known to frequent the Brooklands Lagoon area (Eldon and Kelly 1985). Since the completion of the general fisheries studies cited above, to my knowledge, two other small specialised fish surveys have been conducted. Gibson's Drain was electro-fished six months after restoration from a boxed drain (letter to Rachel Barker, CCC 1997), and the effect of a Kaputone Stream weir on fish passage was evaluated (Sykes *et at.* 1998). Neither of these small studies increased the known species list in the catchment, but did augment knowledge of the fish distribution. Given the variety, intensity and wide distribution of the fishing effort in the catchment, the fish fauna list (as described above) can be regarded as complete. None of the present species could be regarded as endangered either regionally or

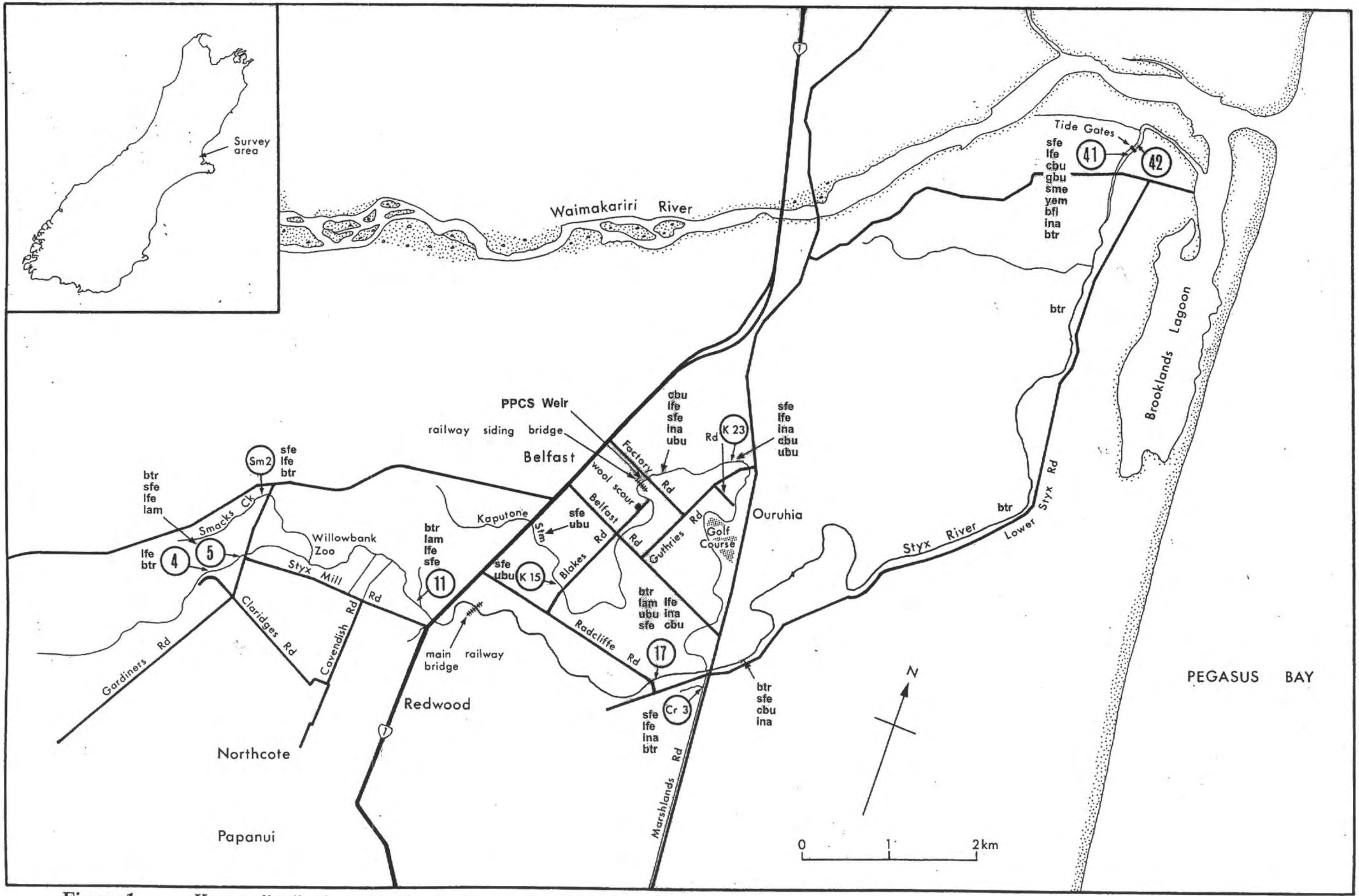

Figure 1. Known distribution of freshwater (and marine itinerant) fish in the Styx River catchment (Locations as designated by CDB (1980)).
(bfl=Black flounder, btr=Brown trout, cbu=Common bully,ina=Inanga, lam=Lamprey, lfe=Lonfin eel, sfe=Shortfin eel, sme=Common smelt, ubu=Upland bully, yem=Yelloweyed mullet)

nationally, although the fishery for two of these species (inanga, and shortfin eel) are vulnerable to over fishing.

