The Styx

Pūrākaunui

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AEL
Aquatic Ecology Limited

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Executive Summary

In April 2005, a field survey was undertaken at low tide to search for inanga eggs along the margins of the lower Styx River. The survey extended from 260 m upstream of the Kainga Road Bridge to the Brooklands Lagoon.

Inanga eggs were identified in the reach between the tidegates and Kainga Road, with particularly high numbers deposited on the true right (south) bank immediately upstream of the tidegates. Eggs were mainly found amongst introduced herbs and grasses, but smaller numbers of eggs were found amongst raupo and native rushes (*Juncus* sp.) on both banks. This is the first time inanga spawning has been recorded from the Styx River, despite intensive searches in the past. Recommendations and management options are made to enhance inanga spawning in this reach.

1 Introduction

In the late 1980's, the lower Styx River was the subject of extensive inanga spawning surveys, but with no success (Taylor *et al.* 1992).

However, in recent years, the nature and quality of the riparian vegetation upstream of the tide gates has changed as native plantings have matured. In addition, better riparian management of the reach between Marshlands Road downstream to the tidegates had led to a river environment more suitable for inanga spawning. Good runs of whitebait, which mature in about six months, were reported from the Waimakariri River mouth in spring 2004. For these reasons, it was considered opportune to resurvey the lower Styx River for inanga spawning. This updated knowledge can then be integrated into the Styx Catchment Management Plan which is currently being prepared.

2 Catchment description

The following description is from Robb (1980)….

"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 21 km 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 (i.e. upstream of the tidegates) but the impedance offered to the river water during each flooding tide ensures that a (freshwater) tidal regime is maintained almost up to Marshland Road where low-flows average between 1.5 and 2.0 m^3/s."

The lower Styx River has been ecologically modified by the operation of tidegates downstream of Kainga Road (Fig. 1). Commissioned in the mid-1980s, the tidegates close on every tidal cycle, and are necessary to prevent spring tides and flood waters from the Waimakariri River (via Brooklands Lagoon) from backwashing up into the lower Styx River. This is necessary because surrounding arable and residential lowlands are highly susceptible to flooding.

Figure 1. The tidegates on the lower Styx River, pushed open by the falling tide.

During normal tide gate operation, upstream water levels vary with the opening and closing of the gates on each tidal cycle. At Kainga Road (Fig. 2), 270 m upstream of the tidegates, backed-up river water levels vary over approximately 0.9 m, whereas downstream of the gates the tidal amplitude is nearly 1.9 m during spring tides, and 1.2 m during neap tides (Walsh *et al.* 1999).

