Habitat enhancement opportunities for inanga in Jenkins, Orphanage, Poorman Valley and Saxton Waterways, Nelson City Council

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The adult inanga is a handsome fish, its whitebait make up about 90% of the whitebait fishery (photo Tony Eldon)

White gold! - the eggs of the inanga (photo Mike Hickford)

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Introduction and background

Jenkins Creek, Poorman Valley Stream , Orphanage Creek and Saxton Creek are waterways administered by Nelson City Council (a small amount of the upper Saxton Creek catchment falls within Tasman District). The waterways drain westward from the slopes of the Barnicoat Range over the Stoke alluvial fan into Waimea Inlet. Their biodiversity values, natural functioning, connectivity and water quality have been compromised to varying degrees as they run this distance. Waimea Inlet and near shore coastal waters are the receiving environment for the nutrients, faecal and chemical contaminants and sediment they convey. The streams have been selected by the Council as candidates for enhancement, with a focus on native fish habitat and in particular that used by the inanga (*Galaxias maculatus*), the most common of the 5 whitebait species. While the most common of the whitebait species, inanga have nevertheless been added recently to the increasing list of native fish classified by national experts as "at risk" (refer Allibone et al 2010), so that now four of the five whitebait species ie inanga, shortjaw kokopu, giant kokopu and koaro fall into this category. The banded kokopu is the only species considered to be not threatened. The purpose of this report is to identify the habitat enhancement opportunities for inanga in the subject waterways and the methods to achieve this.

Undertaking enhancement programmes for these waterways allows the Council and its project partners to address multiple goals as set out in a range of local, regional, and national policies, strategies and plans focused on improving water quality and freshwater habitat. Such goals are set out in the Councils Freshwater Plan, the Waimea Inlet Strategy, the Nelson and New Zealand Biodiversity Strategies and the National Policy Statement on Freshwater. The Councils freshwater biodiversity action plan's vision is : *" Nelson's freshwater ecosystems retain a predominantly native natural character, their ecological health is sustained and fully functioning examples of natural freshwater wetlands and small streams are restored. The ecosystem services provided by freshwater ecosystems are sustained, wisely used and valued."* At the same time other complimentary goals will be met such as those relating to meeting local iwi aspirations for water quality and habitat protection, the promotion of recreational opportunities in urban environments (such as those along restored riparian corridors), improvement of environmental aesthetics and increasing public awareness of nature in a built up environment. It will also stimulate further opportunities for iwi, community, schools, business and landowner participation in riparian and aquatic enhancement initiatives.

To fully address all elements of the lifecycle needs of inanga (ie in freshwater, estuaries and the sea) enhancement options need to span a whole of catchment approach such as the "ridgetops to the sea" concept applied as the focus of the extensive Motueka River Integrated Catchment Management study (e.g. Phillips 2010). This holistic approach is the essence of the Maori concept of mauri e.g. "Every waterbody whether an awa (river), a stream, roto (lake) or wetland has its own mauri (life force). Only a waterbody with intact mauri can sustain healthy ecosystems. Therefore it is considered essential that wai is not polluted in any way, but is nurtured in order to sustain all living things, including tangatawhenua" (Passl 2004).

Habitat enhancement challenges in urban streams

Small urban streams such as those running through Stoke are widely recognised as amongst the most degraded of freshwater systems nationally and world- wide because their small size provides limited resilience to the multiplicity of impacts on their natural form, functioning and biota (e.g. see Paul and Meyer 2001). Fully restoring them to a pre-impact environment is impossible because of the dense infrastructure of housing, business, industry, roading and other services that have developed beside, over, under and through them and the diverse pollutants and rubbish that are conveyed into them through stormwater and other sources. While the lower urban reaches of rivers including those on the Stoke Fan are subject to the greatest modifications, further up-slope, more "rural" sections and the catchment headwaters are subject to multiple land uses such as lifestyle blocks, horticulture, farming and forestry which exert additional pressures on water quality (e.g sediment, nutrients, faecal and chemical contaminants) and habitat. Water abstraction and water supply dams further reduce the amount of wetted habitat available for fish and invertebrates as well as concentrating nutrients and elevating water temperatures which further accelerate slime or bacterial growths (e.g see Taylor et al 2003).

Extensive reaches of urban streams are piped, culverted, straightened and channelised. Floodgates and tidegates in lower reaches have also been widely used to ensure that floodwaters can escape efficiently and prevent saltwater ingress during high-spring tide cycles. Fortunately none of the subject streams have these structures. Various other channel modifications include detention dams, gravel and debris traps. While the overarching concern has been the efficient control of water to provide flood protection for valuable property, land, infrastructure and human safety, New Zealand wide, the collective effect has been to constrain or prevent whitebait and other migratory fish species accessing thousands of kilometres of upstream habitat. Diversity of native fish faunas upstream of barriers is therefore often limited to those fish which have the strongest climbing ability (e.g elvers, koaro, banded kokopu) or which do not need to migrate to and from the sea(45% of NZ freshwater fish undertake such migrations see McDowall 2001) to complete their life history such as the upland bully. Fortunately there is now general recognition that unimpeded linkage of freshwater habitat to the sea is critical to sustaining native fish populations and has led to the development of standards, guidelines, inventories, research and development of techniques to address fish passage needs and retrofit existing structures with fish passage devices (e.g. NIWA 2007, Stevenson and Baker 2009, Boubee et al 1998, Boubee and Richardson 2000, James 2006, Doehring 2009).

Other induced changes to urban catchments affecting flow regime arise because of the high proportion of impervious surfaces such as roads and footpaths. This increases the rate at which rainwater runs off into the stormwater system and eventually into streams, causing flooding and high water velocities. It also reduces the amount of rainwater that can infiltrate the soil to keep streams flowing between rainfall events, and therefore streams dry up more often and for longer. These changes adversely affect fish and invertebrate habitat and living conditions (Suren and Elliott 2004, Timperley and Kuschel 1999).

Across urban, rural and upper catchment reaches the complete removal or extensive modification of the former continuous native riparian corridor, including freshwater and estuarine wetland sequences in the lower reaches, is a feature common to urban streams. The massive scale of removal has had a profound effect on habitat for not just fish and aquatic invertebrates but the diverse community of native birds, terrestrial insects and bats which formerly populated the riparian zone of lowland forest ecosystems. Towering stands of forest and dense understory presiding over very dimly waterways (see Figs 1 and 2) choked with leaves, branches, logs and fallen trees (sources of carbon for the food chain) thriving with aquatic life, have been replaced by straightened channels often with open, grassy manicured banks, exotic weed species and an absence of the natural instream debris which provided the habitat complexity required to support diverse and dense populations of fish and invertebrates (Collier 1994).

Reduced habitat complexity can also increase interactions such as competition (e.g Hartmen 1965) and predation (e.g. Schlosser 1982) between fish species. Along similar lines pest fish have colonised some streams in the Nelson-Tasman region and may compromise aquatic communities by predation and competition effects. For example *Gambusia* or "mosquito fish" have been found in Waimea Inlet tributaries including Orphanage Creek. Eradicating or managing them can be very problematic and expensive (Elkington and Maley 2005). Likewise introduced invasive aquatic and riparian plants need to be controlled to re-establish native aquatic and riparian communities and natural functioning in urban streams.

Fig 1. Fish-eye lens photograph in a representative native forested stream showing the dim light environment (Rutherford et al 1997)

Fig 2.. Putting it back-community planting Poorman Vlly Stream- an existing Council programme.

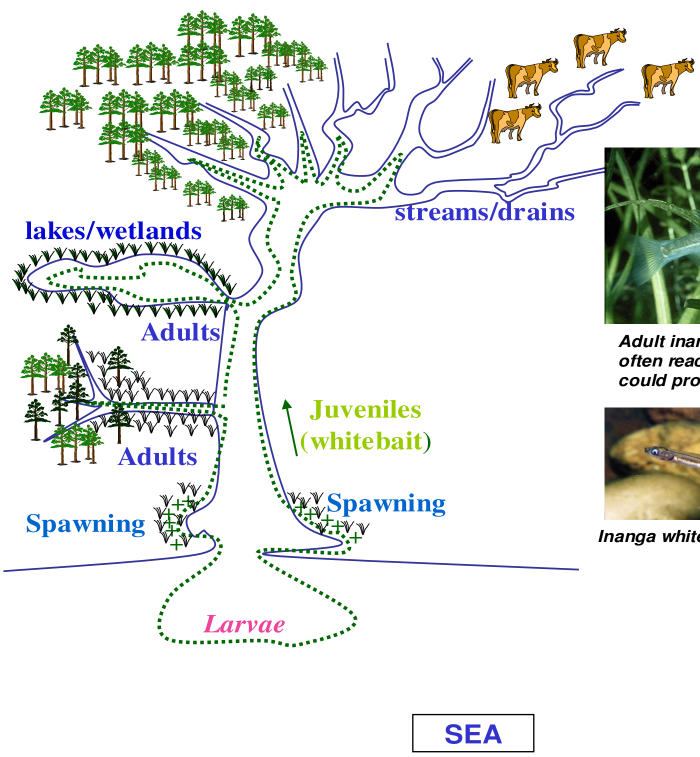
The loss of shading by riparian vegetation has produced one of the most damaging effects on small urban streams by elevating water temperatures which may occur over fairly short distances because of the small thermal inertia and the rapidity of water heating. For example Rutherford et al (1997) reported up to a 5 degree temperature increase over a distance of 1-5km in shallow streams, highlighting the critical importance of re-establishing riparian corridors. Because of its fundamental importance to sustaining aquatic ecology riparian enhancement of urban waterways through native planting programmes has become an increasing activity of New Zealand councils and their participating communities (Campbell et al 2010). Most Council websites explain the multiple benefits from riparian planting including those to water quality, native fish, invertebrate and bird habitat and also provide planting lists of species appropriate for the region and methods for planting and their maintenance (e.g Courtney et al 2003). Likewise Department of Conservation and Ministry for Environment websites provide numerous guidelines on techniques and approaches to riparian and other aquatic habitat enhancement.

