Inanga spawning habitats in the greater Wellington Region

Part 2

Wairarapa

June 2003

Publication No. WRC/RP-T-02/65
www.gw.govt.nz

Prepared by M J Taylor G R Kelly for the Greater Wellington Regional Council

Cover design by Lisa Paton, Morphological Design

NIWA Client Report: CHC01/67
Project No.: WRC01501
July 2001

National Institute of Water & Atmospheric Research Ltd
PO Box 8602, Riccarton, Christchurch
New Zealand
Tel: 03 348 8897
Fax: 03 348 5548

FOR FURTHER INFORMATION

Greater Wellington –
The Regional Council
Wellington
P O Box 11646
T 04 384 5708
F 04 385 6960
W www.gw.govt.nz

Greater Wellington –
The Regional Council
Masterton
P O Box 41
T 06 378 2484
F 06 378 2146
W www.gw.govt.nz

CONTENTS

Reviewed by:

Marty Bonnett

Approved for release by:

Don Jellyman

Executive Summary

Field surveys for inanga (i.e. adult whitebait) spawning grounds were conducted on 12 water bodies in the Wairarapa part of the Wellington Region between 8 April and 11 April 2002. Spawning grounds, as evidenced by inanga eggs, were found on the Whangaimoana and Oterei Streams, and a number of potential spawning grounds, some of which were extensive, were identified on other rivers. The lower Motuwaireka River, Lake Pounui outlet (above the flap valves at Lake Onoke), and a section of the eastern side of Lake Onoke were considered to have good inanga spawning potential. Several catchments draining hill country bordering the Wairarapa valley were evaluated as being wholly unsuitable for inanga rearing or spawning. These were the Wharepapa River, and the Wharekauhau, Hurupi and Putangirua Streams.

Conflicts between landuse and inanga spawning grounds were generally less apparent than in more urbanised areas of the western part of the Wellington region, with stock control required on only one catchment. In contrast to the regions west of the Rimutaka and Tararua Ranges, widespread invasion of exotic riparian and aquatic macrophytes (unsuitable for inanga spawning) was not apparent in the Wairarapa. Management of water levels on Lake Onoke will have some bearing on inanga spawning in tributaries around the margins.

1 BACKGROUND

This report presents the results from the second of two field investigations to identify inanga spawning habitat, or potential habitat, in the Greater Wellington Regional Council (GWRC) area.

The first report (Taylor and Kelly, 2001), completed in the 2001/2002 financial year, focussed on catchments east of the Rimutaka and Tararua Ranges; specifically some selected catchments in the Wellington City suburbs, Hutt Valley, and Kapiti coast north to Waikanae. In contrast, this document will present results from selected catchments to the west of the Rimutaka and Tararua Ranges, that includes parts of the lower Ruamahanga catchment (Lake Onoke subcatchment), and the western seaboard of the North Island north to Castlepoint. Catchments discussed in the report are presented in Figures 1 and 2.

In brief, inanga (the adult lifestage of most common whitebait species) spawn amongst tidally-inundated riparian vegetation during late summer and autumn. The eggs develop over several weeks largely above the waterline, relying on a covering layer of suitable vegetation to provide a moist micro-habitat to maintain egg hydration. Soil porosity, land use, and aspect are also important issues with respect to egg survivability. When the embryo is fully developed, and the eggs are re-inundated with tidal waters, the eggs hatch, and the larvae are washed out to sea. The larvae develop and feed in the open sea over the winter, before they migrate upstream into the river mouths during the spring as whitebait. Whitebait grow and mature into adults (about 90mm long) over the summer in the sluggishly-flowing lower reaches of rivers.

2 OBJECTIVES

Applied Ecology Ltd., has been contracted by NIWA (National Institute of Water and Atmospheric Research Ltd.), to identify, map, and describe whitebait spawning sites in 14 nominated rivers in the Wairarapa area of the Wellington Region.

The objectives were to:

- Carry out surveys of whitebait spawning habitat in the 14 rivers specified by the GWRC (Figs. 1, 2).
- Collect field information that will assist with mapping and describing identified whitebait spawning habitats.
- Prepare a report (including in electronic form) that maps and describes whitebait spawning habitat, including any information that is relevant to management/restoration.

3 METHODS

Field surveys were conducted in a similar manner as the previous year's surveys on the Kapiti Coast and Hutt Valley (Taylor and Kelly, 2001). Tidally inundated riparian vegetation, if present in the vicinity of the upstream limit of saltwater penetration, was subjectively evaluated for suitability for inanga spawning. This includes, but is not limited to, the capacity of vegetation to retain soil moisture and to provide a substrate for egg adherence. Inanga egg searches were conducted in vegetation deemed suitable for this purpose. A motorised 3m aluminium dinghy was frequently used to access untracked river and lake areas, being sufficiently light to be carried a short distance between road and waterway. A Garmin™ Global Positioning System (GPS) 12 channel receiver was used to geo-reference areas of interest, and a Horiba™ conductivity meter was used to determine the presence of seawater in water bodies open to the sea.

Egg samples were collected from the field for developmental staging, and thus to determine spawning date. This was carried out using low-power microscopy and reference to a scientific publication on inanga embryo developmental (Benzie, 1968).

The GPS positional data gathered in the field was imported in TopoMap Pro and Aerial Map Pro software, processed, and downloaded into a format compatible with the GIS (Geographic Information System) ARCVIEW or ARCINFO software utilised by GWRC.

4 RESULTS AND DISCUSSION

4.1 Whakataki River

At the time of the field survey, the mouth was partially closed due to recent heavy seas, and consequently the lower river was flooded with fresh water. Based on conversations with local residents, and zonation of the riparian vegetation, the river level was approximately 300mm above what would be regarded as normal spring-tide levels at the river's closest approach to Mataikona Road. Approximately 600m of the lower river was surveyed by boat on the basis that spawning vegetation could well have been submerged. The upstream limit of the survey extended 30m upstream of the Masterton Castlepoint road bridge, evidently the limit of tidal influence (Fig. 2), but still flooded by approximately 200mm.

At the most downstream limit of riparian vegetation, the soil structure on both river banks was too sandy, and the *Juncus* sp. vegetation present too sparse to retain egg moisture during normal river level fluctuations. For *Juncus* to be used for egg deposition, a root hair mat must also be present.

Generally, the true right bank offered the best potential for inanga spawning, with a long reach of *Festuca* grass (Figs 3, 4). The opposite bank upstream of the township was quite heavily grazed to the waterline, , and bank pugging could conceivably be a problem at normal water levels. Further upstream, but below the road bridge, suitable ungrazed habitat included 2 small raupo beds on the true left bank, and a section of the river which contained gently-shelved sections on both banks. A maturing female inanga was captured downstream of the road bridge. This fish was evidently still approaching spawning condition this season.

A spring-fed wetland complex joins the Whakataki River from the south. Most of the riparian vegetation, while superficially suitable, emerged from a base of pure sand, a substrate generally too porous to support inanga egg development. However, some areas closer to the springheads, and further from the beach, had a moisture-retentive soil structure (Fig. 5), and were considered more suitable.

In conclusion, there were considerable areas of whitebait spawning habitat in the Whakataki catchment, on land under tenure to the Whanau Trust, or classified as River Reserve (GWRC GIS cadastral database). A limited amount of riparian-edge stock grazing on the true left bank of the main river above the township may have reduced the potential spawning area, but there is probably adequate suitable spawning habitat (particularly on the true right bank) in this small catchment relative to the potential spawning inanga population.

4.2 Mataikona River

The mouth of the Mataikona River was almost completely closed at the time of the field survey, with salt water trapped in the lower reaches. The lower reaches of the river was surveyed by boat for 1.3 km, from the downstream limit of bank vegetation to the upstream limit of tidal influence.