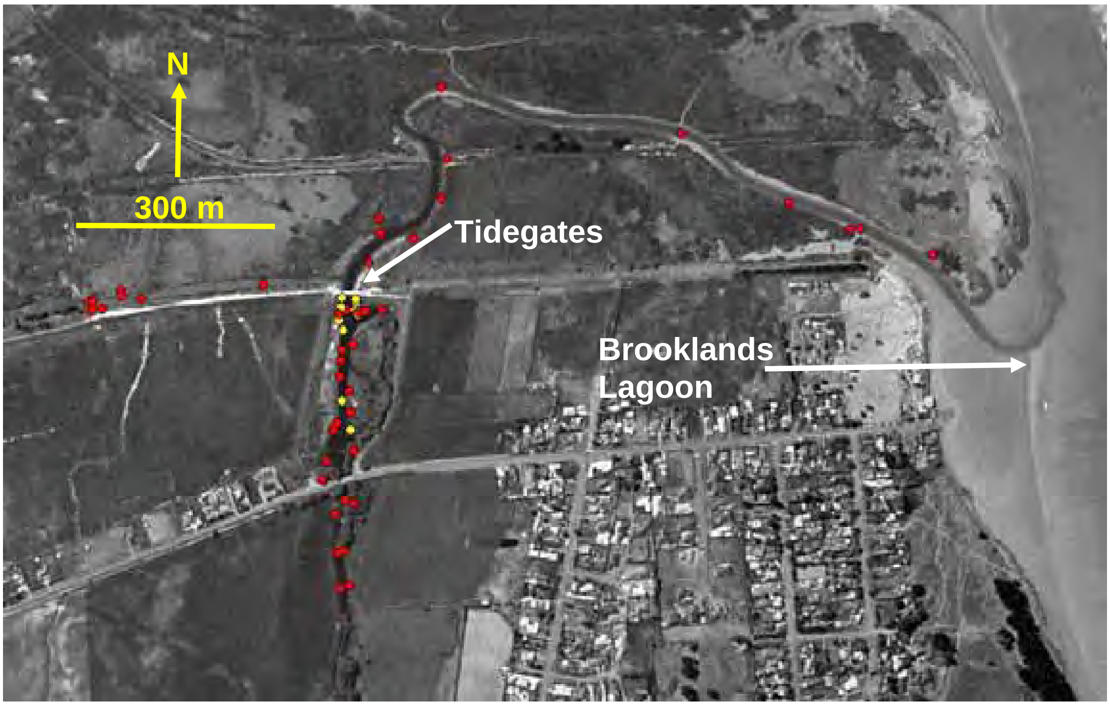

Figure 2. The lower Styx River, indicating egg search locations (red), and egg search locations where inanga eggs were found (yellow).

The closure of the tidegates prevents saltwater from extending to upstream reaches, creating an artificially abrupt juncture of marine and freshwater plant communities on either side of the gates (Walsh *et al.*). Thus, saltwater-intolerant river and bank vegetation extends to the upstream side of the tidegates. This includes the common introduced aquatic macrophyte curly pondweed (*Potamogeton crispus*), and the large raupo beds (*Typha orientalis*) on the true right bank. Ecologically valuable native aquatic species upstream of the tidegates include the endemic creeping herb (*Liliaeopsis novae-zelandiae*). Downstream of the gates the riparian vegetation is less diverse and dominated by three-square (*Schoeoplectus pungens*) and sea rush (*Juncus maritimus*). Tall fescue (*Festuca arundinacea*) is present on the higher ground.

3 Methods

3.1 Survey methods

The methods used to survey the lower Styx River were similar to those used on the Avon and Heathcote Rivers in 2004(Taylor & McMurtrie 2004). Inanga egg searches were conducted at low tide on the 12th and 13th April 2005, using a 2 tier approach. The survey extended from 160 m upstream of Kainga Road to the end of the vegetated intertidal zone at Brooklands Lagoon.

Where the habitat was considered suitable for egg deposition, in terms of vegetation or bank slope, a '1st tier' strategy was used. Where the habitat was considered less suitable, or varied little over significant distances (i.e. > 300 m), the '2nd tier' search strategy was used.

The 1st tier search strategy involved conducting egg searches every 2-3 metres along the most suitable reach. An egg search took between one and two minutes, and if necessary, vegetation was parted back to the soil level in a line which traversed the inter-tidal zone, until the zone of egg deposition was found. In contrast, '2nd tier' egg searches were conducted every 50 – 150 m, either at typical locations, or those which possessed more suitable spawning habitat.

A rowing dinghy facilitated access where banks were steep, or where fringing vegetation was particularly dense. Search locations were logged with GPS Global Positioning System) receivers (Garmin 12, Garmin Etrex legend). If eggs were found, egg density was ranked by the following ordinal scale:

1. less than one egg per cm^2
2. 1-3 eggs per cm^2
3. 4-10 per cm^2
4. greater than 10 per cm^2

Orange marker flags were used to indicate the location of egg deposits in photographs, and notes were taken of surrounding vegetation. White markers indicated locations searched but where eggs were not found.

GPS waypoints were mapped using AerialMap® Pro (ver. 2) software. A small sample of eggs was taken to check identification, egg viability, and development stage. Digital photographs were obtained using a Zeiss stereomicroscope.

4 Results

4.1 Upstream of the tidegates

No inanga eggs were found in reaches upstream of Kainga Road. Within this surveyed reach, the river flowed through steep-banked pastureland, with the true left bank profile vegetated in typical pasture grasses, tall fescue, creeping bent (*Agrostis stolonifera*), but with some patches of mint (*Mentha* sp.), and creeping buttercup (*Ranunculus repens*) (Fig. 3). The true right bank was vegetated with the same grass and soft herb community, but with some mature willow.

Figure 3. True left bank upstream of Kainga Road, looking upstream.

Figure 4. Willow growth on the true right bank (left of picture) upstream of Kainga Road.