Compared with coastal rural pastoral streams of similar size elsewhere in the country, the Styx River fauna ranks about "average" to "fair" in terms of species diversity. With the exception of the bluegill bully, the Avon/Heathcote system has a similar extant fauna list, when relatively recent deliberate introductions are excluded (i.e. rudd, perch, goldfish and Canterbury mudfish). Saltwater Creek (Ashley Catchment), with a rural coastal catchment with virtually no industrial pollution fares somewhat better with 11 freshwater fish species (excluding a spurious salmon record, but including fourbully species). It is also likely that lamprey, while not yet recorded, also inhabit Saltwater Creek. Kaikorai Stream, south of Dunedin (nine records), which possibly suffers from suburban development, ranks rather poorly with only seven species. Of course, modified rural streams like the Styx possess inferior fish values compared with unmodified large streams and small rivers on the West Coast of the South Island (eg. Oparara River, Karamea River). Characteristically, the galaxiid and bully species richness is superior in heavily-bushed catchments. It is worth noting that the Whau River, a riparian-bushed stream which drains the suburbs of Mt Roskill and New Lynn of Auckland City contains banded kokopu, koaro, and giant kokopu, all of which are considered sensitive to habitat degradation.

2.2 Species distribution

2.2.1 Shortfin and longfin eel distribution

Shortfin eels were the most abundant and well-distributed species in the catchment, being found at all sites, bar one (Claridges Road) from the fisheries survey (Eldon and Taylor 1990). Fish lengths ranged between 122 to 900 mm (n = 520), and eels were similar in condition to those obtained from the Heathcote River (Eldon and Kelly 1985). Longfin eels were also well-distributed, but less abundant. Fyke-netted larger longfins were considerably shorter than their counterparts in the Heathcote River, but electro-fished longfins were of similar length in both catchments. Similar to the shortfins, longfin eel condition (a measure of fatness) was also similar between the two catchments.

Eel are occasionally harvested on a recreational and commercial basis from the lower catchment with fyke nets, but the weight of fish harvested in this recreational fishery is known. There is strong interest by the local Tuahuriri Rununga for a lowland cultural fishery (mahinga kai), which would include eels.

2.2.2 Brown trout distribution, age and condition

The findings in this section are based on the fisheries survey conducted in summer 1990 (Eldon and Taylor 1990). Other than the two eel species, brown trout were the most commonly encountered species during this catchment-wide survey. They were found throughout the mainstem, and some tributaries, particularly Smacks Creek. Smacks Creek trout upstream of the Willowbank reserve could constitute a separate population, owing to physical instream barriers in the reserve grounds. In contrast, no brown trout were recorded from Kaputone Stream during the summer survey due to apparent poor quality of the habitat. Large resident trout occupied the middle reaches of the mainstem, and these fish migrate upstream each winter to spawn. Accordingly, small adults and juveniles were found throughout the upper reaches, except for the reach between Gardiners Road and the Smacks Creek confluence (Fig. 1). Fish from young-of-the-year up to more than five years of age were collected, and although growth rates were variable, mean fish condition based on the 1990 study was good (112), and similar to that of an earlier study (111, Hayes 1978).

2.2.3 Brown trout spawning

This section summarises results from the only known published trout redd survey of the Styx River (Eldon and Taylor 1990). Most spawning took place in the mainstem of the river, from 300 m downstream of the Smacks Creek confluence to the Styx Mill Road bridge, particularly the 500 m upstream of the bridge. Further limited trout spawning was recorded in the mainstem headwaters in the vicinity of Claridges Road. However siltation of streambed gravels reduced general suitability in this area. A shallow stream entering the mainstem upstream of Cavendish Road provided small-trout spawning waters. Given its good access and popularity with trout anglers (Teirney *et al.* 1987), it is surprising that other redd surveys have not been undertaken. Although at the time of writing, the North Canterbury Fish and Game Council had just completed a survey. Preliminary results indicate that the mainstem between Gardiners Road to the Main North Road is still the most heavily utilised section for trout spawning, although the number of redds and trout counted this year (21 redds, 15 fish) is substantially less than that counted on 22 June 1989 (36 redds, 60 fish) (B. Ross pers. comm.).

Considerable numbers of trout were found in the upper reaches of Smacks Creek, and there was good spawning gravel above the Willowbank wildlife reserve, which is presumably used by the local adult trout population (Eldon and Taylor 1990). However, from the reserve to the confluence most of the substrate gravels were unsuitably silted and covered with filamentous algae for trout spawning to occur. Siltation was also a problem in Kaputone Stream, despite the presence of 'potentially good' spawning gravel in the upper reaches. General pollution, and riparian herbicide use were cited as other reasons for deterring spawning adults migrating upstream (Eldon and Taylor 1990).