Based on our survey, spawning habitat appeared to be quite limited in this catchment. The riparian grasses were generally unsuitably sparse, and rooted into steep clay banks. Some limited areas of marginal habitat with a shallower profile and better soil structure were found on the outside of the river meanders (Figs. 6 and 7). A spent inanga (i.e. one that had spawned) was observed just upstream of the habitat depicted in Figure 6. A tributary entered on the true right bank at the upstream limit of the survey, but this was considered to be unsuitable.

Land tenure on the true right bank of the river is classified as road reserve, with some DOC (Department of Conservation) land in the upper reaches, and near the river mouth. The true left bank, and the area of some limited spawning potential, borders Owhanga Station. There appeared to be little potential for enhancing spawning in this catchment, owing to the unsuitability of soil types and bank profiles. Neither of these features could be regarded as manageable on a river of this size. Unlike the Whakataki River, reported above, there appeared to be no flow-stable spring-fed tributaries entering the main river.

4.3 Pahaoa River

The Pahaoa River was open to the sea at the time of the survey, and the water was salty at the surface (and presumably throughout the water column), even at low tide. This river had little spawning habitat as most of the tidally-influenced habitat was comprised of un-vegetated gravels (Fig. 8), with very dry grasses above the tidal level. The very dry lower reaches were surveyed on foot and although a close inspection of the opposite (true left) bank was not possible, it was apparent even from a distance that all of this bank was dry, steep, and entirely unsuitable. The extent of the foot survey is shown in Fig. 9.

Despite the dryness of the surrounding environment, seepage from a hillside had facilitated growth of a lush sward of pasture grasses (creeping bent), growing through native toetoe grass on the true right bank (Fig. 10). The growth extended upstream over a distance of approximately 280m, although suitable vegetation was patchy near the upstream limit. Presumably other seepages along the true right bank had facilitated the growth of good vegetation along this reach.

Land tenure of the river margin with suitable vegetation for inanga spawning is either held by the Pahaoa and Cameron Trust, or classified as road reserve. At the time of this survey, this area appeared to be either ungrazed, or grazed at very low stocking densities. There was no indication of unsuitable woody plant species invading the site (e.g. willow, blackberry), and the area did not appear to be under any obvious threat other than natural changes in river course.

4.4 Motuwaireka Stream

Like other streams along the East Coast, this stream had been closed recently by heavy seas, and had flooded surrounding low-lying vegetation. A channel to the sea had been recently excavated, but levels were still high at the time of the survey. The waterway was surveyed by boat and foot to a distance of 1.2 km upstream (Fig. 11), where sub-surface seawater was still detected by the water conductivity meter. Given the nature of the saltwater-intolerant riparian vegetation along the stream channel, it was considered that salt intrusion may have been an artefact of trapped saltwater from the recent heavy seas. Saltwater intrusion into the stream may be minimal in normal circumstances.

It was clear that there was an abundance of suitable inanga spawning habitat throughout the lower catchment. In the lower-most reaches, this consisted of an area of native rushes and pasture grass on the true left bank near the sea (Fig. 12), and small raupo beds along the true right bank (Figs. 12 and

13). A shoal of adult inanga was seen amongst the flooded grasses on the true left bank, but high water levels precluded an egg search at this location. Cattle had access to this area during normal dry conditions, (evidenced by droppings), although the land has DOC tenure.

Further upstream, the stream formed a deep wide channel, banked with long pasture grass apparently inaccessible to stock (Fig. 14). This area was also considered to be good spawning habitat, but given the abundance of suitable vegetation further downstream, this area may not be heavily utilised by spawning inanga.

4.5 Whareama River

The Whareama River is a substantial waterway which discharges 9 km north of the Motuwaireka River. At the time of the boat survey, the river mouth was open, and the tide high and rising. A considerable amount of driftwood and kelp lining the lower river attested to recent heavy seas. Remarkably, the river was salty at the surface, (and estuarine crab-holes present) even 5 km upstream from the sea, the upstream limit of the survey (Fig. 15). Thus the ‘saltwater wedge’ endpoint must extend even further upstream. Unfortunately, constraints on boat operating range precluded further inland incursion. It may be beneficial to resurvey this substantial river using a vessel with greater range and boat speed.

While a good proportion of the banks along the lower reaches were dry, steep, and eroded (Fig. 16), there were some good reaches of suitable spawning habitat. In particular, one area on the true left bank (Fig. 17) was bordered by a young pine plantation, and fenced from stock. However the trees were pruned, allowing good light levels to promote a lush grassy sward of *Festuca* grasses. The extent to which this and other sites will be utilised will depend on the availability of suitable vegetation in the vicinity of the ‘saltwater wedge’. A local resident spoke of the considerable size of the whitebait catches taken from the Whareama River near the main road bridge (18.5 km upstream from the sea). Available aerial photos of the area upstream of our survey indicated improving riparian tree cover, more fertile and extensive river flats and a sinusoidal river course. Thus, the sluggish flows and richer soils could provide more suitable spawning vegetation.

4.6 Oterei Stream

The tidally influenced reaches of Oterei Stream (c. 800m of this waterway) were surveyed by boat on a low and rising tide. While there were many wholly unsuitable regions with steep clay banks, some areas with a more gentle relief had very good spawning habitat. In particular, three areas had good habitat for inanga spawning (Fig. 18).

The most downstream of these was an area below the Te Awaiti Station bridge, where good spawning habitat extended on the true right bank for a distance of approximately 125m (Fig. 19). The mixture of tall fescue and twitch-type grass formed a tangled mass of foliage over a moist soil surface, and was regarded at the time as one of the best spawning habitats we had seen in the Wairarapa. Suitability further downstream was restricted by the development of a camping ground with vehicular access, thus leading to ground compaction, and an unsuitably short grass sward. Upstream of the good habitat, the grass was stunted and the ground dry, and further upstream above the bridge on the true left, the bank deteriorated to an unsuitable clay bank.

However, the opposite (ie. true left) bank, somewhat further upstream of the bridge and with land tenure held by Te Awaiti Station, offered better potential (Fig. 18). This low terrace of tall fescue extended over approximately 130m, and a large school of adult inanga were seen just downstream of this area. However, no eggs were found there.

The third area with suitable vegetation was found back on the true right bank (Fig. 20) along a shallow terrace of tall fescue. On this occasion inanga eggs were found in quite high densities extending over an area of approximately 11m in length x 0.8m in width.

Two samples of eggs were obtained from separate areas for evaluating developmental stage, and by back-calculation, the dates of spawning (Table 1). Two developmental stages were evident in the samples for the Oterei Stream; eggs at stage 17 (eyes silvered), and another, younger, stage (eyes grey). Assuming a uniform developmental temperature of approximately 14^{o}C, and thus an embryonic development period of 6 and 8 days respectively, these eggs resulted from two separate spawning events around the dates of 2 April and 4 April.

4.7 Whangaimoana Stream

The Whangaimoana Stream was surveyed on foot over the lower 1.2 km, where it flows southeast and parallel to Whangaimoana beach (Fig. 22). The stream was closed to the sea at the time, but it was apparent that occasionally it broaches to the sea at various points along the beach. Thus, the riparian vegetation on the seaward side of the channel is quite undeveloped and growing from a porous coarse sand substrate that is unsuitable for inanga spawning. In contrast the landward side supports relatively mature vegetation and soil structure.

Table 1: Embryonic development stages of collected eggs and estimated spawning dates.