Inanga habitat as a focus for aquatic enhancement actions

Whitebait are a cultural and gastronomic icon to many New Zealanders and inanga are the mainstay of the whitebait fishery. Inanga are of great importance to maori culturally and as a customary food source. Their historical importance and the sophisticated techniques and traditions used in capturing them are described in Best (1929). Familiarity with whitebait and their importance to people make inanga a great choice as a focus for restoration effort. For example the 'Whitebait Connection" (www.whitebaitconnection.co.nz) education and awareness programme has had success nationally, and has locally been developed into to the "Waimaori" programme which with financial support from the Council and DOC has delivered to schools and other groups the message about protecting waterways within the maori kaupapa.

The life history of the inanga variously involves: adult life in freshwater and estuaries and movement between the two environments; autumn spawning of adults in the estuarine reaches of waterways; the eggs hatching and the larvae (about 7mm long) rearing in estuaries and the sea and then after about 6 months the familiar springtime run of inanga whitebait (about 50mm long) into freshwaters. Adults live usually for 1-2 years exceptionally for 3.

Lifecycle of inanga



Adult inanga are an attractive fish and often reach about 10cm. The fish pictured could produce up to 10,000 eggs

Inanga whitebait about 50mm long

modified after West (2009)

Successful completion of this life history cycle requires free passage of fish between freshwater-estuaries and the sea and the provision of suitable habitat and water quality conditions in each environment. In considering and meeting the ecological needs of inanga, the needs of the whole suite of native fish can be largely met. This is because of the similarity in their basic requirements ie fish passage, good water quality and flow regimes and the provision of suitable instream and riparian habitat. However, the specialised requirements inanga have for spawning habitat need particular attention to ensure this critical part of their life cycle is protected and enhanced. There is general recognition that the lack of suitable spawning habitat is a bottleneck limiting inanga populations nationally (McDowall 1990). The eggs that are deposited amongst vegetation on stream banks during springtides are particularly vulnerable to mowing activities, stock and human trampling and the deposition of rubbish or other material. Deciduous trees such as willows leaf fall leading to smothering is also detrimental to egg survival and require management. The vegetation chosen for depositing eggs into is quite variable and includes both introduced and native plant species of a variety of forms and textures (e.g. see Richardson and Taylor 2004). For example throughout New Zealand un-grazed rank pasture grasses have been found to provide very good spawning habitat with high egg survival. Fundamentally, the vegetation whether it is native or exotic, needs to trap sufficient moisture at its root base to ensure inanga eggs remain moist until they hatch when inundated by the next cycle of spring tides. Another feature of the plants that eggs are deposited onto/into is that they are usually adapted to freshwater; spawning in saline adapted vegetation is rare.

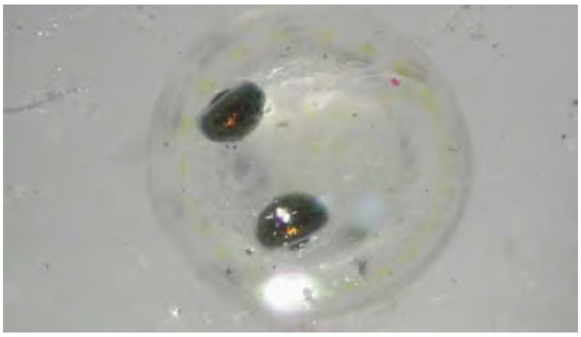


Fig 3. Photo of a well-developed inanga embryo. Egg size is approximately one mm (from Taylor 2005).

Eggs (see Fig 3) also face predation from a range of species including mice, crabs and other fish such as bullies and eels (Baker 2006). Emphasizing the importance of the shading function of vegetation at inanga spawning grounds the recent research by Hickford found that without adequate shade from vegetation about half of whitebait eggs died in good habitat but that increased to 95 per cent in poor habitat, with even slight increases in temperature and radiation exposure having a major impact (C. Hickford article in "The Press" 1/9/11).

In terms of providing fish passage, because inanga whitebait have the least capability to climb and surmount obstacles of the five species meeting passage requirements for inanga will also provide access for the other four species (e.g. Doehring 2009). Unlike the other whitebait species (e.g banded kokopu) which become more solitary as they get older, inanga retain the schooling habit that they show in the whitebait stage. The adult fish move around in mid-water schools ranging from small groups of 10- 20 fish to thousands. Adults favour gently flowing and still waters - estuaries, lowland rivers and streams, lagoons and backwaters (McDowall 2000).

As noted above addressing water quality issues in these tributaries to Waimea Inlet will assist in improving water quality in the Inlet which is a primary long term goal for Tasman and Nelson Councils and the project partners involved. Good water quality, habitat and food supply in Waimea Inlet is critical for the larvae of freshly hatched inanga eggs to thrive and likewise the juveniles of other migratory native fish freshwater fish and many species of marine fish such as snapper and kahawai (Davidson 1990, Stevens and Robertson 2010) which also use the Inlet.

Other freshwater fauna such as inverterbrates (e.g caddisflies, snails, mayflies, freshwater shrimps) will benefit from improvements to water quality and instream and riparian habitats in the waterways subject to enhancement. In the case of inanga, which forms about 90% of the whitebait catch, increasing fish numbers through enhancement projects, benefits not just the whitebaiters targeting this species but also the wide range of fish and bird predators that feed on inanga at both the whitebait and adult lifestages in freshwater, estuarine and marine habitats. Furthermore, because inanga and other whitebait species such as the banded kokopu (*Galaxias fasciatus*) are not a "homing species" and their larvae disperse widely in the marine environment (ie they do not necessarily come back to the stream where they were spawned) any improved production of fish from enhanced waterways is "exported" to other waterways regionally or even wider.

Aquatic habitat values and condition of the subject waterways and options for enhancement

The following sections provide a general description of existing knowledge of the aquatic fauna and environment present in the four subject streams (Fig 5.) and then identify the main issues and opportunities that would enhance habitat for inanga and benefit other native fish and the aquatic environment.

Fig 5. The four streams of interest drain westward across the Stoke Fan into Waimea Inlet

Saxton Creek

Existing environment and aquatic community

Saxton Creek (upstream of Stoke /Salisbury Road) has a catchment area of nearly 600 hectares that ranges in elevation from near sea level to 500 m above sea level. The catchment is relatively flat in its lower reaches but steepens significantly towards its headwaters. Calculations of rainfall run off indicate that the 50-year return period peak discharge from the catchment is in the order of 24 cumecs (24000 litres per second). The Creek has an estimated mean flow of 62 litres per second (lps), a mean annual low flow (malf) of 7 lps and a 5 year low flow of 4 lps (Wilkinson 2007). This represents a very high degree of flow variability but the essential feature is the creeks small size and exposure to very low flows. It has the smallest flow of the four streams considered for enhancing inanga habitat.

Data that has been collected as part of Council surveys based on representative measurements showed wetted stream width for Saxton Creek sites ranged from 0.6-3.1 metres and bank full width 2.95 metres (Wilkinson 2007). Collapsed banks and shallow pools were reported as features associated with the Creek in the Saxton Field Extension and Concept Plan.

Bottom substrate conditions were poor and dominated by fine substrate types-mostly finer gravels, silt and sand which offer poor habitat for invertebrates and fish - including those native fish which require cobbles to spawn on such as cockabully species. The origin of sediment has not been investigated but is probably coming from multiple sources in the catchment which has a diversity of land-use types and includes upper slope agricultural land, some horticulture, forestry, urban/lifestyle holdings and the lower-most industrial reach bordered by the old freezing works property. An inspection of the reach downstream from the old freezing works, including within the Whakatu Drive culvert, showed extensive deposition of thick mud and sand which had a strong smell of ammonia when disturbed (pers. obs.).

Water quality measurements at the lower catchment monitoring site showed very poor conditions for aquatic life. Water was of poor clarity with high suspended sediment levels, low oxygen, elevated temperatures, severe faecal contamination and high nitrate, ammonia nitrogen and phosphorus levels -these were likely to be arising as a point source from organically polluted water; measurements of algal cover in Saxton Creek have also shown elevated growths (Wilkinson 2007). Measurements of pH were usually in the normal range ie around 7 with the occasional outlier of 5-6 indicating increased acidity. While there were some elevated temperature readings of significant concern such as at spot reading of 36 celsius overall the median spot temperature at Saxton Creek was 12 degrees and Wilkinson (2007) suggested that the overall capacity for impairment was not high.