Downstream of Kainga Road to the tidegates, along a reach of approximately 280 m, an extensive native vegetation planting programme had established, of which a significant component formed part of the ZONTA programme. However, within the zone subject to tidal-influenced inundation, the vegetation comprised a diverse mixture of both native and introduced plants; rushes, grasses, and soft herbs.

The true left bank had a steep profile, and was vegetated in tall fescue, creeping buttercup, monkey musk (*Mimulus guttatus*), raupo (*Typha orientalis*), *Juncus* sp. and flax (*Phormium tenax*). Some blackberry was present near the waterline. Stands of cabbage trees (*Cordyline australis*) were present away from the water's edge. Inanga egg deposits were found amongst native *Juncus* sp. and raupo near the tide gates (Figs. 5, 6). The egg density at these locations was low and the distribution patchy.

Figure 5. Inanga spawning (arrowed) on the true left (north) bank amongst raupo upstream of the tidegates.

Figure 6. Inanga eggs (orange flag) were found amongst native *Juncus* sp. rushes on the true left (north) bank of the lower Styx River, immediately upstream of the tide gates.

The ‘intertidal’ zone along the true right (south) bank also possessed a diverse plant community including all the species found on the true left bank. This bank was more sun-exposed than its northern counterpart. A patch of eggs was found in a bed of mint at the confluence of a spring-fed tributary with the mainstem (Fig. 7).

The highest egg densities (level 4) were concentrated towards the southern tide gate (Fig. 8) where the eggs formed an almost continuous mat near the soil surface (Fig. 9). At this location, inter-tidal vegetation consisted of soft herbs (mint and monkey musk) with a thick sward of tall fescue grass. With distance upstream from the gate, egg density decreased to level 1, where an extensive raupo bed shaded out the grasses and herbs.

Figure 7. A marker flag indicates the location of inanga eggs amongst a bed of mint along the true right bank of the Styx mainstem.

Figure 8. A panoramic view of the true right bank immediately upstream of the tidegates. Eggs were found in a continuous band as arrowed.

Figure 9. An extensive mat of inanga eggs, which appear as white dots in this photograph.

Photomicrography of a sample of eggs taken from this location revealed that all embryos were viable, motile, and well-developed (Fig. 10). The presence of discernable xanthophores (yellow chromatophores), but the lack of gill slits indicated that eggs were approximately at development Stage 20 (Benzie 1968). Based on previous field-based egg development studies (Taylor 1998), the eggs were approximately 19 days old. It was considered likely that eggs would hatch on the full moon tides at the end of April.

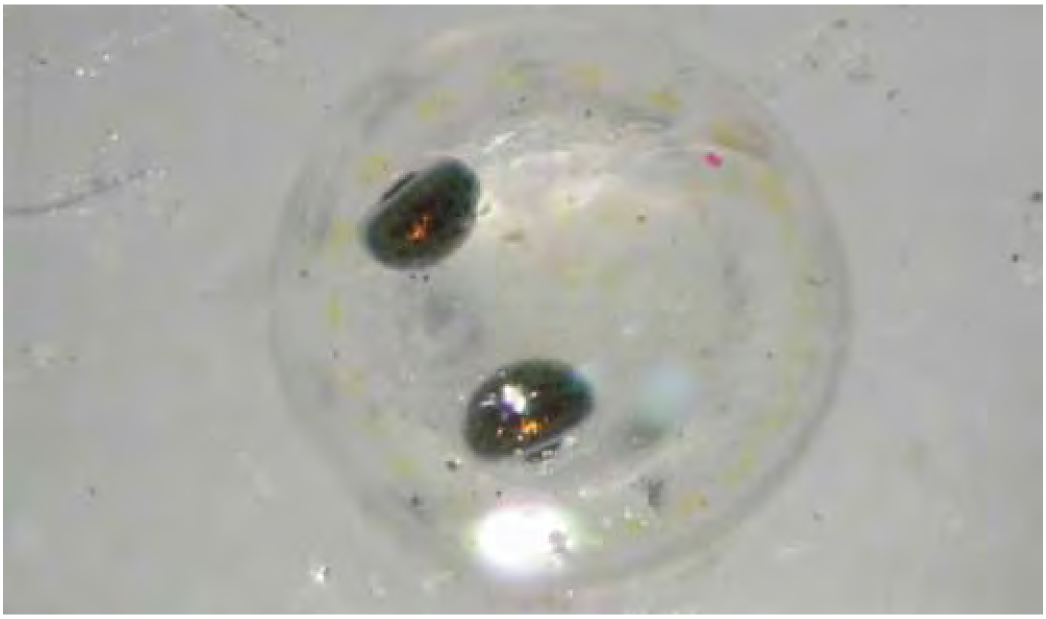

Figure 10. Photo of a well-developed inanga embryo. Egg size is approximately one mm.