Location	Egg stage	Number of eggs	Estimated spawning date
Oterei Stream	17	5	2 April
	15	1	4 April
	14 (late)	1	4 April
Oterei Stream	15	6	4 April
Whangaimoana Stream	12	9	6 April

At the time of the survey, the water was clear, and entirely fresh. Several inanga shoals were observed along the waterway, and one specimen from a shoal was captured for inspection. This fish was a mature male, and proved to be a strippable (i.e. It exuded milt from the vent when gently squeezed). It was considered likely that the inanga shoals were composed of fish yet to spawn. These shoals were observed from a distance, and their activity appeared to be concentrated on a reach on the true left (landward) bank.

When the vegetation in the vicinity was inspected, inanga eggs in large numbers were found 5 to 10cm above the waterline adhering to the stems of the emergent grass. Samples of the eggs and vegetation were taken, and later microscopic examination of the eggs showed reasonably young eggs (Stage 12, Table 1), with a spawning date of around 6 April. The grass was identified later (by Plant ID services, Landcare Research) as mercer grass (*Paspalam distichum* L.,). The spawning zone extended over approximately 10m of stream bank (Fig. 23), but straddled a section of tall native *Juncus* vegetation. Other areas of apparently equally suitable vegetation on either side of the spawning area were searched but no eggs were found.

Mercer grass is regarded as a noxious plant that is displacing pasture grasses in wetter areas around New Zealand. It has been rarely associated with habitats for inanga spawning (National Inanga Spawning Database), this being only the second observation in the North Island, where the plant is more common. It must be one of the first records of inanga eggs being found directly on the plant. Mercer grass is quite widespread along the channel, and this incidence of spawning may be an 'act of desperation' rather than one of preference.

The narrow ribbon of spawning vegetation lies between a steep bluff and the sea, and is relatively inaccessible to stock. Pedestrian and vehicular traffic utilised the other bank, which is unsuitable for inanga spawning. The habitat could be damaged if the sea broached through the beach in stormy conditions, or if salt intrusion damaged the vegetation. The area is on the boundary of privately owned land (Prickett, Hugh Rolleston), but given its lack of access, and lack of pastoral values, landuse conflicts are unlikely.

4.8 Putangirua and Hurupi Streams

Both of these small waterways drain the Western foothills of the Aorangi Range, and are short, steep and unsuitable for inanga rearing (Figs. 24, 25). They lack spring-fed tributaries in the lower reaches, and have a stony riverbed and floodplain. Consequently, they lack riparian vegetation that would be flooded on a tidal periodic basis, and thus are also unsuitable for inanga spawning.

4.9 Wharepapa River and Wharekauhau Stream

These two waterways drain the south-eastern flanks of the Rimutaka Range, and discharge into Palliser Bay, west of the Ruamahanga River (Figs. 26-28). These two systems are also unsuitable for inanga spawning and rearing; the tidally-influenced margins of both lacked riparian vegetation of any description, and the lower reaches of the Wharekauhau Stream was comprised of unstable-looking braids.

4.10 Lake Onoke and Ruamahanga River

The Lake Onoke wetland comprises the lagoon of the Ruamahanga River, but is also fed by both Lakes Wairarapa and Pounui (Fig. 29). Lake Onoke was open to the sea, and was just sufficiently deep (ca. 0.4m) to be negotiable by small boat. Generally the lake looked low in respect to the margins. All lake inlets were examined, and the lake shore evaluated for inanga spawning suitability every 500m (as logged by the GPS receiver).

There is a significant inlet and lagoon at the south-western tip of the lake (Fig. 29), at the base of the shingle spit. However, this sub-system, which is close to the sea, generally appeared to be too salty, with riparian areas comprised of unsuitable salt rush growing through beach gravel.

To the north, the lake margin vegetation appeared botanically quite uniform, consisting of jointed rush growing through a muddy substrate. There appeared to be little material upon which inanga eggs could adhere, with the lake margins emerging vertically 30cm above the current lake level (Fig. 30). Two channelised drain inlets were examined in the vicinity, with riparian vegetation composed of a mixture of tall fescue and Mercer grass. However, this vegetation generally lacked a root mat which spawning inanga seem to prefer.

The Lake Pounui outlet, which was discharging at the time, is controlled by flap valves. The vegetation downstream of the flap valves was found to be unsuitable for inanga spawning. East of the outlet, the lake edge consists of an artificial straight gravel beach for 1.6 km. In the sheltered shallows of the bay west of the Ruamahanga River mouth, a floating (probably exotic) grass mat, impenetrable for our vessel, prevented access to the lake margin. Such areas may offer spawning potential, although owing to its inaccessibility, we cannot comment of its suitability (Fig. 31).

In the vicinity of the peninsula (to the west of the river’s outlet), the substrate consisted of sand, with sparse emergent jointed rush, still inadequate to preserve egg humidity. The lower reaches of the Ruamahanga River was surveyed for approximately 700m upstream, and although there was some tall mixed fescue and clover communities on the true right (west) bank, the vegetation was again sparse (Fig. 32). At the most upstream extent, the water margins were comprised of mud flats. The true left bank was even less suitable, being eroded to form vertical unvegetated banks.

The eastern side of Lake Onoke has clearly the most suitable inanga spawning vegetation, which generally increases in suitability with distance away from the Ruamahanga River outlet, and towards Lake Ferry (Figs. 29 and 33). A 470m section of lake edge, fed by a number of springs, discharges directly into the lake, or enters waterways in this area. Inanga spawning was recorded here by DOC (in 1999) in a spring-fed stream (Fig. 34). On this occasion, large schools of inanga were observed, but a search failed to locate any eggs. The outlet of the stream was closed to the lake at the time, due to low lake levels, and the stream was comprised entirely of fresh water. Lake water in the vicinity was quite fresh (0.8 $mS.cm^{-1}$), probably due to spring-water infusion, in contrast to the far side of the lake where the water was brackish (5.0 $mS.cm^{-1}$). Land tenure in the suitable area is privately held (T.H. Warren) to the lake edge, and although the inshore areas were grazed, the area where inanga have been observed spawning was not impacted by stock. Further towards the mouth, the riparian zone was too stony to support inanga spawning.

4.11 Lake Pounui Stream

The Lake Pounui Stream outlet was assessed for spawning suitability by a foot survey over several hundred metres upstream of the flap valve outlet on the northern edge of Lake Onoke. Generally, this area had very good suitability for inanga spawning (Fig. 35), although the flap valve gates may inhibit spawning activity by restricting spawning shoal movement, and/or confusing physiological cues. At the time of writing, land tenure for this area was unknown.

At a distance of 3.3 km upstream, at the Western Lake Road, the Lake Pounui outlet is rather swiftly flowing, beyond the tidal influence, and gravel banked; thus clearly unsuitable for inanga spawning. Available aerial photographs indicate the best spawning habitat may be restricted to the unchannelised section between the lower ponds on Sheep Hill Island, and Lake Onoke.

5 OVERVIEW

Generally, the tidally-influenced riparian margins in the Wairarapa were dry and steep, with hard clay-based soils. From the perspective of providing a good spawning habitat, vegetative cover was therefore unsuitably poor and thin. Actual and potential spawning areas were found where spring seepages facilitated a thick sward of vegetation (Lake Onoke, Whakataki River) or where soil conditions were more favourable (Oterei Stream, Whangaimoana Stream). Thus natural factors like bank profiles and vegetation, soil types and their moisture levels, appeared to be obvious limitations on spawning potential. Many of these factors are linked to the low rainfall of the region, especially along the east coast which is in rain shadow from the coastal hills. This was consistent with recent discussions on the regional variations in inanga habitat and spawning in New Zealand (Taylor, 2002). Therefore, from the outset of this survey, the approach was to select a subset of rivers which, based on their hydrology, had some potential for inanga rearing, (i.e. a potential spawning population), and then examine riparian areas on these systems which were somewhat less arid.