Invertebrates recorded in Saxtons Creek are those types expected to be present in degraded waterways and are dominated by species of worms, snails (*Potamopyrgus antipodarum*), amphipods(*Paracalliope*; *Phreatogammarus*), midges (Orthocladiinae) and sandfly larvae (*Austrosimulium* sp.). Existing data indicate that contamination from metals and oils was not an issue at the mouth of Saxton Creek.

Other information on riparian vegetation reported in Wilkinson (2007) indicated channel shading into the 51- 75% shade class with poorer shading on average in the lower reaches compared with the upper reaches and a dominance of grass. The report, however, noted the need for checking the robustness of the methodological approach used in assessing shade. The presence of some fencing to manage stock access was also noted but did not specify details. A walk through survey of the Creek and establishment of monitoring sites higher in the catchment would help provide a fuller understanding of fish populations, aquatic habitat features, water quality(including potential contaminant sources) and any structures which may be constraining fish passage that would better inform options for enhancements benefitting inanga and other fish species. Such information gathering would for example include gathering information about the artificial reservoirs/ponds in the catchment which occur at both lower and upper slope locations – these may contribute to elevated water temperatures and may also influence nutrient regimes but at the same time may serve to reduce sediment inputs.

State of Environment reporting (NCC 2010) gave Saxton Creek a long-term classification of E (very degraded based on ANZECC 2000 standards) on the basis of its present condition, making it an obvious but the most challenging candidate of the four subject waterways for enhancement (Fig 8.).

Enhancing habitat for inanga and other aquatic life

Saxton Creek has not been subject to much survey effort for freshwater fish - especially in its upper reaches, so knowledge is incomplete. Existing information from sites lower in the catchment is recorded in NIWA's New Zealand Freshwater Fish Database (NZFFDB) and in Doehring and McIntosh (2008). Species recorded to date include: common bully (*Gobiomorphus cotidianus*), inanga (*Galaxias maculatus*), longfin eel (*Anguilla dieffenbachii*), shortfin eel (*Anguilla australis*) and yellow-eyed mullet (*Aldrichetta forsteri*). Yellow-eyed mullet is an estuarine species which forages in the lower reaches of Waimea Inlet tributaries during high tide penetrating long distances upstream on spring tides (pers. obs.). In addition to fish, the northern koura (*Paranephrops planifrons*) a species of large crustacean (listed as in gradual decline in Hitchmough 2007), has also been recorded.

The fish present are those known to be more tolerant of poor water quality and habitat conditions (e.g Rowe et al. 2000). which is consistent with what currently is known about Saxton Creek. It is significant that the species of particular interest for enhancement ie the inanga has been recorded in the creek in the past, because it shows that it is worthwhile pursuing habitat enhancement for this species. Furthermore, a recent inspection of the lower reaches showed small schools of inanga whitebait both downstream of and within the Whakatu Drive culvert (pers. obs. August 2011). These fish and ongoing runs of whitebait are likely to penetrate further upstream seeking suitable habitat to live in and grow to reach adulthood. However, the inspection showed eroding banks without riparian vegetation immediately upstream of Whakatu

Drive currently unsuitable for juvenile or adult inanga or as inanga spawning habitat (Fig 6.). This area is currently subject to works involving bridge construction. When this is completed bank stabilisation including re-contouring to reduce steepness and plantings with a suitable mix of native species (e.g. see Courtney et al 2003) to provide shade and fish cover are potential enhancement options. Generally where bank work is required in Saxton or the other subject streams the emphasis needs to be on soft engineering works such as the placement of woody debris, logs and rock in combination with use of other materials such as geotextile roll and mat and vegetative geogrid to incorporate fish habitat into erosion protection measures(e.g see Tonkin and Taylor 2008).

Observations of spring tide water level and salinity regimes will be needed in order to select the right native plant species for planting. This is also the key to determine the best locations for inanga spawning enhancements such as the planting of species which optimise egg survival and for the creation of spawning "benches" which have been successfully created in Christchurch rivers such as the Heathcote River (e.g. Taylor and McMurtrie 2003). Likewise a survey of lower river reaches during the autumn inanga spawning season (e.g. see Rutledge 2011) will also be needed to evaluate the number of adult fish present and any fish concentrations indicating interest in undertaking spawning activities. However spawning itself in Saxton Creek seems an unlikely prospect given the existing poor habitat conditions. Fortunately some exotic pasture grasses such as tall fescue (provided it does not get too rank) and some other exotic herbaceous species may support good inanga spawning grounds(Richardson and Taylor 2004) so growths of these species do not necessarily need intensive management if they invade banks within the water-level zone generated by spring tides. The main activities to avoid are cutting the grass in this zone over the egg deposition and development phase (late January- late May), trampling by people and stock or by depositing any type of material including sediment. As mentioned earlier once spawning has been established in the Creek control of mice and possibly rats may benefit inanga egg survival.

To future proof enhancements for lower Saxton Creek and the other waterways it would be prudent to also consider the projected effects of sea level rise on salinity regimes and potentially also the frequency of extreme rainfall events/droughts in the long-term under a climate change scenario.

Fig 6 .Saxton Creek immediately upstream from Whakatu Drive enhancement opportunities

Fig 7 .There are many options for enhancing fish passage including the use of conveyor belt material (Courtesy Trevor James TDC)

Adult inanga prefer slow flowing water and pool habitat (e.g. Sagar 1993, Richardson and Taylor 2002) so that the existing slow current velocities observed at the site and those very likely to be present in the low gradient reaches further upstream are suitable. The main opportunity for these areas and indeed for the rest of the upstream catchment is riparian planting in primarily native species to enhance the shade, fish cover and food supply (both aquatic and terrestrial insects) for post whitebait and adult inanga and other native fish species such as bullies and eels. Additional benefits for native birds are gained by including nectar producing varieties such as flax and kowhai in plantings. Where appropriate some exotic species such as *Eucalyptus leucoxylon* which provides nectar at times of the year (April to October) when nectar feeding birds and insects have few other native plant alternatives could also be considered. While there may be obvious constraints at sites, where possible, planted vegetation should simulate that occurring over a natural watercourse to provide the greatest effectiveness with plantings immediately adjacent to and over the channel. The creation of heavy shade, plant derived woody debris and marginal habitat complexity such as undercut banks and irregularities formed by root structure would be the optimal outcome for fish habitat.

If field surveys show water depths to be too shallow for adult inanga then artificial deepening to create pools and the creation of small embayments could be considered. As discussed earlier soft engineered bank protection and more novel bank supporting structures could be used where necessary to provide "homes" and habitat spaces for fish on the creek margins. Removal of grazing, riparian planting and re-contouring of hazardous steep banks were identified as actions for Saxton Creek under the Saxton Field Extension and Concept Plan including the provision of pathways for walkers and cyclists.

Good numbers of adult inanga are already established in the detention pond on Orphanage Creek immediately upstream of Main Road Stoke (pers. obs.). Adult inanga would very likely also do well in the large irrigation pond at Saxton Creek about 300 hundred metres above Whakatu Drive- if they are able to access it. The same applies to the other ponds and dams further upstream provided adequate access is available. That inanga whitebait will colonise habitats well upstream in Stoke Fan streams is shown by records of inanga several kilometres upstream in Poorman Valley Stream (Tom Kroos pers. comm.) and in Orphanage Creek above the Councils water recorder site at Ngawhetu (see later discussion).

Because usual flows in Saxton Creek are small the amount of instream habitat available for inanga and other fish species is a primary habitat bottleneck along with inanga spawning habitat as discussed above. Therefore providing access into and enhancing habitat within artificially created ponds would make a valuable contribution to boosting inanga populations. In ponded areas the establishment of riparian vegetation and native water-emergent rushes and reeds (see Fig.11) that would benefit inanga and other species (e.g see Richardson & Taylor 2002) could be explored with landowners. Retaining the stream channel rather than any further piping or culverting of the watercourse will retain habitat and better maintain passage for inanga and other species.

Any fish passage barriers found through survey work should be able to be remedied using a variety of techniques (e.g. see Fig. 7) with the full understanding of the requirements for inanga whitebait passage already provided in the locally based study by Doehring (2009) using a range of technical methods to address them (e.g. Boubee *et al* 2000).

Ongoing monitoring is needed to detect and control invasive exotic fish species such as Gambusia (which were eradicated from nearby Orphanage Creek by DOC in 2004) and invasive aquatic plants. Gambusia can be particularly aggressive towards small fish such as whitebait. Unfortunately new infestations of Gambusia have been found recently in other small waterways nearby draining into Waimea Inlet such as Borcks Creek and are subject to ongoing control efforts. It has also been suggested that improving instream habitat quality, for example through riparian planting, may reduce the abundance of some nuisance introduced species such as Gambusia (Ling 2004).

As discussed earlier, addressing water quality issues throughout their length is fundamental to enhancing the Stoke Fan waterways and Waimea Inlet. The tolerance inanga have to reduced water quality including reduced oxygen, suspended sediment and ammonia (Richardson and Taylor 2004) will assist their survival while water quality issues are addressed. The Council through the Nelson Resource Management Plan and other provisions such as those relating to freshwater habitats and stormwater such as the Stormwater Asset Management Plan 2009 – 2012 and Reticulated Stormwater Quality Improvement Plan (RSQIP 2009) which promotes best practice methods to address pollutants in stormwater and other run-off. The Council also promotes the incorporation of sustainable stormwater design into new subdivisions by applying rules which seek to minimize hard surface areas and reduce the adverse ecological effects of quickflow on small watercourses.