2.2.4 Brown trout recreational fishery

Despite good numbers of fish recorded from the Styx river (Eldon and Taylor, 1990), results from a postal survey questionnaire indicated that, in 1987, the waterway was regarded as polluted by many anglers, and cut-weed snagged lines in the tidal reaches. This perception of water pollution, and reduced water quality was also shared by other fisheries workers (Hardy 1986). However, despite this, it was fished by more anglers than any other lower Waimakariri tributary (Teirney *et al.* 1987). Compensating factors includes its closeness to the city and easy access, but other neighbouring waters (e.g. Cust, Selwyn River) share these benefits and also provide a more pleasant angling experience. Results from the 1994/96 National Angling Survey showed that the Styx River fishery was exposed to an seasonal (October-September) fishing pressure of 437 fishing hours per annum, comparable to the Irwell River (433 hrs) and Cust River (362 hrs) (Unwin and Brown, 1998). However the Styx River is under-utilised when compared to the nearby Kaiapoi River (5247 hrs) or Waimakariri River (58357 hrs), although these systems both support popular salmon fisheries. But even the Avon River has a surprisingly superior fishing pressure (1017 hrs).

2.2.5 Common bully distribution

The common bully was present in the lower reaches of the mainstem (Fig. 1), and in Kaputone Stream prior to the fish **kill in** February 1990 (Eldon and Taylor 1990). The abrupt termination of its mainstem distribution, without any apparent change of instream habitat, led this writer to suspect that an instream obstruction was curtailing its distribution (letter to Barker (CCC) 1997, NIWA files). A subsequent investigation established that a concrete weir in the grounds of the PPCS abattoir effectively prevents upstream colonisation of two native fishes with sea-going lifestages; the common bully and inanga (Sykes *et al.* 1998). The weir was evidently negotiable by both shortfin and longfin elvers - juvenile eels which can climb damp surfaces -because adults are found above the structure. Non-migrating fish (e.g. upland bullies) were not effected by the structure's presence, and they were found well upstream in the Kaputone River system, but not the mainstem (Fig. **1).**

2.2.6 Distribution of other species

A migrating adult lamprey was found in the mainstem in the vicinity of Gardiners Road, whereas juveniles (ammocoetes) were recorded from 3 mainstem sites: Gardiners Road, above the Main North Road, and below Radcliffe Road. The adults parasitise marine fish before migrating up rivers to spawn in gravel-based headwaters. After the lamprey eggs hatch, the resulting juveniles (ammocoetes) inhabit silty embayments along rivers for several years, filter-feeding from the water column, before migrating to the sea (McDowall 1990).

The behaviour of yelloweyed mullet was observed both upstream and downstream of the tidegates below Harbour Road (Eldon and Taylor 1990). Mullet swum upstream from Brooklands Lagoon on the ebbing tide, but by the time they get to the tidegates, the tide has turned, and the gates are already closed. They congregate in large numbers just below the gates, until the gates open again 2 hours after high tide, when the congregating mullet can swim upstream above the gates to feed on algae and macrophytes.

Common smelt is another species that normally occupies the tidally-influenced zone in rivers. Similar to the yelloweyed mullet, its foraging appeared to be restricted by the action of the tidegates with little inland penetration. Mullet and black flounder were not recorded upstream of Harbour Road (Eldon and Taylor 1990), nor were giant bullies which were found as far upstream as the tide-gate area. However shoals of mullet have been observed well upstream of Harbour Road and their maximum upstream distribution should be regarded as unknown. Mullet comprise a valued recreational fishery in the lower Styx River (A. Crossland, CCC pers, comm.)-

2.2.7 Inanga and the whitebait fishery

Adult inanga were infrequently recorded from the Styx River in 1990 (Eldon and Taylor 1990), with a maximum upstream penetration somewhere between the Main North Road and Radcliffe Road in the mainstem, and to the PPCS weir on Kaputone Stream (Fig. 1). The lower reaches of the river are difficult to sample efficiently, and the shoaling and pelagic nature of inanga contribute to their evasiveness. It is therefore possible that the 1990 survey may have failed to assess the size and maximum upstream penetration of the inanga population in the lower reaches. Many adult fish were seen schooling in the vicinity of the tide-gates, foraging for invertebrates, but despite many hours of reconnaissance, no schools of spawning fish were observed in late summer (NIWA field data). The operation of the tide-gates is considered by this writer to inhibit inanga spawning in the otherwise suitable vegetation above it, and NIWA is currently computer-modelling tide-gate modifications to allow inanga to spawn (Ton Snelder, NIWA pers. comm.).