However, while spawning areas may be limited in the Wairarapa because of the dry conditions, riparian landuse conflicts were less apparent in areas where spawning could (or did) take place. In this respect it differs from potential spawning areas in more urban areas (Taylor and Kelly, 2001), where spawning areas may be limited by mowing, weirs, impervious bank cladding, flood control, and pollution. Generally, the Wairarapa had far less riparian modification, and stock (with the exception of the lower Motuwaireka Stream), had been kept away from the river margin by fencing or utilising natural barriers.

Water levels in Lake Onoke may have a bearing on inanga spawning in its periphery. Water level changes induced by wind-induced Seiches influenced inanga spawning on Lake Ellesmere inlets (Taylor *et. al* 1992), and this may also apply to Lake Onoke. Similarly, the timing of lake openings and lake level management will also impact not only in inanga spawning in the autumn, but also on whitebait recruitment in the spring.

The vegetation used for spawning was similar to that used in other pastoralised areas of New Zealand, in particular tall fescue (*Festuca arundinacea*) dominated the communities. Opportunities for native-plant dominated spawning areas were scarce, as riparian landuse favoured pasture grass dominance. Moreover, should native spawning areas be established, the physical isolation of many of the areas would make their monitoring and maintenance expensive. However, there were some limited areas where native plant communities dominated, with relatively good access. For example, on the Whakataki River where isolated raupo beds (*Typha orientalis*) and native rushes were present.

The utilisation of introduced Mercer grass for spawning (*Paspalam distichum*) is uncommon, but its utilisation has been recorded from the North Island before. It is therefore unclear if it more suitable than the grass it displaces. The equally invasive Reed Sweet Grass (*Glyceria maxima*), which appears to be avoided by spawning inanga (Mitchell, 1993), was (fortunately) not identified on this survey, though commonly encountered on the Kapiti Coast (Taylor and Kelly, 2001). The noxious aquatic macrophytes *Lagarosiphon*, and Parrots Feather (*Myriophyllum aquaticum*) which could block channels (and spawning migrations) in small waterways, were not identified on this survey, although the unidentified floating plant mass at the outlet of the Ruamahanga River into Lake Onoke warrants investigation. Therefore, the Wellington Regional Council should continue to be vigilant on controlling the spread of invasive exotic water weeds.

6 ACKNOWLEDGEMENTS

We thank the NIWA Greta Point staff for organising a reliable 4WD vehicle and aluminium boat. We also thank Marty Bonnett for reviewing the typescript, and Carol Whaitiri for formatting the final document.

7 REFERENCES

Benzie, V. 1968. Stages in the normal development of Galaxias maculatus attenuatus (Jenyns). New Zealand Journal of Marine and Freshwater Research 2: 606-627

Taylor, M.J. 2002. The National Inanga Spawning Database: trends and implications for spawning site management. Science for Conservation No. 188. Department of Conservation.

Taylor, M.J.; Buckland, A.R.; Kelly G.R. 1992. South Island inanga spawning surveys 1988-1990. New Zealand Ministry of Agriculture and Fisheries, Freshwater Fisheries Report No. 133. 69 p.

Taylor, M.J.; Kelly, G.R. 2001. Inanga Spawning habitats in the Wellington Region, and their potential for restoration. NIWA Client Report CHC01/67. 61 p.

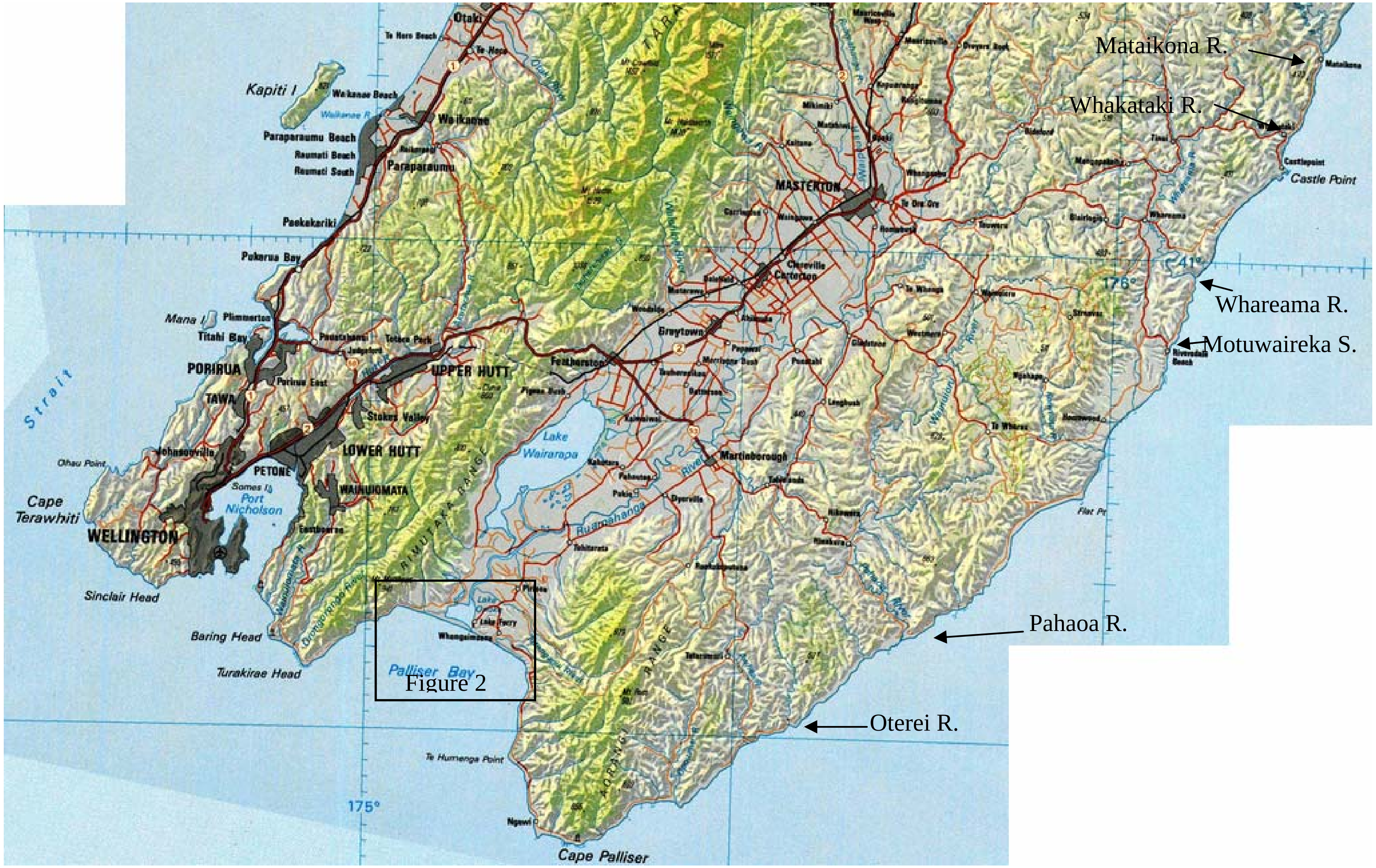

Figure 1: The 12 surveyed water bodies surveyed in the Wairarapa part of the Wellington Region. For clarity, the boxed region is depicted in Figure 2.