Engaging with landowners and businesses and the broader community to promote a cooperative approach to finding solutions and education to encourage awareness of aquatic ecosystem values should be pursued by the Council and partner groups and organisations. Likewise the promotion of riparian planting and other enhancements could be facilitated by a Saxton Creek stream care group through school and community linkages including the delivery of advocacy programmes such as Waimaori. Interpretation along walkway infrastructure would provide further opportunity to raise awareness and appreciation of inanga and other native fish.

Orphanage Creek

Existing environment and aquatic community

Orphanage Creek which enters Waimea Inlet about 700 metres east of Saxtons Creek has the largest catchment and highest mean flow (216 lps) of the Stoke fan streams with a MALF of 12 lps and 5 year low flow of 4 lps (Wilkinson 2007). Its furthest upstream reaches near Saxton Hill are about 7 river kilometres from the sea and over 400 metres above sea level. While having the largest mean flow it has proportionally a much lower minimum flow regime because of the nature of storage in the catchment making the aquatic ecology more subject to stress under low flow conditions. The catchment drains rural and forestry areas as well as having a significant length running through urban development and a smaller amount through the lower industrial reach. Total catchment size is 1023 hectares. There is a significant stormwater infrastructure connected with the Creek that covers 175 hectares, with 27 stormwater pipes listed (RSQIP 2009) with under passes of major roads such as Main Road Stoke and Whakatu Drive. These and piped infrastructure affect fish passage to varying degrees (e.g. Hay and Young 2004). Walkways and riparian plantings are associated with esplanade reserves and there is existing and proposed mixed native and exotic plantings associated with the Saxton Field development. Other riparian plantings exist as part of Council initiatives and subdivision developments. The detention pond at Saxton Field immediately upstream from Main Road Stoke creates some aquatic habitat diversity within the system and has excellent raupo beds and flax plantings around its fringes (Fig. 11). However the downstream weir that retains it does limit passage for some species and increase exposure to predation (Fig. 9). Council removes up to 800 m³ of gravel every 2 years from this pond and for a distance of 100 m above pond with potential adverse effects g on ecological and habitat values.

Water quality has been reported on in Wilkinson 2007 and NCC 2010 with the summary evaluation (Fig. 8) highlighting its better standard than that in Saxton's Creek. The overall ranking for Orphanage Creeks long term classification is D (degraded)but poorer nitrogen and macroinvertebrate scores dropped the grade to E (very degraded) for 2008.

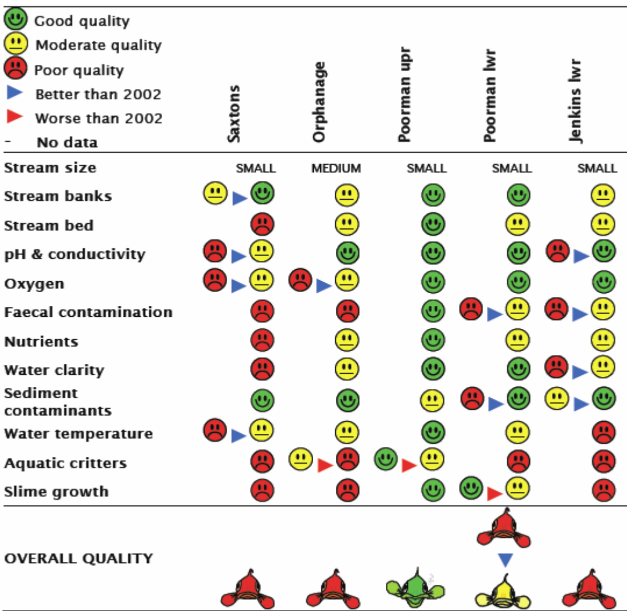


Fig. 8.Summary of stream health/ water quality scores (extracted from NCC 2010)

Fig. 9 A whitefaced heron intercepts whitebait migrating up the face of the detention pond weir

The narrowness of the channel, limited number of pools, fine sediments and slime growths are factors which are not conducive to optimising fish habitat. Streambed and banks received moderate ratings. Probably the general narrowness of the channel under high flow conditions and the limited number of pools and habitat complexity that would provide refuge for fish from being swept downstream, also may limit carrying capacity. This effect would not be so pronounced in the lower gradient reaches where current velocities would be less accelerated compared to the middle- upper reaches.

Aquatic invertebrates sampled in lower Orphanage Creek were of similar kinds to those found in Saxton Creek which reflected poor water quality and sediment conditions. Snails, fly larvae, small crustaceans such as amphipods and ostracods and flatworms were common.

Native fish species recorded from Orphanage Creek include, common bully, redfin bully , inanga, koaro (as whitebait only), banded kokopu , longfin eel , shortfin eel and yellow-eyed mullet and the crustaceans koura and freshwater shrimp (*Paratya curvirostris*) which is an excellent food source for fish. While longfin eel and koura are spread throughout the catchment, adult banded kokopu occur in the less modified upstream catchment, while yellow eyed mullet occur in the lower most reaches (see Doehring 2010 for more detailed distribution analysis of fish in Nelson streams). Inanga, the species of interest for enhancement, penetrates in good numbers well upstream occurring in pools and slow runs. As noted in Hay and Young (2007) despite the several impediments to fish passage posed by four bridge aprons and weirs good numbers of adult inanga were present throughout the reach between Waimea Estuary and beyond the Ngawhatu flow recorder weir about 3 km upstream. However a fish survey following a storm event in 2008, which caused erosion and a significant change to bed level. showed inanga were no longer present above the weir (unpublished data). Since then the Council has taken steps towards remedying passage but a follow up fish survey has yet to be undertaken. Fully restoring passage is the desired goal.

Enhancing habitat for inanga and other aquatic life

Orphanage Creek supports extremely high numbers of adult inanga in the reaches downstream of Main Road Stoke (e.g. Hay and Young 2007) including within the detention pond and some very large fish (over 150mm) are present (pers. obs.). Although the weir downstream of the detention pond constrains passage and increases predation exposure to herons, the number of adults upstream suggests that the existing fish pass and wetted weir face provide adequate passage. However, further improvements to passage at the weir should be investigated to ensure that sufficient fish are available to fully saturate upstream habitat which will improve under the enhancement programme. Likewise the apron at the downstream end of the culvert (Fig. 10) under Main Road Stoke (and potentially others) is subject to erosion with a steep facing slope that may increase with further down cutting during large floods which could further reduce passage for inanga and other weaker swimming or non climbing migratory species. Inspection and direct observations of fish behaviour-including how well flow activates fish passage pathways could inform potential improvements to passage. As discussed for Saxton Creek inspection of structures to identify fish passage issues and develop solutions for the whole catchment is an integral part of enhancement for inanga and other native fish.

Fig.10 ongoing erosion at the downstream end of the apron could constrain fish passage (*photo taken in 2007*)

Fig. 11 Raupo and flax in and around the detention pond provide excellent cover and habitat for inanga

The detention pond has been invaded in the past by Gambusia and control operations by DOC appear to have been successful. Ongoing monitoring and control of Gambusia, potentially other pest fish and invasive aquatic plants will be needed to maintain existing native fish communities and habitats.

Inanga spawning was reported by a member of the public in Orphanage Creek in 2002 just upstream from Whakatu Drive. In March 2011 the 340 metre reach between Main Road Stoke and Waimea Estuary was surveyed for spawning fish with particular attention paid to the area just upstream from Whakatu Drive (see Fig.13). Very large schools of both inanga and yellow eyed mullet were present throughout the entire reach but no spawning activity was observed (Rutledge 2011). However, inspection of riparian vegetation showed plenty of rank grasses and other herbaceous riparian vegetation suitable for spawning to be present in the reach. Overhanging grasses also provide cover for adult fish which are present in high densities throughout this reach. Future spawning checks should focus on the area immediately upstream and downstream of Whakatu Drive in autumn 2012. The spring tide sequences from about 8-13th March onward till the end of May should be targeted as the main period for surveys with periodic observations during normal hide tide sequences during the period in between spring tides to make additional observations on spawning behaviour. General methodology for inanga spawning and egg survey work is outlined in (Richardson and Taylor (2004).

If spawning is found then low tide inspections to determine the extent of the spawning area used and the number of eggs deposited should be made and the data recorded on the regional inanga spawning database and the Council advised so that management actions can be taken to protect the site. The main management tool in this reach where spawning has been found in the past and where suitable spawning vegetation currently exists is to avoid the cutting of grass and other streamside vegetation during the inanga spawning season- indicatively mid January- 30th May. Planting of the reach with native vegetation to provide shade and cover for both adult inanga and to improve shade levels for eggs in spawning areas is important. Some planting has already been undertaken but as discussed elsewhere to be effective it needs to provide shade over the watercourse and eggs to be optimal. Given that previous surveys have found spawning already takes place in this reach in rank streamside grasses/herbs then retention of a significant amount of grasses/herbs interplanted with a mixture of native plants is more likely to optimise spawning habitat retention. As discussed for Saxton Creek information on water level height range and salinity during spring tide cycles as well as considering sea-level rise and regional climate change scenarios will assist in developing riparian planting plans for inanga spawning areas in the subject streams.