The most popular whitebaiting area is immediately below the tidegates where the fish congregate before the gates open. Only limited whitebaiting takes place above the gates, and although both scoop nets and set nets were used, scoop nets appeared to be more popular in the river's clear water (Hardy 1986). Whitebaiting effort through the season appeared fairly consistent (7-30 persons/day, mean = 16), owing mainly to the stable flows of the river. While whitebaiters are notoriously secretive about all aspects of their catches, it appeared the best catches took place in late October (Hardy 1986).

The boxed drains that enter the lower Styx have not fished to date, largely because considerable experience has shown that such habitats are almost depauperate of fish. However, inanga and two other small fish species were recorded from Janet Stewart Reserve, a former section of boxed drain downstream of Lower Styx Road that had been recently restored (letter to Rachel Barker, CCC). Despite the newness of the works, the fishes were quite abundant throughout a variety of constructed microhabitats.

3 INVERTEBRATE VALUES

Invertebrates have several **important roles** in the Styx River, and **other** aquatic

habitats. From an ecological perspective, invertebrates serve a critical role in converting primary production, either from detritus and leaf fall entering the river, or from river vegetation and/or algae, to invertebrate biomass. As invertebrates, this energy is then available to other animals, but importantly food for fish. With the exception of the filter-feeding lamprey amrnocoetes, all fish in the Styx River are carnivorous, feeding partly or wholly on invertebrates. In terms of resource management, the other useful aspect of invertebrates is that they are good biological indicators of water quality (Stark 1985). To my knowledge there have been five reports on invertebrates of the Styx River; two on the instream fauna by the former Christchurch Drainage Board (CDB 1980, 1989), and three reports upon their value as fish food (Parrot 1929, Hayes 1978, Eldon and Taylor 1990).

3.1 Value of invertebrates as fish food

The earliest reference to Styx River invertebrates (Parrot 1929), noted that 10 Styx River trout (col. January 1929) had stomachs almost exclusively filled (99%) with caddis larvae, and **a** few stonefly larvae (O. Plecoptera), the latter taxa generally indicative of good water quality. In the same report, from a small sample of bullies examined, small **bullies** less than 45 **mm,** ate amphipods (probably *Paracalliope fluviatilis),* whereas those between 45 and 100 mm preferred 'water snails' (probably *Potamopyrgus* and/or *Physa* sp.), or if greater than 100 mm in length, ate freshwater shrimps *(Xiphocaris curvirostrus* now called *Paratya curvirostris).*

Examination of stomach contents from four species of fish obtained from the Styx River (Eldon and Taylor 1990), confirmed the importance of both aquatic and terrestrial invertebrates to fish diet; particularly gastropods (snails), the ubiquitous

Potamopyrgus antipodarum and *Physa* sp. The common amphipod *{Paracalliope fluviatilis)* is another favourite food along with two species of caddis larvae *(Hudsonema amabilis,* and *Pycnocentria sp).* Chironomid larvae are a common food item for bottom-dwelling fish in silty areas, like shortfin eels, but other fish may occasionally feed on them. Unlike the other fishes, the brown trout feeds during the day, and then on a wide range of food, often from the surface (Hayes 1978, Eldon *et. al* 1990). Accordingly, willow grubs, flies, adult beetles, earwigs and grasshoppers are characteristically found in trout stomachs. Koura (freshwater crayfish) have been recorded once, from the headwaters, and **would not appear to be common** in the catchment. Occasionally koura have been observed in the stomachs of large trout and eels from other catchments (pers. obs.).

3.2 Invertebrate diversity and their value as a water quality indicator

In 1979, the Styx River invertebrate fauna comprised 61 invertebrate taxa and supported a more diverse, abundant, invertebrate fauna than either the Avon or Heathcote Rivers (CDB 1980). Further, the Styx River's invertebrate fauna was regarded as more uniformly distributed and abundant than that found in the city rivers. The abundance of caddis fly larvae in the Styx, compared to the relative paucity in the Avon and Heathcote, was of particular note, with four species identified that were not recorded in the city waterways. These four species *(Paraoxyethira hendersoni, Pycnocentria evecta, Oeconesus maori* and *Hudsonema aliena)* are commonly found throughout New Zealand (Winterbourn *et. al* 1981). The higher level of invertebrate diversity in the Styx River was attributed to weed-clearing and siltation in the urban waterways, which leads to a reduction in invertebrate fauna. Of note, four4 species found only in the Styx River but not the city rivers, are commonly associated with weed beds or are detritivores (CDB 1980).

The Styx River was subject to another biological survey in 1987/88; it was concluded that the macroinvertebrate **fauna had changed little over the** 8 years between surveys, and that the water quality (as indicated by the invertebrates) was of a generally high standard (CDB 1989, Tables 1,3). However Plecoptera (stonefly) larvae were absent from the fauna recorded by the Christchurch Drainage Board during both surveys, although an unidentified species was recorded earlier this century (Parrot 1929). Plecoptera are usually, but not always, found in waters of the highest quality (Table 3, Stark 1985). This may indicate that the Styx River water quality has fallen from a pristine level early this century, or the physical habitat (possibly the substratum) has changed to the detriment of Plecoptera. I suspect that both events have occurred.