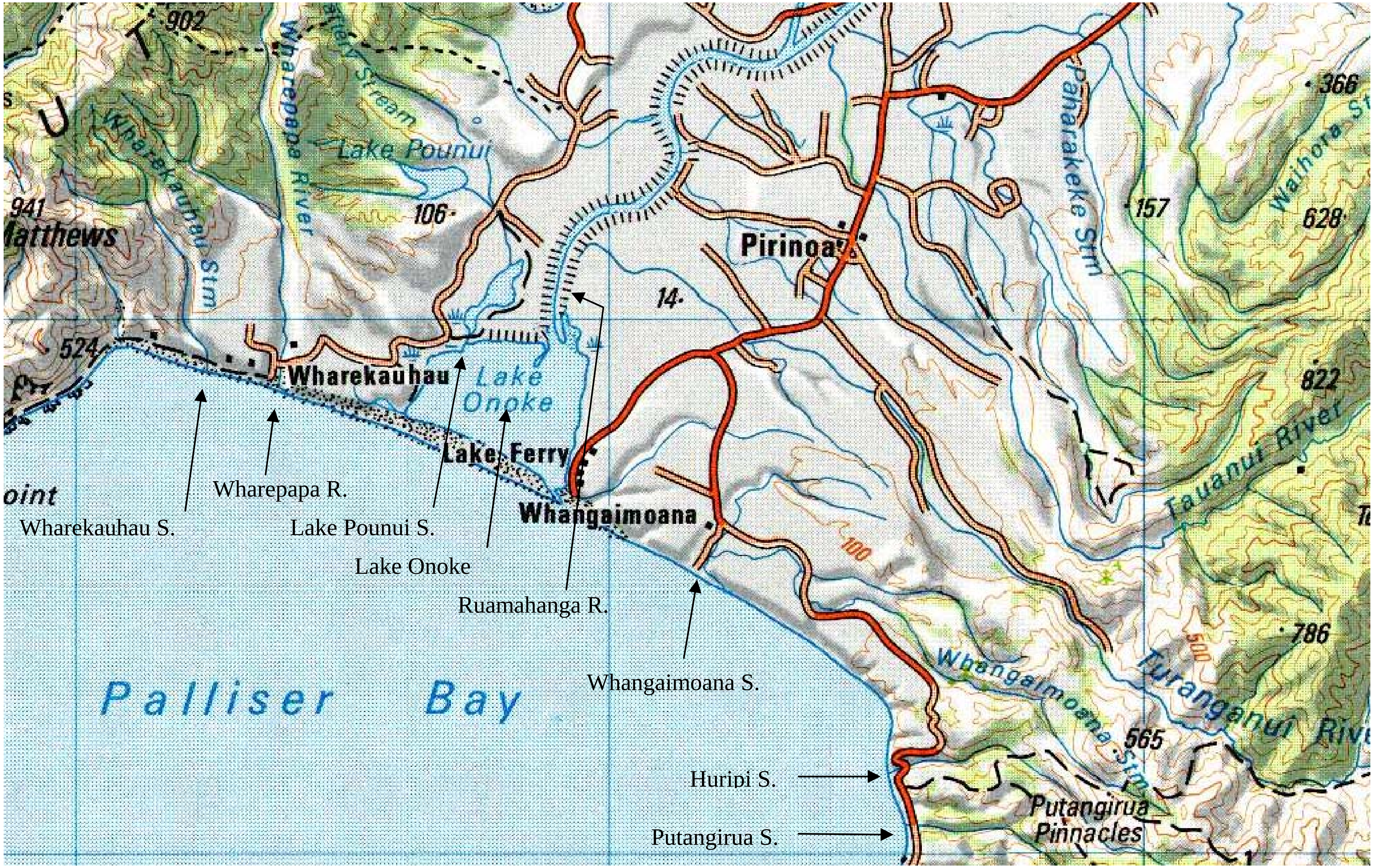

Figure 2 Surveyed water bodies in the Palliser Bay region.

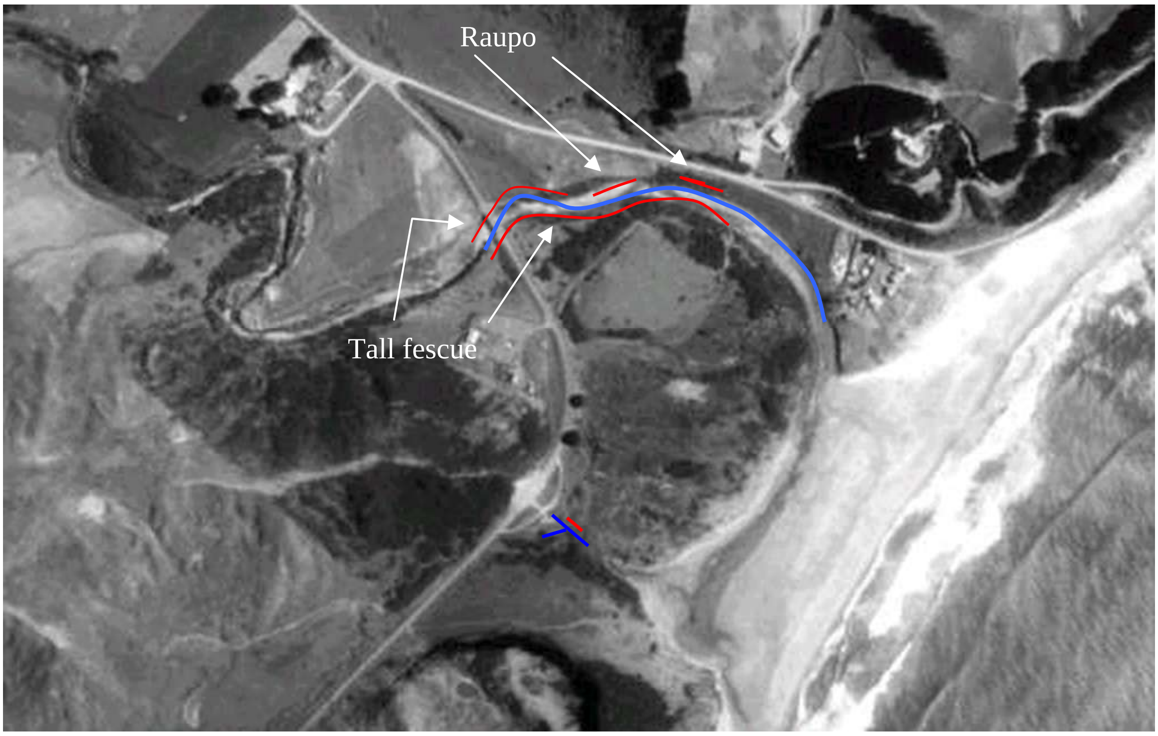

Figure 3: Lower reaches of the Whakataki River. The blue track shows the extent of the spawning survey, whereas the red track indicates the area of suitable spawning vegetation.

Figure 4: A long reach of tall fescue vegetation on the true right bank of the Whakataki River, arrowed in Figure 3.

Figure 5: Suitable spawning area in a spring-fed tributary of the Whakataki River. Suitability was restricted to areas close to the spring heads, and away from the sandy beach.