Fig. 12 lower Orphanage Creek about 150m upstream of Whakatu Drive has potential for riparian plantings

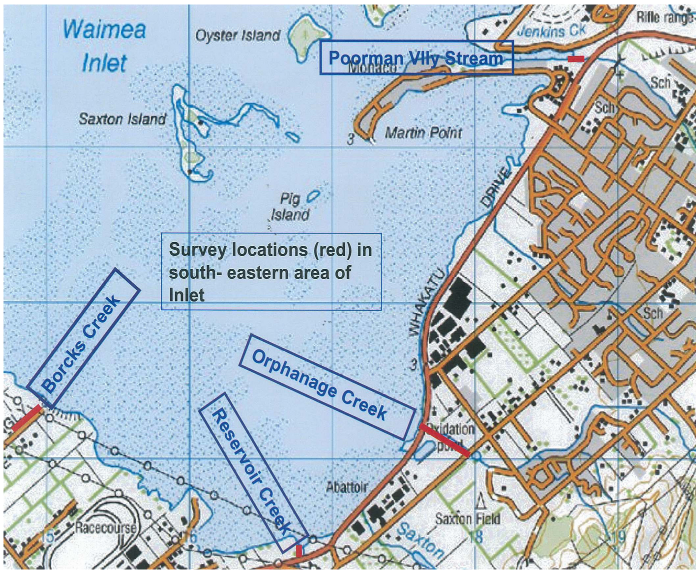


Fig. 13 Area surveyed for inanga spawning in 2011marked red (from Rutledge 2011)

For riparian plantings upstream of the tidal zone where enhancement of adult inanga habitat is the main driver, the starting point would be to use existing Council information to develop an inventory and map of existing riparian vegetation, including existing plantings, their quality and effectiveness in terms of providing shade over the watercourse. This information would then inform prioritising areas for augmentation plantings (to increase shade where necessary in existing plantings) and new plantings including development of lists of optimal species, techniques, placement plans and a timeframe for planting and planting maintenance. To maximise success of plantings maintenance in the order of 3-5 years would be expected with regular inspection to identify maintenance requirements with budgets provisioned to ensure that losses from unseasonable weather, browsing or grazing can be replaced.

Plantings over pools and slower deeper runs where adult habitat for inanga and other fish is already best optimised would be one way of using resources most effectively. Areas where there is opportunity for localised habitat enhancements by bank re-contouring of steep hazardous banks or where soft engineering solutions for removing existing hard- edged bank protection would work should be identified and implemented where practical. Where the Council removes gravel and sediment as part of channel management and flood protection programmes such as within and upstream of the detention pond this work should be carefully managed and other potential solutions for addressing sediment build up evaluated.

Addressing water quality issues associated with rural, residential and industrial zones will rely on a partnership approach with landowners, communities and businesses to implement an improvement plan which uses existing Council data to develop a priority list of actions including advocacy. Stream cleanups of in-stream rubbish and bank debris could make use of streamcare groups, businesses and schools to target priority areas. Unfortunately dumping of garden waste, offal, shellfish and fish frames is a feature of watercourses traversing rural and urban areas including Orphanage Creek (pers. obs.) These, besides increasing bacterial loadings, also reduce oxygen levels as these decompose.

Poorman Valley Stream

Existing environment and aquatic community

The headwater catchment of Poormans Valley Stream is contained within the Marsden Valley Reserve in the hills soutth east of Stoke, it is in the best condition of the four catchments proposed for enhancement and supports significant indigenous vegetation and fauna. The total catchment area is 1090 hectares. The reserve adjoins Roding Water Reserve to the south, Brook Conservation Reserve to the east, Council owned forestry land on the Barnicoat Range to the west and privately-owned land in lower Marsden Valley to the northwest. The main part of the reserve in the upper catchment is freehold land covered by a Conservation Covenant pursuant to Section 77 of the Reserves Act 1977, which is administered by the Department of Conservation. Other parts of the reserve, alongside the stream in the lower valley, are esplanade reserves some of which have been subject to riparian planting over many years and there is significant further scope for plantings. Planting programmes have involved weed control and restoration plantings by the community and school groups with approximately 7,000 children have been involved in the planting over the years and around 30,000 plants and upwards of $250,000 spent on the project. A trapping group has been operating for several years controlling pests in the Reserve and this has significantly contributed to improving native biodiversity (NCC 2009).

The stream flows through rural land down Marsden Valley and into primarily residential land then adjacent to Broadgreen Intermediate and Nayland College before entering Waimea Inlet near Jenkins Creek mouth on the south east margins of Nelson Airport land. Poorman Valley Stream has a mean flow in its lower reaches of 119lps with a 5 year lowflow of 15lps and median flow of 55lps. The stormwater catchment covers 98 hectares with 72% serving residential areas, about 1% commercial and the remainder in roads, footpaths and open space (RSQIP 2009).

The Council has data from sites in both the upper and lower catchment for stream health and water quality which are summarised in Figure 8 and details are available in Wilkinson (2007) and references therein. Upper Poormans was the best quality stream sampled in Stoke and Nelson City. Not unexpectedly the upper sampling site showed good water quality with low levels of contaminants and healthy communities of aquatic insects consistent with the benefits of the degree of intactness of the upstream catchment. The upper site did have some elevated sediment contamination however. The lower Poorman Valley site was of poorer quality, with more fine sediments in the stream bed, higher bacterial counts, higher nutrient concentrations with slime growths and some contamination of the sediments with heavy metals.


Deleatidium


Coloburiscus


Oxyethira


Potamopyrgus


Sandfly larva

The community of aquatic insects at the upper site consisted of species typical of high water quality including the spiral cased caddis *Helicopsyche, Deleatidium* and *Coloburiscus* mayfly, and larvae of various other fly and beetle species groups (see photo's above by Stephen Moore Landcare Research). In contrast the lower site community was typical of more degraded conditions with fly larvae, amphipods, ostracods and *Potamopyrgus* snails abundant, with the small axe-head caddis *Oxyethira* (more tolerant of poor water quality) also recorded. Stream bed, and riparian vegetation assessment at the lower site showed cobbles and gravels prevalent with stream shade provided by trees and long grass in the 25% category with shading at the upper site (also with cobble - gravel prevalent) in the 50-75% category provided by trees and scrub. Wetted channel widths were 1.8-3.0 metres at the upper site and 2.8-3.9 metres at the lower site. Detailed information on bank condition and instream habitat features is not available, however, lack of general habitat diversity and notably an absence of deeper pool and run habitat (e.g. see Fig. 16) which would provide greater amounts of habitat for species such as adult inanga, eels, bullies and kokopu species was a feature noted in the lower reaches. Poormans Creek (upper) has a long term classification grade of C with a 2008 grade of E reflecting poorer nitrogen, clarity and macroinvertebrate scores compared with earlier scores. Poormans Creek (lower) has a long term classification of E with a 2008 grade of C because of improved macroinvertebrate and periphyton scores (NCC 2010).

Council activities to remove gravel build up take place up to 75 m upstream and 20 m downstream of the Whakatu Drive culvert after high flood events. This activity and the removal and deposition of removed material require careful management to avoid adverse effects on the aquatic habitat present including inanga spawning grounds nearby. Another feature of the streambed about 40 metres upstream from Whakatu Drive about in this area is the significant change in bed level of about 1 metre over a very short distance induced by activities within the channel which presents an impediment to upstream migrating native fish juveniles including whitebait and bully species (Fig 14). The extent of barriers to fish passage within the catchment have not been studied in detail, however, major barriers seem unlikely given the presence of weaker upstream migrating bully species such as common bully well upstream. Nevertheless the accumulated effect of multiple culverts and partial obstructions can eventually by attrition prevent upstream passage and recruitment for even strongly migrating species (as shown for some NCC streams in Doehring 2009). Restoration of natural bed profile is recommended.

Fig. 14 significant induced bed level change above Whakatu Drive

Fig. 15 one of the few small pools in the lower river suitable for adult inanga where depths and water velocity is optimal

Poorman Valley Stream shows the greatest overall abundance and diversity of native fish of the subject streams. The species list includes smelt, inanga, common bully, redfin bully, upland bully, giant bully, giant kokopu, longfin and shortfinned eel, with banded kokopu and koaro recorded as whitebait only (NZFFDB records). Larger specimens of the latter two species are likely to be found following more intensive survey of higher quality upper reach habitats. Koura and freshwater shrimps are also common. Brown trout (up to about 18 centimetres long) have been recorded in the upper and lower reaches. The high diversity of native fish and the presence of brown trout which is more sensitive to degraded water quality than the native fish species reflect good habitat conditions in particular good levels of dissolved oxygen and cooler water temperatures.

The record of an adult giant kokopu in 2004 from a pool in the lower reaches (about 100 metres upstream of Nayland Road) remains the only one for the NCC region but reflects the potential for this species to be supported in this stream if suitable habitat is available (deep pools, heavy shade and complex cover). When captured the giant kokopu was living in a deep pool and the undercut bank formed around a willow tree and its root wad; larger eels and a few trout were also present. Over following years the subsequent loss of this fairly unique habitat in the lower reaches removed the cover and there have been no further records of giant kokopu.