Generally, while the scientific value of the Styx River invertebrate fauna would not appear to be great, there may be species or lifestages which are of interest to specialist entomologists. However, limnologists have realised that the resident invertebrate fauna in a stream often reflects the general water quality of the waterway over a relatively long time period (Stark 1985), in contrast to spot-records of biochemical Oxygen Demand (BOD), adenosine-5-triphosphate (ATP), chlorophyll a (Ch1 *a)* , carbon radioisotope (C14) uptake, etc. (Hickey 1985). The use of macroinvertebrate (aquatic invertebrates visible to the naked eye) communities to assess water quality has been formalised into the MCI (Macroinvertebrate Invertebrate Index) index (Stark]985). Since the mid-eighties, the MCI methodology has been further refined, and even more sensitive to water quality. Further, it has been increasingly accepted by local bodies as a reliable guide to meaningful temporal and spatial changes in water quality, without apparent seasonal bias or spurious temporal variation, often manifested as short-term spikes. Using a living biological system to measure water quality seems a more appropriate and integrated measure of stream 'health' than a series of sometimes contradictory biochemical parameters. While originally calibrated for streams with a stony substrate, MCI scores was calculated for the sand/shingle based Kaiapoi River to assess the effects of point-pollution discharges (Stark 1985). This was justified thus:

"The application of the MCI to slow-flowing, sandy, silty, or muddy streams and rivers should be investigated ... it appears that the technique may be capable of detecting gross enrichment in such conditions but, inevitably, there will be a loss in sensitivity.... (Stark 1985)"

Accordingly, it was applied to sample sites along the Styx River in 1990, using macroinvertebrate fauna data collected in 1987/88, in an effort to objectively assess water quality along the mainstem (Fig. 10, Eldon *et al* 1990). Little regard was placed on the magnitude of the MCI scores {because there was no baseline data on unpolluted silty streams), but more on the direction and degree of change at known polluted sites. The MCI score based on the headwaters (Site 2, just below Sawyers Arms Road) was very low probably because of the ephemeral nature of the habitat (Eldon and Taylor 1990). From Sites 3 to Sites 14 inclusive, MCI indexes were consistent and relatively high, with a strong unexplained decline at site 12 (5 m upstream of main north road), which may have been to the influence of a drain tributary which enters here. Downstream of Site 14, the MCI declines sharply and steadily as the river runs through swampy farmland in Marshlands. There is no sharp decrease in the MCI below the confluence of Kaputone Stream, but the index continues to decline steadily to Site 22. After the combined successive input from an unnamed drain, and then Browns drain, the mainstem MCI index rises significantly, and then even higher after the input of Treleavens Drain. Downstream of this tributary, the MCI is reasonably flat until the saltwater influence at the tide-gates changes the invertebrate fauna, and the applicability of the MCI.

4 DISCUSSION

Under the Asset Management Strategy, the city's wetland 'assets' are rated on six related values: drainage, ecology, landscape, recreation, heritage, and culture (CCC 1999). The Council desires to maximise the worth of these assets by optimising those values already present, or developing infrastructure (plantings, walkways, interpretative signage) so that new 'values' are added. The recognition of the multiple values of waterways is a profound and welcomed change in resource management philosophy, but successful integration of these values requires considerable input from existing diverse information bases. This discussion addresses the long-term strategy for the Styx River in respect to fish and invertebrate values, a reflection of water quality and general ecological values.

Has water quality, as reflected by the invertebrate fauna, changed between 1979 and 1988 ? Although this question was not addressed in the 1990 fisheries survey, when the respective invertebrate faunas are inspected, there appears little evidence of water quality deterioration. In 1979, the invertebrate fauna of the upper 15 sites on the upper Kaputone Stream (above Blakes Road) comprised only two caddis species, one unscored by the MCI system, and the other *(Oxyethira* sp.) having an index of 2 (cf. high of 10). Below Blakes Road, nine caddis species were identified with a mean MCI index per taxon of 4.5. In 1987, three caddises were identified from upstream of Blakes Road, with a mean MCI index of 4.3, whereas below Blakes Road 10 species were found, six with a mean MCI index of 6. This implies, if anything, an improvement in Kaputone Stream water quality over the period 1979 to 1988. Nevertheless, the quality of the upper catchments waters would appeared to have been poor. Compare these data with the three Smacks Creek collection sites, where 11 caddis species were identified in 1979, and a mean MCI per taxon of 6.3. In 1988, 13 species were identified with a mean MCI per rated taxon of 6.1. Note that the MCI of the lower Kaputone Stream was little different from that of Smacks Stream, but there is a strong disparity in water quality (as indicated by the MCI) between the upper and lower reaches of Kaputone Stream.