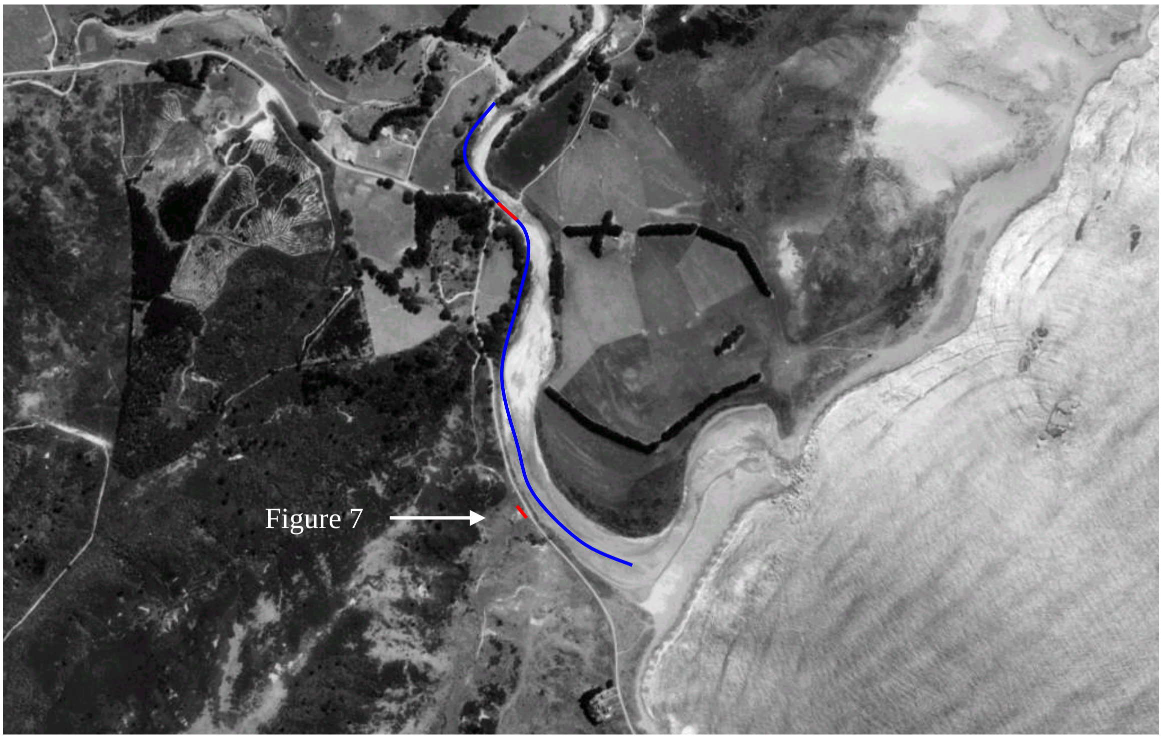

Figure 6: Lower reaches of the Mataikona River. The blue track shows the extent of the spawning survey, whereas the red track indicates the area of suitable spawning vegetation.

Figure 7: There were limited areas of suitable spawning vegetation on the Mataikona River. This is one such area, where a mixture of tall fescue, and creeping jenny grasses grew from a shallow shelf on the outside bend of the river. Bank damage and driftwood piles from flooding were common.

Figure 8: The lower reaches of the Pahaoa River at low tide. Much of the lower river was gravel-banked with little inter-tidal riparian vegetation.

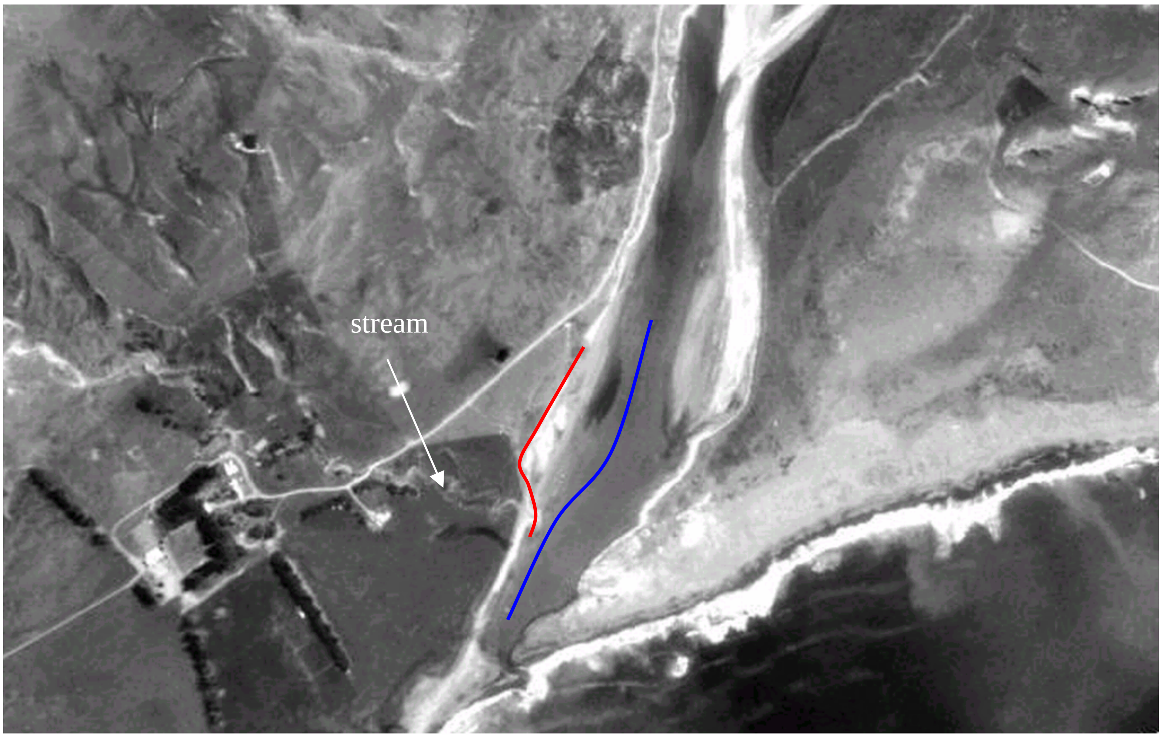

Figure 9: The lower reaches of the Pahaoa River. The blue track shows the extent of the spawning survey (by foot). The red track indicates the area of suitable spawning vegetation. The stream entering from the left of the photo (arrowed) supports lush riparian vegetation in this otherwise very dry environment (Fig. 10).

Figure 10: Highly suitable spawning vegetation on the true right bank of the Pahaoa River. Note the line of tide line of driftwood through the vegetation.

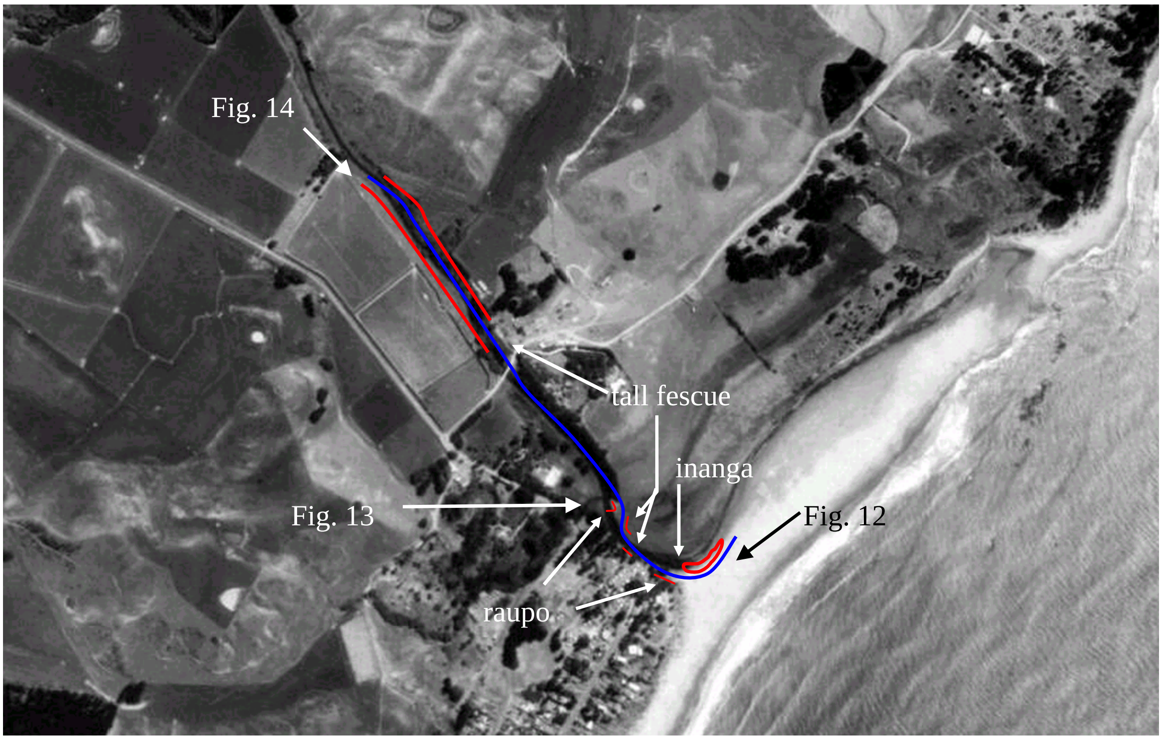

Figure 11: The blue track shows the extent of the spawning survey (by foot). The red track indicates the area of suitable spawning vegetation.