Recent survey work for inanga spawning (Rutledge 2011) checked the 50 metre reach immediately downstream of Whakatu Drive on March 22nd 2011 (see Fig.13). The spring tide had peaked and was just beginning to run out. A strong signature of milt (Fig. 16) and large numbers of adult inanga were seen on the true right bank approximately 25 metres downstream of the culvert. This area has a lower gradient bench covered with rank grass. There are some native plants including toi toi bushes (Fig 17) immediately to the east of the site, making relocation of the spawning site straight forward. Inspection amongst the grasses following further recession of the tide showed a few fish to be trapped amongst them and several large longfin eels were swimming amongst the grasses on the stream margins and further out in the stream channel attempting to feed on fish and probably their eggs. Observations were continued on both banks for a distance of about 50 metres downstream and while suitable vegetation was present no other obvious spawning activity was noted.

Fig. 16 milt from spawning inanga in rank grasses on benched area Poormans Ck.

Fig. 17 spawning site viewed from opposite bank bank showing toi toi's behind site

Enhancing habitat for inanga and other aquatic life

Ongoing protection of the inanga spawning habitat in the reach below Whakatu Drive is fundamental to maintaining the inanga population. In particular no gravel from instream works or other material should be dumped in the zone downstream of the culvert as it seems likely that the existing rank grasses on both sides of the bank are suitable for spawning. If bed material is removed to maintain channel capacity upstream or within the culvert then undertaking this well before or well after the spawning season to prevent siltation of deposited eggs is recommended. No control of streamside vegetation downstream of the culvert should be undertaken by the Council at the moment. Although some may be needed in the future to optimise grass growth characteristics and humidity for egg deposition and survival. During and following the inanga spawning and egg development season -potentially from about early February - end May eggs are vulnerable to trampling by people so a notice advising of this could be deployed at the site.

Planting a range of native species to provide additional spawning substrate including larger stature trees and shrubs for shading purposes amongst the existing rank grasses should be pursued at the site following consideration of salinity tolerances and spring tidal height range. A spawning survey should be done in 2012 to determine if the site is in regular use for spawning and to check if spawning may be occurring nearby. Because use of the site for spawning cannot be ruled out earlier in the spawning season surveys should ideally commence in early February during the spring tide cycle and continue until the end of May if possible.

Re-establishing the natural bed level above Whakatu Drive (refer Fig. 9) will improve natural rates of passage for inanga and other species and reduce predation exposure for fish delayed downstream of this structure by eels and herons which actively feed in this reach (pers. obs.). At the same time if possible a pool and run habitat sequence should be established to provide habitat for adult inanga and other native species with riparian plantings adjacent to the area that provide shade and cover. Creation of additional pools and areas of slower water further upstream should be considered following walk through surveys to identify suitable areas. These created habitat hot spots should be targeted for riparian plantings and the addition of instream structures to encourage cover seeking fish such as giant and banded kokopu to colonise. Earlier records of giant kokopu in the stream adjacent to Broadgreen Intermediate and records of banded kokopu whitebait suggest this is a realistic possibility. If this did not eventuate then other techniques are possibly worth investigating. For example work in Hamilton urban streams has highlighted the potential for actively introducing giant kōkopu into sites where natural recruitment may be limited (Collier et al 2008). It is thought that some juvenile galaxiids respond positively to specific concentrations of adult pheromones released into the water by adult fish so where desired species are absent or population numbers are very low, active reintroductions of fish to physically suitable sites may be needed to ensure new recruits are attracted to habitat enhanced streams so that the long-term sustainability of populations can be maintained.

Both Broadgreen Intermediate and Nayland College pupils have been involved in monitoring and planting activities on Poorman Stream over several years including participation within enviroschools and the Waimaori programmes in conjunction with NCC and DOC. Nayland College pupils have also trialled artificial substrates to assist in identifying inanga spawning areas in conjunction with Trevor James from Tasman District Council. Recently Nayland College pupils established the poormanstreamsavers website and produced a dvd introducing the streams values and ways of enhancing it by riparian planting and enhancing water quality. The proximity of the schools and their history of interest in conjunction with a stream that is in reasonable condition and likely to respond well to enhancements make this a site very promising for investing resources in.

With appropriate training the schools and interested community under an umbrella stream care group could be actively engaged in fish monitoring, enhancement projects and advocacy for protection. As discussed for the other subject streams partnering the broader community of landowners and businesses would be part of this concept in order to effect a comprehensive approach to protect and enhance habitats from headwaters to the sea. The range of prioritised enhancement actions would develop from surveys and inventories of riparian condition, structures affecting fish passage and identifying local water quality issues including the potential for reducing stormwater contaminants and rubbish. It is noted that the Council already has programmes underway to assist in protecting stream water quality for example by assisting rural landowners who wish to re-vegetate and fence river margins, as well as help with pest management.

Jenkins Creek

Existing environment and aquatic community

Jenkins Creek has a catchment of 635 hectares with a mean flow of 129 lps a median flow of 51 lps and 5 year low flow of 3 lps (Wilkinson 2007). While carrying similar flow to Poorman Stream, it is subject to more extreme low flows under dry conditions with less buffering arising from its more modified catchment characteristics. The more extreme low flows impose a harsher habitat bottleneck for fish compared with Poormans for example. Its lower reaches are also much more intensively affected by urban and industrial developments with a 360 hectare stormwater catchment of which about one third is inner city commercial industrial area. Most of the lower stream is constrained, channelized and otherwise modified to protect adjacent residential and commercial areas. Much of the catchment surface area is impervious (roads, carparks, roofs etc) which impacts on the hydraulic function of the stream. There is also significant culverting including a 50m reach beside Whakatu Drive. The top of the catchment near Jenkins Hill is 770 metres high at a distance of about 7 river kilometres from Waimea Inlet. Upper catchment land use is a mixture of heavily modified rural types. Channel width in the lower reaches showed large variations between 1.3 and 5.9 metres wetted width with limited shading dominated by shrubs and grass and a bed predominantly composed of gravels and cobbles but with the largest amounts of finer sediment of the 4 subject streams (Wilkinson 2007).

Water quality and stream health data as summarised in Figure 8 for its lower reaches shows it to be second only to Saxton's Creek in terms of water quality issues. Higher levels of contaminants including zinc, PAH's (Polycyclic Aromatic Hydrocarbons : compounds from asphalts,fuels,oils and greases)and SVOC's (Semi Volatile Organic Compounds) have been a concerning feature of water quality and sediment sampling undertaken in the Creek (e.g. NCC 2002, Wilkinson 2007, NCC 2010).

Jenkins Creek has a long term classification of D degraded with a 2008 grade of E because of poorer nitrogen, and *E. coli* scores (NCC 2010). The increased amount of data provided by seven years of sampling showed lower Jenkins Creek to be in better condition than originally indicated, with improvements in a number of water quality criteria. This was considered consistent with its recovery after major channel works in 2000.The types of aquatic insects in this creek are typical of poor conditions including snails, fly larvae, crustaceans and worms with elevated temperatures and growths of algal slimes. Where high levels of contaminants have been found such as in lower Jenkin's Creek the Council has undertaken additional work to identify and rectify the sources where possible. A Council commissioned study of stormwater discharges in the industrial area found that only four of thirty stormwater sites inspected had entirely adequate stormwater management practices. Other issues identified were lack of esplanade strip, poor rubbish and dust management, poor hazardous waste storage practices, poorly maintained construction sumps, sediment traps, oil traps and wash down facilities and lack of awareness of the potential effects on the environment. Jenkins Stream has two grit traps including one by SH6 at the end of the concrete culvert and another below the bridge over SH6 where an excavator is used to remove material following high flood events.

Fish surveys in the Creek have identified a range of native species including inanga, banded kokopu, common bully, upland bully, longfin and shortfinned eel, yellow eyed mullet and a single record of koaro. (NZFFDB records). Koura and freshwater shrimps are also present in the catchment. Better overall water quality and habitat conditions such as streambed and banks (as reported in NCC 2002) in upper reaches compared to the lower reaches would account for the presence of banded kokopu. A survey of Arapiki stream undertaken in 2001 (Orbit Environmental 2001) also provided data on native fish, habitat condition and fish passage. This showed that like the records of banded kokopu in the main stream, banded kokopu in Arapiki stream tended to be concentrated in the few suitable pools in upper reaches where there is cover provided by native and exotic vegetation.). Both species of eels were also present while inanga were confined to the lower reaches because they were limited by fish passage obstacles.   Observations of banded kokopu with fungus in Arapiki Stream indicate that fish are under stress (Fig. 18) Existing information suggests that no inanga spawning surveys have been undertaken in Jenkins Creek.

Fig. 18. banded kokopu in Arapiki Stream showing fungus on head and tail (photo Debra Bradley).