It is instructive to examine water quality data collated by the Council to see if it supports or refutes the assertion that water quality varies considerably in Kaputone Stream. Since 1989, the Christchurch City Council has been monitoring the water quality at eight sites on the Styx River (Gilson 1999). These include the Styx River headwaters, Kaputone Stream at Blakes Road, Smacks Creek, and the mainstem lower reaches. The Styx River is considered the least polluted of the Christchurch Rivers in terms of nutrients and BOD, but Kaputone Creek is the most polluted of the tributaries (Gilson 1999). Biological Oxygen Demand (BOD) in Kaputone Creek commonly exceeds Ministry for the Environment (MfE) guidelines (2ppm), and appeared to get worse over between April 1989 and June 1997. There are high recorded levels in ammonia and reactive phosphorus in the upper reaches of Kaputone Creek (measured at Blakes Road), upstream of the Wool Scour and the PPCS abattoir. Ammonia is very toxic to animals, including fish and their eggs (Hill, 1976). Ammonia can reach disturbingly high levels at this site, twice exceeding 0.8 ppm, and once reaching 1.0 ppm in 1992. Of concern, is that recorded peaks in ammonia are becoming more frequent, and the mean levels of ammonia were increasing up to the end of the monitoring period (1997). In addition these data is collected on a routine weekly sampling regime, therefore high maximal peaks (or lows) of ammonia between sampling events would be missed. Ammonia levels decline further downstream between Blakes Road and Belfast Road, in fact Kaputone Creek ammonia levels measured at Belfast Road show a declining trend between 1989 and 1997. There is clearly a localised ammonia pollution source upstream of Blakes Road. In other parts of the catchment, ammonia did not reach these high levels.

The lower and middle reaches of the Styx River mainstem are dominated by trout, and most spawning occurs between Marshlands Road and the Kaputone Creek confluence. Trout are conspicuously absent from Kaputone Creek, probably because of the pollution levels and history of fish kills every few years in that system (Eldon and Taylor 1990). Levels of pollutants (particularly ammonia and phosphorus) in the upper reaches are quite alarming. In the case of ammonia, there is an indication of a dilution effect further downstream, but as ammonia levels continue to rise, dilution will be less effective in rendering ammonia concentrations to safe levels. Low water pH renders ammonia (NH_3) to the less toxic ammonium ion (NH4+), but the pH of the Styx River is unknown, but is probably near to average (7.0). Conversely, a high pH in Kaputone Stream, and high water temperatures would accentuate the problem with ammonia pollution. Some action will need to be taken to control the increasing levels of ammonia in the upper catchment above Blakes Road, There are other problems with Kaputone Stream which also warrant attention; stock effluent and grazing, rubbish dumping, and improper use of herbicides (Eldon and Taylor 1990). The writer endorses the recommendations of the 1990 fisheries report, and a specific investigation is required to determine the sources responsible for the poor water quality in the Kaputone Stream headwaters.

In summary, it would appear that the Styx River water quality may have deteriorated since the work by Parrot (1929). While this is hard to prove with the scarcity of 'pre-impact' data, it would not be surprising given the changes in landuse in the catchment. Between 1979 and 1988, catchment-wide water quality, as indicated by the invertebrate fauna, appears to be unchanged, with a noticeable improvement in the poorly-rating upper Kaputone Stream. However, water quality data compiled since 1988, indicate a worsening situation in the upper Kaputone Stream above Blakes Road.

It is clear from the literature that the Styx River has suffered from siltation, and pollution of agricultural, horticultural, and industrial origin (Eldon and Taylor 1990). With the suburban zone of Christchurch growing to the north, larger areas of the formerly rural catchment are being sub-divided, which will lead to a slow, but inevitable change in the catchment hydrology of the river. Further, the perceptions of the new residents are likely to differ from those of the rural landowners, and hopefully place higher expectations on aesthetics, water quality, and recreational values. However, in the transition period between rural and suburban landuse, mechanisms will have to be in place to protect the Styx River from the large quantities of silt generated from subdivision development. Riparian strips and set-backs greatly assist in this regard, and the writer knows the Council has experimented with swale construction, and soil percolation of roof-runoff rainwater. It is understood that the application of these methods is dependant on the nature of the existing soil and subsoils.