Figure 12: Suitable spawning vegetation, comprising of mixture of native rushes and pasture grass near the mouth of the Motuwaireka Stream. A school of inanga were seen amongst this vegetation. Cattle sign was evident in this DOC-owned land.

Figure 13: Raupo beds close to the sea, such as this example on Motuwaireka Stream (photo centre and right), are frequently used by spawning inanga.

Figure 14: The extensive fenced and ungrazed reaches of the Motuwaireka Stream, near the upper limits of the surveyed area, looking downstream. These grasses offered good spawning potential.

Figure 15: The lower Whareama River. The blue line indicates the extent of the boat survey (5.1 km), and the red section an area of suitable vegetation. The river mouth is in the lower right corner of the photograph.

Figure 16: The lower Whareama River looking downstream towards the fishing village. The river banks in many areas in this location are dry, steep, eroded, and offering little spawning potential.

Figure 17: A relatively rare example of stable grassy bank on the lower Whareama River. Even 3.5 km upstream driftwood, kelp, and estuarine crab holes were common.

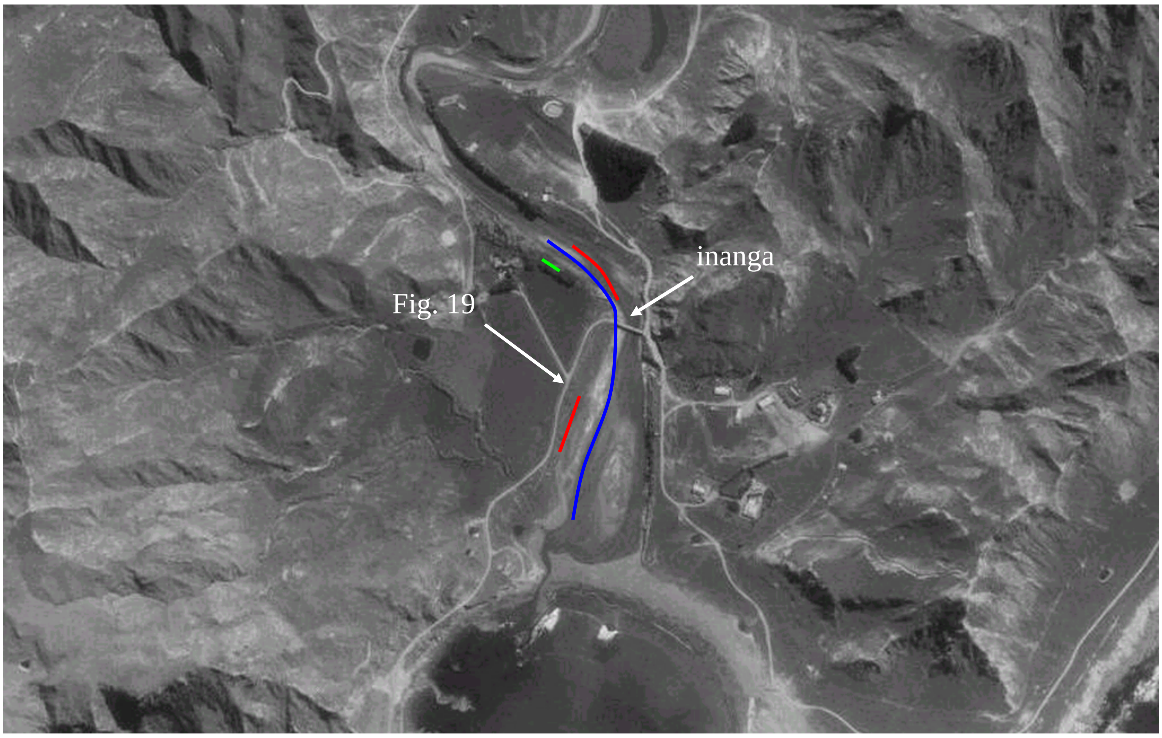

Figure 18: Lower reaches of the Oterei Stream. The blue line indicates the extent of the boat survey, the red section indicates area of suitable vegetation, and the green section an area where inanga eggs were found.

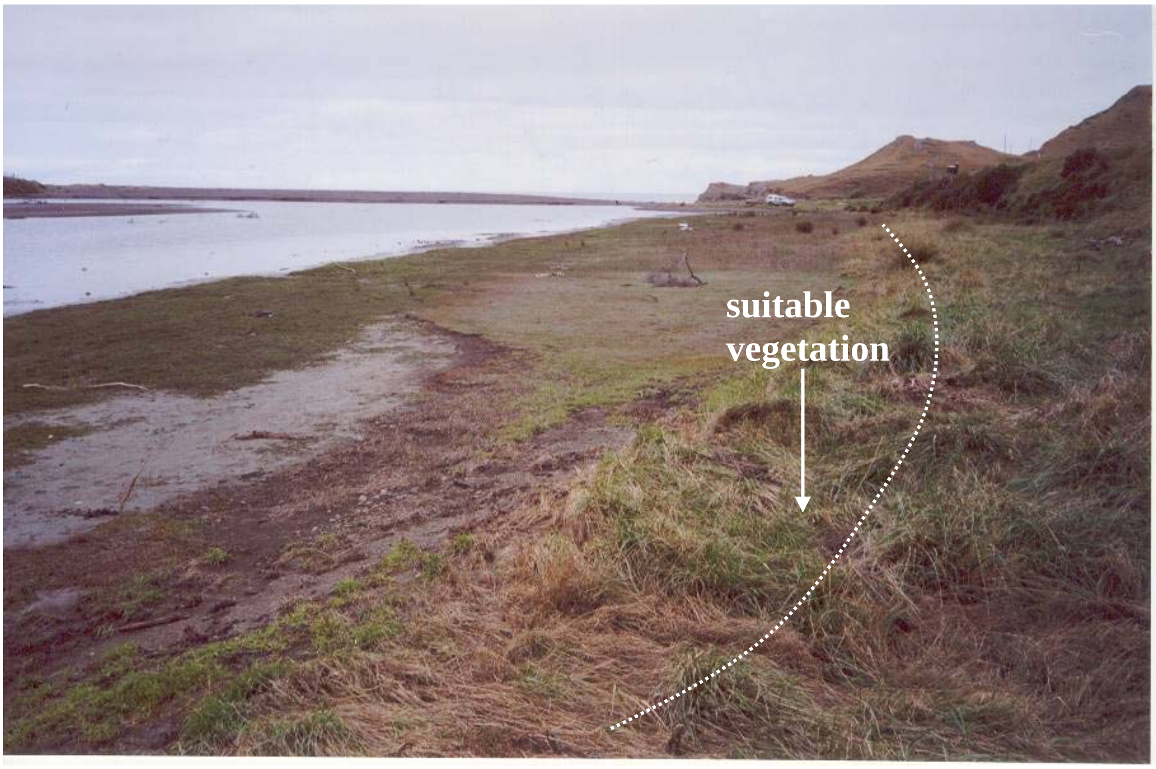

Figure 19: Suitable habitat downstream of the Te Awaiti Station Bridge on the true right bank.

Figure 20: Inanga spawning grounds on the Oterei Stream. The dashed line indicates the elevation at which eggs were found.