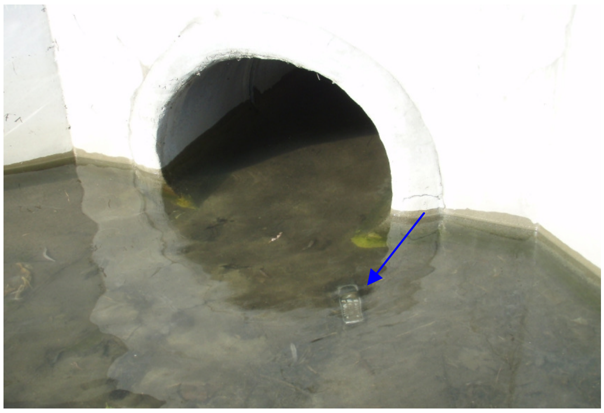


Fig. 19 a moblie phone discarded in stormwater drain lower Jenkins Creek

Enhancing habitat for inanga and other aquatic life

While water quality and habitat is compromised in lower Jenkins Creek it appears to be within the tolerance limits for adult inanga and other tolerant species; the presence of inanga in fairly recent surveys is a positive sign that enhancement is worthwhile. However, adult inanga (and other native fish) rely on invertebrate foods and the higher levels of contaminants in the sediments such as metals, PAH's and SVOC being discharged into stormwater are known to bio-accumulate and suppress recovery of invertebrate populations (e.g Suren and Elliott 2004). Addressing these sources of contaminants and reducing water temperatures needs to be given a priority in order improve general ecosystem life supporting capacity and increase native fish and invertebrate diversity in both Jenkins Creek and Waimea Inlet.

Formation of a catchment streamcare group that engages landowners from the upper to lower reaches may be an effective method to address the water quality and sediment issues arising from the various land use types in the catchment including the general problem of urban rubbish dumping in streams (Fig.19). Elevated water temperatures throughout the catchment should reduce with the further establishment of a more extensive riparian corridor that produces more effective shading over the watercourse. In common with the approach suggested for other streams an information gathering exercise including a walk through survey will be needed to inform a planting plan which develops timeframes and identifies the resources needed to implement it within the context of the needs of the 3 other subject streams enhancement programmes. At the same time as walk through surveys for riparian inventories are undertaken other habitat enhancement "hotspots" should be identified where the existing channel structure could be improved for adult inanga by increasing the amount of habitat where water velocities, depths and cover regimes are optimised beneath existing riparian cover. The practicalities of this and the ongoing retention of such habitat long term would need to be factored in along with consideration of any risks of exposing existing infrastructure to increased vulnerability. Given the current habitat bottleneck imposed by summer lowflows ensuring that flows are protected and enhanced where possible is a priority.

Identifying priorities for improving passage for inanga and other native fish to increase their access to habitat further upstream will need to be informed by surveys of existing structures. Additional technical assessment will be needed to identify the best method to retrofit structures and bring passage surfaces, gradient, water depths and velocities within the range for inanga. For example Doehring (2010) installed ramps at perched culverts at sites in several Nelson streams which enabled fish to pass the culverts. To provide passage for inanga, velocities should ideally be below 0.3 m/s for adults and below 0.2 m/s for juveniles (Stancliff *et al.* 1988; Boubee *et al.* 1999). To maintain the function of fish ramps and culverts ongoing inspection and maintenance is required annually especially prior to the start of migration periods. Maintenance generally includes the removal of debris or bedload accumulations on the ramp and/or at the culvert outlet and inlet (Doehring 2009, Cotterell 1998).

Inanga spawning surveys to determine any existing use of lower Jenkins Creek for spawning and/ or the presence of ripe fish should begin about mid – February and continue through into late May during the spring tide cycle. The surveys should document existing riparian vegetation and its suitability for spawning and the opportunities for enhancing it by replanting or renovation, including the management of debris or unsuitable vegetation. Recontouring of banks and/or the establishment of spawning benches are other enhancement options that need to be evaluated during survey work. Salinity, spring tide water level heights and sea level rise should be considered in determining plantings (Fig.20) type and placement.

Fig. 20 riparian plantings to enhance the lower tidal zones, such as this tidal tributary of Jenkins Creek, will need to take into account salinity regimes under sea level rise effects

Implementing enhancements and measuring success

A range of measures can be used to measure the success of enhancement initiatives. Council data on stream health and water quality and contaminant levels and flows collected under State of Environment and other monitoring programmes provides a very useful baseline against which future improvements could be measured so this monitoring should be continued. If resources allow adding additional monitoring sites at upper catchment locations for Saxtons, Orphanage and Jenkins would increase understanding of what is happening at these locations under enhancements over time. Likewise the collection of an even more detailed water quality and stream health dataset down the longitudinal profile of each waterway could also be considered. This would be interesting from a scientific viewpoint and provide more detailed understanding of the nature of changes in water quality and stream health through the various land use types and potentially identify any "hotspots" of concern such as elevated faecal contamination, temperatures, nutrient or contaminant regimes. Participation by landowners, businesses, schools, NMIT, streamcare groups and the Waimaori programme with assistance from Council and local analytical and technical specialist such as Cawthron could be a method to assist the design and implementation of a monitoring programme. The Waimaori programme may wish to also use iwi indicators to assess water and ecosystem health.

As discussed above for Jenkins Creek, where Council studies have already identified issues with stormwater contamination in the industrial zone the implementation of a range of proposed mitigation methods could be tracked on a database using measures such as the number of sumps/sites with effective sediment and contaminant control/number of new filter strips established etc. to measure improvements.

An inventory of existing Council data (e.g location maps of culverts, gravel traps, trash racks, bridges or other structures) with a detailed walk through survey to identify key fish passage constraints (including where necessary water depth and velocity measurements) should inform a process to prioritise addressing fish passage issues. Fish surveys upstream and downstream of potential barriers/impediments to passage would assist in determining the extent of effects and to evaluate the number of inanga passing. Making observations of fish actually scaling existing fish passes such as the one on the Orphanage Creek weir immediately above Main Road Stoke could lead to design improvements that increase passage success for inanga and other fish. The experimental work of Doehring (2009) on remedying passage issues for inanga at culverts will be very useful in informing retrofitting where necessary or making other adjustments. Council engineering staff will need to work with other local experts with retrofitting designs or other structural adjustments to improve passage. The measure of success of passage enhancements could be by direct observation of fish using retrofitted culverts for example and/or the increase in the number of fish and diversity of fish species observed upstream following retrofitting or other adjustments. A Council database of structures and a numerical record of the number of structures assessed and improved could be established which also tracked fish observational data and an inspection/maintenance programme to ensure that structures are functioning properly.

Following data acquisition and walk through surveys of each waterway to determine the quality and extent of riparian vegetation (including existing plantings) and of instream habitat for inanga and other native fish, the success of a prioritised planting and fish habitat enhancement plan can be measured using a variety of techniques. For example: length of stream planted, length of stream fenced, number of plants, extent of shade and bank overhanging vegetation, number and size of new pools/runs/habitat structures created and the number of fish/invertebrates counted in enhanced sections. Gathering the information and undertaking the enhancement work could be undertaken by landowners in partnership with people from a broad range of community/streamcare groups following training sessions from Council or other people/organisations with expertise. Where possible existing fish survey sites should be used as baselines to measure the general abundance of species, although additional data such as size classes of fish could be collected to examine in more detail population responses over time to enhancement.

Inanga spawning surveys and the condition and extent of spawning habitat need to be assessed for the tidal reaches of each waterway and build on the existing information (Rutledge 2011) with the goal of developing a planting and management regime for each site. A key matter for the Council in the interim is to ensure that the known spawning areas in Orphanage Creek and Poorman Valley Stream are not subject to mowing during the spawning season and that any river works or management activities do not disturb or lead to sedimentation at the sites. A national expert visiting Nelson in

March 2012 will be able to provide training and additional ideas for enhancing spawning habitats in the subject streams. Area surveyed, area of egg deposition, number of adult fish using site, area of planted/managed vegetation, area of created spawning benches/ length of regraded bank and amount of deposited rubbish are all potential measures to assess enhancement success at spawning sites that could be recorded in a database. It is important to note, however, that abandonment of spawning sites for no apparent reason has been a feature of spawning site monitoring over the years.

A number of social and advocacy goals will accompany the enhancement programme. These outputs might be measured by surveys to assess general awareness of the programme, participation in the programme (for example as a streamcare volunteer) any behavioural changes(e.g. relating to protecting stormwater quality by not washing cars on the road etc) and general levels of satisfaction. More specific advocacy measures might relate to the number of interpretation panels about the waterways and the programme that are established, the number of inanga spawning sites that are sign posted or the number of stormwater sumps with fish logos painted beside them.

The timeframe for measuring success in terms of improved water quality and increased inanga or other native fish populations is probably in the order of 2-5 years given the time it will take to implement the enhancements and the length of time it will take for shady riparian corridors to establish and make inanga spawning and other general instream habitat improvements. Potentially the quickest response may be where a fish passage blockage or impediment is removed and very large numbers of fish are able to saturate habitat that they had limited or no access to formerly. More immediate success is likely for measures such as those relating to social and advocacy achievements but these will be dependant on the level of resourcing available.

Enhancement summary

Inanga are an iconic species already occurring within all four of the subject waterways that provide an excellent focus for galvanising a whole of community, whole of catchment approach, to enhancing their living and spawning habitats. There is already a reasonable level of community interest in these waterways and a range of existing Council and other initiatives to build upon to accelerate enhancement actions. These will benefit not just inanga but the range of native fish and invertebrate species present and the broader biodiversity associated with riparian zones such as native birds. Waimea Inlet as the ultimate receiving environment for contaminants will likewise benefit from improvements to water quality in these waterways. Riparian corridors will provide social benefits from the glimpses of nature they bring to people in urban environments and for the potential pedestrian and cycle traffic that may be possible along their lengths. Dedicated streamcare groups besides being a cost effective mobiliser of community resources, will foster social cohesion and promote a sense of ownership that leads to long term care of these waterways.