With the exception of the upland bully, and brown trout, all other species of fish found in the Styx River have marine lifestages. This is a reflection of the coastal nature of the system, and has profound implications in respect to fish values in the Styx River. First, it implies that the main river is used as a 'ecological corridor' for the up-river fauna, even if migrating species do not use the habitat, except as a conduit. Second, instream obstructions, depending on their severity, can deny entire subcatchments from being utilised by seagoing fishes. The critical importance of fish passage has meant that the fish species richness of some of the restored reaches (e.g. Sheldon Park) has been halved because of instream obstructions further downstream (Kaputone Creek weir at the PPCS abattoir). Reaches of degraded habitat are also likely to deter further upstream migration for some species. There is merit in the concept of restoring habitats in a sea-to-source order, so that restored waterways function as *both* an improved resident fish habitat and as an enhanced 'ecological corridor' to the upstream reaches. Conversely, the closer an instream obstruction or degraded habitat is to the sea, generally the worse are its deleterious effects in denying catchment habitat area from colonisation by recruiting from the sea.

Commercially unexplioted coastal eel habitats of significant size are now rare in New Zealand (Jellyman 1993). Such waters could serve as important rearing areas to compensate the national fisheries from the ravages of over-fishing. This applies particularly to the shortfin eel, which have a mainly coastal distribution. It is hoped that the Travis Wetland, and ecological corridor will serve this role in the Avon/Heathcote System, and conceivably the Brooklands lagoon and lower Styx could serve a similar role. In the past, the Brooklands lagoon's ecological value has been compromised by pollution from a number of sources (Eldon and Kelly 1985). With the projected changes in the Styx River's watershed, water quality could well improve, and the Brooklands lagoon, if restored, could reach its full ecological potential.

The tide-gates are a difficult issue. Clearly, they inhibit the natural foraging behaviour of several fish species, the upstream migration of whitebait, and probably prevent the spawning of inanga. Generally the tide-gates curtail the influence (and energy flow) of the estuary ecosystem into the lower river, and truncate the saltwater/freshwater ecological zone. Decommissioning of the tide-gates would produce significant land loss through tidal flooding, and effected marginal land would lose pastoral (and thus commercial) value. Retention basins may assist, and could have intrinsic bird and fish values but they would have be of substantial size. For example, these lowlands would serve as an excellent rearing ground for inanga and shortfin eels, and the emergent rushes would provide excellent protection from the predation of trout.

The ditches which enter the lower Styx River hold considerable potential as habitat for native fish, especially inanga, and common bullies. Currently, a number of small native species must 'run the gauntlet' of predatory trout and large eels in the lower Styx River to gain access to suitable upstream habitat. If the ditches entering the lower Styx River had even reasonable quantities of instream cover, then small native fish could reside in these tributaries and avoid possible predation by trout in the mainstem. In the case of inanga, this would also decrease the length of the spawning migration to the tidal reaches in the autumn. The fish fauna in the Janet Stewart Reserve indicates how restored boxed drains are readily utilised by small native fish.

The following list suggests actions to improve instream values in the Styx River catchment.

- The invertebrate fauna needs to be resurveyed to identify gradual long-term changes in instream values. Recalculated MCI values can then be compared with those computed from 1980 CBD data, and the water quality data compiled by Gilson (1999). This would provide a useful comparison with, and interpretative extension of, recently published water quality parameters for the period 1986-1997. NIWA has the resources to undertake this work, and a preliminary estimate of costs for this work, based on 36 invertebrate samples from 12 sites, and report compilation would be $8000.

- Identify instream obstructions in the Styx River catchment impeding upstream access for the predominantly sea-going fish fauna, and provide site-specific recommendations. NIWA has the resources to undertake this work, and a preliminary estimate of costs for this work, including report compilation would be $4,000.

- Advice on the restoration of waterways in a 'sea-to-source' sequence, concentrating on the lowland boxed drains which are not currently compromised by poor access and pollution. Examine the provision of small-fish cover in the main stem. NIWA has the resources to undertake this work, and a preliminary estimate of costs for this work, including report compilation would be $4,000.

- A 'trouble-shooting' investigation is required in Kaputone Creek to identify the probable multiple sources of pollution levels in the upper Kaputone Creek, which are currently environmentally unacceptable. Sources of head-water pollution must be identified and dealt with, possibly in a 'source-to-sea' sequence. Point sources of pollution, rural run-off and siltation need to be addressed. This work largely falls within the responsibilities of the Canterbury Regional Council.

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TABLE 1 : Distribution of invertebrates and aquatic weeds: Kaputone Stream