Figure 21: A cluster of inanga eggs from Oterei Stream. The circled zone encompasses some of the more conspicuous eggs, which are slightly less than 1mm in diameter. In this situation, eggs adhere to the root hairs of pasture grasses.

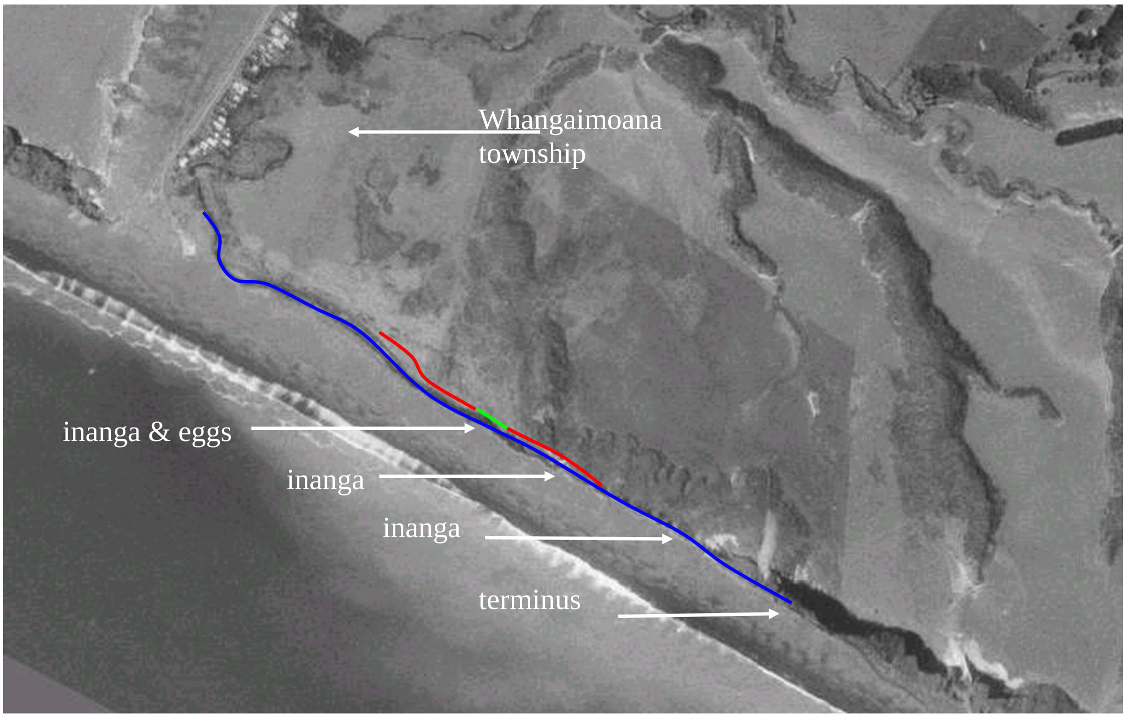

Figure 22: The lower reaches of the Whangaimoana Stream, the blue line indicates the extent of the foot survey, the red section indicates area of suitable vegetation, and the green section an area where inanga eggs were found.

Figure 23: Inanga spawning grounds on the Whangaimoana Stream. Eggs were found either side of the tall Juncus vegetation amongst the introduced weed Mercer grass.

Figure 24: The gravel bed of the lower Hurupi Stream.

Figure 25: The lower reaches of the Putangirua Stream.

Figure 26: Wharepapa Stream, looking downstream towards the mouth.

Figure 27: Wharekauhau Stream, looking downstream. The mouth looked nearly closed at the time of the survey.

Figure 28: Wharekauhau Stream, looking upstream. Note the unstable braids which constitute the lower reaches. This habitat lacks the stability and grassy margins which are associated with inanga spawning habitat.

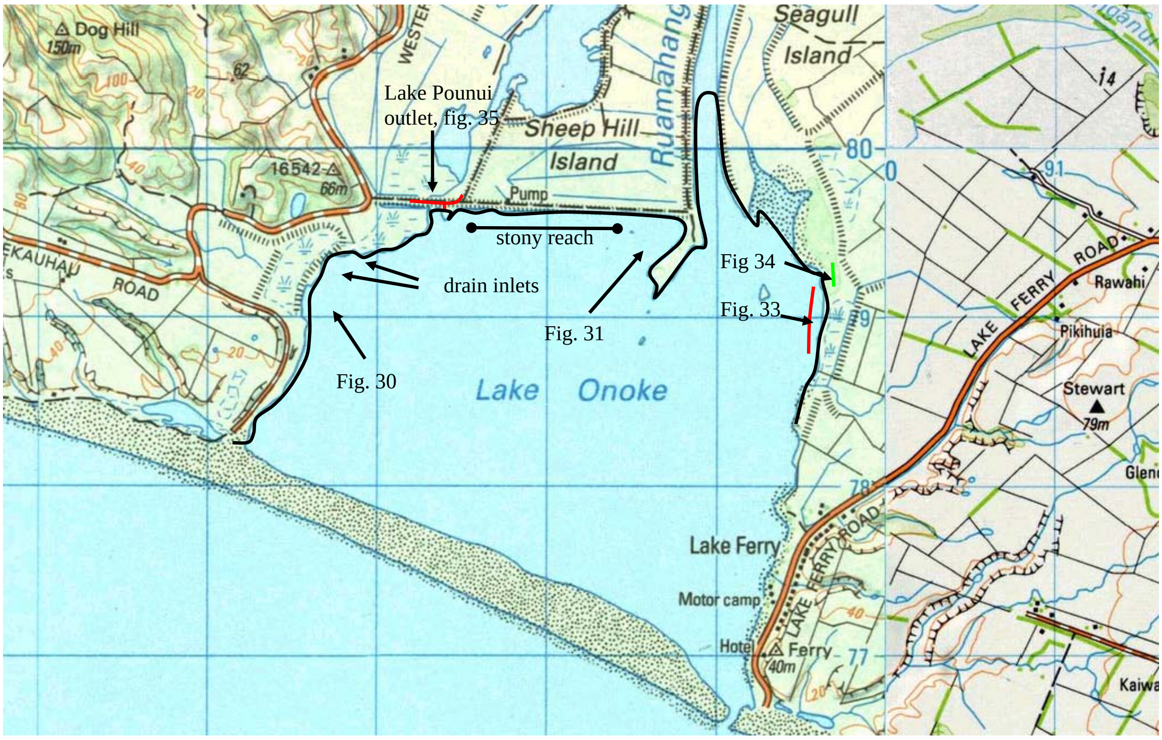

Figure 29: Lake Onoke wetland complex. The black line indicates the extent of the boat survey around the riparian margins, and the red line favourable spawning areas. The green line indicates a known inanga spawning area.

Figure 30: Native rush vegetation typical along the western shore of Lake Onoke. The vertical banks are probably due to wave-cut induced by the prevailing winds.

Figure 31: Emergent grass growing out over the sheltered lake waters. Some suitable spawning vegetation may exist in this inaccessible area.

Figure 32: Thin grass cover on the true right bank of the Ruamahanga River looking downstream. Lake Ferry is discernable across the lake in the back ground.

Figure 33: Suitable spawning vegetation north, and looking towards, Lake Ferry. Spring water rises amongst the vegetation here and the spring feeders supports lush vegetation at this location.

Figure 34: Spawning was recorded from this clear spring-fed stream in 1999. However, at the time of this survey, the stream was occluded from Lake Onoke by low lake levels, and although large shoals of inanga were observed here, no eggs were found.

Figure 35: Lake Pounui outlet upstream of the flap-valve outlet to Lake Onoke. The grassy vegetation here was excellent for spawning, but the gates may inhibit spawning if they seal completely.