Martin Rutledge
September 2011

References:

Allibone, R , David, B, Hitchmough, R, Jellyman, D, Ling, N, Ravenscroft, P and Waters, J (2010) 'Conservation status of New Zealand freshwater fish, 2009', New Zealand Journal of Marine and Freshwater Research 2010, 1-17

ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australia and New Zealand Environment and Conservation Council.

Cindy F. Baker (2006): Predation of inanga (*Galaxias maculatus*) eggs by field mice (*Mus musculus*), Journal of the Royal Society of New Zealand, 36:4, 143-147

Baker C. F. & Boubee J. A. T. (2006) Upstream passage of inanga (*Galaxias maculatus*) and redfin bullies (*Gobiomorphus huttoni*) over artificial ramps. *Journal of Fish Biology*, 69, 668-681.

Baker C. and Hicks B. 2003.

Basher L.R. 2006 Management of gravel extraction by Nelson City Council Landcare Research Contract Report: LC0506/137 Prepared for Nelson City Council

Best Elsdon 1929. The Fishing Methods and Devices of the Maori Dominion Museum Bulletin, No 12, 1929

Boubée, J., Nichols, S., & Jowett, I. 1998: *A Review of Fish Passage at Culverts – With Potential Solutions for New Zealand Native Species.* National Institute of Water and Atmospheric Research, Hamilton. 79 p.

Boubee, J., Williams, E., and Richardson, J. (2000): Fish passage guidelines for the Auckland Region. Auckland Regional Council Technical Publication No. 131. 40p.

Campbell J. Heijs J. Wilson D. 2010 Urban stream restoration and community engagement: examples from New Zealand. 2010 Stormwater Conference Proceedings. Wellington Water New Zealand. 25p.

Collier, K.J. 1994. Restoration of freshwater habitats introduction and synthesis. In: Collier K. J. (ED) Restoration of Aquatic Habitats. Selected papers from the second day of the New Zealand Limnological Society 1993 Annual Conference. Department of Conservation. 171p.

Collier, K.J., B.D. Clarkson, B.M.T.A. Aldridge, and B.J. Hicks. 2008. Can urban streams be restored? Linking vegetation restoration with urban stormwater mitigation. Proceedings of the NZWWA Stormwater Conference, Rotorua, New Zealand Water and Wastes Association.

Courtney S. P., Bradshaw D. H., Moore S. H. and Atkinson M. A. 2003. Living Heritage: growing native plants in Nelson. Published by Department of Conservation Nelson Marlborough Conservancy and Nelson City Council. 52 p.

Davidson, R.J. & Moffatt, C.R. (I990). A report on the ecology of Waimea Inlet, Nelson. Department of Conservation, Nelson

Doehring, K. A. M. and McIntosh, A. R. (2008) *The distribution of native freshwater fish in the Nelson City Council Area.* Nelson City Council.

Doehring, K.M. 2009 .Urbanisation influences on freshwater fish distribution and remediation of migratory barriers. A thesis submitted in partial fulfilment of the requirements for the Degree of Master of Science in Ecology in the University of Canterbury New Zealand

Elkington S and Maley R 2005. Eradication of Gambusia (*Gambusia affinis*), koi carp (*Cyprinis carpio*) and rudd (*Scardininius erythrophthalmus*) from the Nelson/Marlborough Conservancy. Department of Conservation, Occasional Publication.

James T. 2006. Fish Passage in the Tasman District update report May 2006 report to Tasman District Council. 31p.

Hartman, G.H. 1965. The role of behavior in the ecology and interaction of underyearling coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). *Journal of the Fisheries Research Board of Canada 22*: 1035-1081.

Hay J and Young R 2007. A spotlight fish survey of Orphanage Creek in relation to potential fish passage barriers. Prepared for Nelson City Council. Cawthron Report No. 1284. 7p.

Hitchmough R. Bull L. and Cromarty, P. 2007. New Zealand Threat Classification System Lists. Department of Conservation

McDowall, R M. 1990. New Zealand freshwater fishes. A natural history and guide. Heinemann Reed, Auckland. 553pp.

McDowall R. M. (2001) *Freshwater Fishes of New Zealand*, Nature Series, Reed Publishing (NZ) Ltd., Auckland, 230p.

Mitchell, C. P. 1990: Fish Passes for Native Fish: A Guide for Managers. MAF Fisheries, Rotorua. New Zealand Freshwater Fisheries Miscellaneous Report No. 45. 20 p.

Nga Taonga Tuku Iho Ki Whakatu Management Plan 2004

Nelson City Council 2002. Nelson City State of Environment Report Freshwater 83 p.

Nelson City Council, 2008. Esplanade and Foreshore Reserves Management Plan

Nelson City Council 2009 Reticulated Stormwater Quality Improvement Plan

Nelson City Council, 2009 Conservation and Landscape Reserves Management Plan 2009

Nelson City Council 2010. Nelson City State of Environment Report 2010. 128 p.

NIWA 2007. Fish-friendly floodgates ready to go. Freshwater Update 23. July 2007

Orbit Environmental 2001. Freshwater faunal, habitat and fish passage assessment Arapiki Stream Nelson. 29 p.

Passl, U. (2004): "Nga Taonga Tuku Iho Ki Whakatu Management Plan" – prepared for Ngati Rarua Iwi Trust, Te Runanga o Toa Rangatira, Te Atiawa Manawhenua Ki Te Tau Ihu Trust, Ngati Koata No Rangitoto Ki Te Tonga Trust and Ngati Tama Manawhenua Ki Te Tau Ihu Trust

Paul M. J. & Meyer J. L. (2001) Streams in the urban landscape. Annual Review of Ecology and Systematics, 32, 333-365.

Phillips, C. 2010. Integrated Catchment Management for the Motueka River. Final Version CD Report. Landcare Research New Zealand in collaboration with Institute for Resources, Environment and Sustainability University of British Columbia, Canada

Richardson, J. and Taylor, M.J. (2004). A guide to restoring inanga habitat. NIWA Science and Technology Series No. 50. 31 p.

Richardson, J.; Jowett, I. (2005). Restoring streams for freshwater fish. *NIWA Science and Technology Series No. 53.* 55 p.

Rowe D., Hicks M. & Richardson J. (2000) Reduced abundance of banded kokopu (*Galaxias fasciatus*) and other native fish in turbid rivers of the North Island of New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 34, 547-556.

Rutherford J , Davies-Colley R, Quinn J, Stroud, M and Cooper A 1997. Stream Shade: Towards a Restoration Strategy prepared for Department of Conservation NIWA Client Report: DOC303 National Institute of Water & Atmospheric Research Ltd PO Box 11-115, Hamilton. 161 p.

Rutledge M.J 2011 Inanga Spawning Surveys of Waimea Inlet Tributaries Preliminary Survey March 2011. Unpublished DOC internal report 8 p.

Schlosser, I.J. 1982. Trophic structure, reproductive success, and growth rate of fish in a natural and modified headwater stream. Canadian Journal of Fisheries and Aquatic Sciences 39: 968-978.

Stevenson, C.; Baker, C. (2009). Fish Passage in the Auckland Region – a synthesis of current research. Prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Report 2009/084.

Stevens L, Robertson B, 2010: Waimea Inlet: Vulnerability Assessment and Monitoring Recommendations; prepared for Tasman District Council

Strickland R. and Quarterman A. 2007 Assessment of effects on Fish Passage at Tide Gates Using DIDSON Technology.Prrepared for Tasman District Council. Cawthron Report No. 1260.12p

Suren A. and Elliott S. (2004) Impacts of urbanisation on streams. In: *Freshwaters of New Zealand* (eds. Harding J., Mosley P., Pearson C. and Sorell B.), pp. 35.1 - 35.18. New Zealand Hydrological and Limnological Societies, Christchurch, New Zealand.

Suren A. Graynoth E. Biggs B. McMurtrie S. Barker R. 2002. Stream enhancement in Christchurch *Water & Atmosphere 10(2)*

Taylor, S.L., Roberts, S.C., Walsh, C.J. and Hatt, B.E. (2004) Catchment Urbanisation and Increased Benthic Algal Biomass in Streams: Linking Mechanisms to Management' Freshwater Biology, 49, 835-851.

Taylor, M. 2005. Inanga spawning on the lower Styx River. Aquatic Ecology Limited contract report No. 28, prepared for Christchurch City Council. AEL, Christchurch.

Taylor, M.J. and Kelly, G.R. 2001. Inanga spawning habitats in the Wellington Region,inanga habitat restoration techniques

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.

Tonkin & Taylor 2007 unpublished letter report : Engineering and environmental aspects associated with the development of a combined structure plan for the Nelson – Richmond area.

Tonkin and Taylor 2008. Mangakotukutuku Stream Erosion Control and Aquatic Habitat Restoration. Report prepared for: Mangakotukutuku Stream Care Group. 27p.

Walton B. M., Salling M., Wyles J. & Wolin J. (2007) Biological integrity in urban streams: towards resolving multiple dimensions of urbanisation. Landscape and Urban Planning, 79, 110-123.

West D. 2006 (unpublished). Whitebait lifecycle diagrams. Unpublished images held by Department of Conservation.

Wilkinson, J., (2007): Surface Water Quality in the Nelson Region: Second Report 2002 to 2007.
Cawthron Report No. 1306 Prepared for Nelson City Council.