Site	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15
Phaenocora sp									+				o		
Oura pinguis		+		*	*	o		o		+		+	+		+
Neppia montana														o	
Tubifex tubifex	o	o	o	o	o	*	*	*	+	*		+	o	o	o
Lumbriculus variegatus	o	+	*	o	*	*	o	*	*	+		*	*	+	o
Eiseniella tetraeda															o
Potamopyrgus antipodarum	*	*	o	o	o	o	o	+	o	+		o	*	+	*
Gyraulus corinna							o			+				o	
Physa sp	o	o	o		o		o	o		*		*	o	+	o
Sphaerium novaezelandiae	o	+	+	*	o		o	+	+	*		*	+	*	*
Pisidium sp										*					
Simocephalus sp										*		o			
Herpetocypris pascheri		o			o							o		*	
Eucyclops serrulatus	*			o			o		o	o		*	+		
Paracalliope fluviatilis	o	+	+	*	o	*	o					o	o		
Acarina (unidentified)												+	+	*	o
Xanthocnemis zealandica															o
Microvelia macgregori					o	o	o								
Sigara arguta									o	*		+	+	o	o
Neurochorema confusum														o	
Oxyethira albiceps										o				o	
Pycnocentria evecta														o	
Liodessus plicatus	*	*	o									o			
Helodidae	o														
Zealandotipula sp		o	o												
Paralimnophila skusei		o	o												o
Culex sp	o							o				o	o		
Chironomus zealandicus						o	+	o	+	o		*	+	+	*
Orthocladinae	o	o			o	o	o						o		
Tanypodinae								*							
Limnophora sp															o

TABLE 1 : (Cont'd)

TABLE 1 : (Cont'd)

Site	K16	K17	K18	K19	K20	K21	K22	K23	K24	K25	K26	K27	K28	K29	K30
Phaenocora sp					o				o	o					o
Cura pinguis	o		o	o	*	*					o	*	+	*	*
Tubifex tubifex	o	o	+	*	+	*	*	*	+	+	*	+	+	*	*
Lumbriculus variegatus	o	*	+	*	+	+	*	*	+	*	*	+	+	+	+
Eiseniella tetraeda		o			o				o			*	*		
Potamopyrgus antipodarum	*	*	*	*	+	+	*	*	+	+	*	o	*	*	*
Gyraulus corinna			+	o	*	*	*	o	*	o	o	o		o	*
Physa sp	*	o	*	o	*	+	*	*	*	*	*	*	o	*	+
Sphaerium novaezelandiae	o	*	+	+	*	o	+	o	*	+	*	+	+	+	+
Pisidium sp						+	o		o						
Ferrissia sp											o				
Simocephalus sp							o		+						
Herpetocypris pascheri	*				o	o			+		o	o		*	*
Eucyclops serrulatus			o	o		o			+						
Acarina (unidentified)	o	o	*	o											
Deleatidium sp									o						
Xanthocnemis zealandica							o								
Microvelia macgregori															o
Sigara arguta	o	o	o	o	o				o						
Polyplectropus puerilis				*											
Hydrobiosis parumbripennis		o													
Oxyethira albiceps				o		o			*						
Pycnocentria evecta		*							o						
Pycnocentrodes aureola						+									
Oeconesus maori		+													
Triplectides obsoleta	*	o	o	*											
Hudsonema amabilis	o	+				*				o		o			
Hudsonema aliena									o						
Oecetis unicolor				o	o	o	*	*	o	*	o	o			
Chironomus zealandicus	o	*	*	+					+	+	+	+	+	+	+
Orthocladinae			o	o	o		*	+	*	*	o	o	+	o	o
Tanypodinae									o			o	*	*	
Ceratopogonidae				o											
Limnophora sp	o	o				*									

TABLE 3 : Distribution of invertebrates and aquatic weeds: Smacks Creek (November 1988)

Site	Sm1	Sm2	Sm3
Chlorohydra viridissima			o
Oura pinguis	*	*	*
Lumbriculus variegatus	+	+	*
Glossiphonia multistriata	o		o
Barbronia weberi			o
Potamopyrgus antipodarum	+	o	o
Gyraulus corinna	o		
Physa sp		*	o
Sphaerium novaezelandiae	*	o	*
Herpetocypris pascheri	o	*	*
Eucyclops serrulatus		o	o
Paracalliope fluviatilis	*	*	+
Paraleptamphopus subterraneus		*	o
Acarina (unidentified)	o		
Deleatidium sp		+	o
Coloburiscus humeralis		o	o
Zephlebia nodularis			o
Austrolestes colensonis			o
Microvelia macgregori	o	o	o
Polyplectropus puerilis		*	o
Hydrobiosis parumbripennis		o	

TABLE 3 : (Cont'd.)

TABLE 3 : (Cont'd.)

Site	Sm1	Sm2	Sm3
Psilochorema bidens		o	o
Neurochorema confusum		o	
Oxyethira albiceps	*	*	+
Paroxyethira hendersoni			o
Pycnocentria evecta		+	o
Pycnocentria aeris			o
Pycnocentrodes aureola		o	
Olinga feredayi		o	
Aoteapsyche colonica		*	o
Hudsonema amabilis		+	*
Oecetis unicolor		o	
Liodessus plicatus	o		o
Zelandotipula sp		o	
Mischoderus sp		o	
Chironomus zealandicus		o	*
Maoridiamesa harrisi			o
Orthocladinae	o	+	*
Austrosimulium sp	o	o	
Muscidae	o		