4.2 Downstream of the tidegates

Downstream of the tidegates, intertidal vegetation was less diverse than the plant community upstream, and was generally consistent with that of a salt-marsh. Near the tide gates, and above the spring tide level, tall fescue grass, red clover and flax dominated (Fig. 11). However, the lower reaches were dominated by oioi, or jointed wire rush (*Leptocarpus similis*).

Figure 11. Tidal area downstream of the tidegates. Tall fescue was still dominant in many areas. White marker flags (arrowed) indicate locations of unsuccessful egg searches.

Vegetation on both banks was similar, and deposited silt amongst the vegetation was much more apparent than upstream of the tide gates (Fig. 12). Aquatic macrophytes were sparse, and water clarity poor due to high levels of suspended silt. Snails (*Potamopyrgus* sp) were also extremely abundant amongst the riparian vegetation. Despite an extensive search, no inanga eggs were found downstream of the tidegates.

Figure 12. The muddy, wet microhabitat in grasses below the tidegates. Note abundant aquatic snails (*Potamopyrgus* sp.) (arrowed).

5 Discussion

Of the three Christchurch Rivers, the Styx River has proved to be the most difficult on which to establish the location of inanga spawning grounds. Spawning surveys began in 1987 and 1988 by MAF Fisheries Staff, and further searches were conducted by the Department of Conservation (A. Spencer, S. Charteris, Martin Rutledge DoC, pers. comm.) and the Regional Council (Malcolm Main, formerly of ECAN). All of these surveys have been unsuccessful at locating inanga spawning grounds.

A major difficulty in locating the spawning grounds was the lack of knowledge of how tidegates affect spawning behaviour. Evidence in Christchurch and elsewhere indicate that inanga spawning behaviour is cued by exposure to saltwater (Richardson & Taylor 2002), and it is known that the Styx tide gates close early on the rising tide, and, based on 1980's studies, effectively isolate the lower river from any saltwater intrusion (Taylor *et al.* 1992). For this reason, previous searches tended to concentrate on the reach downstream of the tide gates. However, due to its low gradient, there was a considerable area to search; and surveying this extensive area with often minimal resources presented a problem.

One reason for success on this occasion might be because of good whitebait recruitment from the previous spring. Catches of whitebait running into Canterbury Rivers during the previous spring were high, with a 'bumper season' reported (The Press, October 27, 2004). This may have led to a sizeable population of fish in lowland rivers, and making previously undiscovered spawning grounds easier to detect. Another reason is due to improving rearing and spawning habitat in the river. With the Christchurch City Council gaining more control of the riparian margin of the lower reaches, the aquatic habitat has clearly improved for supporting inanga populations. This is discussed further below.

5.1 Rearing habitat improvement

As the planted native vegetation develops and spreads in the lower river, the river reaches becomes more suitable for inanga rearing. Inanga prefer rearing habitats with water-emergent rushes and reeds adjacent to deep slow-flowing open water, but with some aquatic macrophyte beds (Richardson & Taylor 2002). Inanga require slow water velocities to feed from the surface (Jowett 2002), therefore the creation of slow-flowing embayments in the vicinity of the Janet Stewart Reserve are favoured as inanga rearing habitat (Fig. 13). Marginal water-emergent bank vegetation along the main Styx River channel also provide areas of slow-flowing water suitable for inanga feeding (Fig. 14), and this vegetation also allows refuge from predatory trout in the lower river.

In the past, stock-accelerated bank erosion was severe upstream of Kainga Road (pers. obs). Our recent survey indicates an improved situation with formerly bare eroded slopes now grassed over (see Fig. 3). This is probably due to decreased stocking along this reach. Elsewhere, the CCC has obtained land tenure over significant lengths of the riparian margin, and this would undoubtedly reduce the scale of this problem.

Figure 13. Extensive open water areas fringed by emergent vegetation downstream of Marshlands Road (Janet Stewart Reserve).

Figure 14. The establishment of marginal aquatic macrophytes, cabbage trees and flaxes on the true right bank of the lower Styx River.

5.2 Spawning habitat improvement

While a lack of monitoring data frustrates any strong conclusions, the existing vegetation is at least as good for supporting inanga spawning as it ever has been. Fortunately, the yellow-flag iris does not appear to have invaded inter-tidal habitats along the lower Styx, as it has on the lower Avon River where the weed has eradicated soft herb/grass communities favoured by spawning inanga (Taylor & McMurtrie 2004).

On the Styx River, some of the native vegetation on the south bank was utilised for inanga spawning, and records of native plant associations with inanga spawn are rare. This is because native riparian vegetation in most lowland rivers has been dominated by introduced aggressive grasses and weeds near the water line. For this reason, it has been unclear as to what native vegetation was preferred by spawning inanga, although they do spawn satisfactorily amongst a number of introduced grasses.

The utilisation of raupo beds for inanga spawning was reported from Waikewai Creek which feeds Lake Ellesmere (Taylor *et al.* 1992), and it was interesting to see that raupo beds on the north bank of the lower Styx River were also used for this purpose.

Raupo stands develop layers of dying raupo leaves and stems which form a moist microhabitat for inanga egg development. Native rush (*Juncus sp.*) stands are occasionally used (e.g. Saltwater Creek, Ashley Catchment), and these too were utilised on the lower Styx River. In this instance, eggs were found on the root mats and stems.

In the 1990s, The Zonta International organisation, a voluntary women's group, cleared willow and blackberry from the existing raupo and flax beds upstream of the tide gates, and replanted native vegetation in other areas (Heremaia, 1995). Over time, these plants have matured, and their range increased in area. Other native plants has probably colonised naturally from other parts of the catchment. The onset of inanga spawning in this region represents another later stage in the naturalisation of the lower river.

5.3 Inanga spawning site management

It was clear from this survey that inanga egg density was concentrated towards the tidegates, with a density decline with distance upstream. In fact, the writer has not previously seen inanga egg densities this high, albeit over a limited reach of river bank. The decline in egg density with upstream distance could be explained if the tidegates were closed when the inanga were spawning, and the fish were concentrated on the upstream side of the gate. Probably some leakage of saltwater through the gates, and a water level rise after gate closure, triggered a spawning response.

In the 1980s, adult inanga were observed in the vicinity of the closed gates, but fish did not spawn (MAF raw field data). However, the improved riparian vegetation, and possibly larger inanga numbers, has allowed spawning to take place.

If spawning is found to now occur reliably without modification of the tidegates, then the *status quo* is probably acceptable in terms of managing the spawning ground. It was clear from the field survey that willow saplings and other woody adventives are already being removed along the reach used for inanga spawning. However, if spawning is sporadic, and only coincides with trace amounts of salt water upstream of the gates, then the inclusion of an adjustable valve or similar in the gates may be sufficient to allow a trace of saltwater upstream of the gates to trigger regular spawning events. This follows the concept introduced by Walsh (1999), where a valve would allow a small volume of saltwater (c.a. 1-10 m^3/day) to enter the reach during the inanga spawning season. If the small saltwater inflow is laminar and follows the thalweg, the riparian vegetation should be unaffected, as the saltwater should lie in the bottom of the deep river channel. The saltwater would be flushed from the reach when the tidegates open on the ebbing tide. If necessary the valve could also be shut off outside of the inanga spawning season (i.e. shut from May to January).

6 Recommendations

AEL recommends the following:

- Continue to monitor and remove willow sapling regrowth, and encroachment from blackberry, yellow-flag iris and other weeds.

- At places, the true right bank downstream of Kainga Road has slumped, and the intertidal zone comprises a vertical surface of unvegetated soil. These bare banks could be graded to a gentler angle, and planted in native *Juncus* rushes to facilitate further inanga spawning and rearing.

- Field measurements and trials be undertaken to understand if the operation of the gates, or their modification can influence spawning activity.

7 Acknowledgements

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