*DRAFT*

# *Delimitation of inaka (whitebait) spawning in coastal Otago Rivers*

**Figure 1. Waitati Stream looking towards the estuary. Spawning is occurring along both margins where the water touches the bank vegetation.**

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## *Contents*

# 1. Introduction

Whitebait (*Galaxias maculatus*) whitebait spawning areas have been identified by the Minister of Conservation as being of immediate concern. A number of inaka spawning sites across the coastal Otago region were identified by DOC and survey during the 1990s. The DOC spawning site survey programme ran 1989 – 1999 and the resulting data exists in the National Spawning Database, however, information is incomplete and poorly developed for the Otago area. When published in 2002 the National Spawning Database held 562 records, there are now three with three additions, (2004, 2004, 2005, 565 records). As a result of that work several sites were were protected through fencing. The current condition of previously identified sites is unknown. In addition, there are important inanga populations in many of the coastal streams for which spawning sites are as yet unknown. Resurveying known sites and delimitation of spawning extent across a range of new sites was under taken April May 2019. Current threats and restoration opportunities were assessed. The aim of this work is to develop oversight of the crucial spawning sites in the eastern coastal Otago area and to identify and prioritise future restoration work.

# 2. Aims

- Provide a current inventory of eastern coastal Otago inaka spawning sites.
- Prioritise the sites where significant inaka populations exist and the spawning sites which require securing and protecting.
- Provide information to landowners as to the biodiversity value of their streams and likely threats.
- Identify the range of threats to spawning sites and suggest remediation.

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# *3. Methods*

## Site surveys

The Department of Conservation maintains a spawning database,[1] this was accessed to determine where prior spawning events had been identified. Known sites were revisited using the GIS shapefile for the locations was obtained from DOC.[2] New sites identified primarily with regard to stream size and catchment order, since larger streams are likely to have a greater population and a greater contribution to the metapopulation. Permission to access was granted in most cases however Trotters Creek and Drivers Creek were not accessed due to concerns from the owners that they would face pressure from DOC with regard to land management practice.

The New Zealand Freshwater Fish Database[3] was accessed (March 2019) and downloaded for each stream and all whitebait species (known to occur in the region).

The Waihemo and Waikouaiti Rivers were accessed during 2017 – 2018 and revisited 2019. The Waikouaiti River work was funded under the Bioheritage Project Theme: Predicting and managing ecosystem tipping points.[4] Many of the learnings there were used in this work and in the Waihemo which was undertaken by local whitebait fisher, Grant Ward. Both those prior datasets are not in the National Database and so area reported here.

## Timing, moon phase and spawning effort

Although spawning is thought to happen at low levels across the year the majority of spawning occurs off the back of a spring tide (full moons), on the days immediately following peak tide and throughout the main spawning months (March to May). Survey work begin early April so only two spring tides were available for assessing spawning. Detection and evaluation of the spawning area occurred throughout 23rd March – 18th May 2019. Spawning is evident for the month following spawning as

[1] Taylor, M.J. 2002. The National Inanga Spawning Database: trends and implications for spawning site management. Department of Conservation, Science for Conservation No. 188. 37pp.
[2] Data accessed courtesy of Dave West.
[3] https://nzffdms.niwa.co.nz/search
[4] http://www.biologicalheritage.nz/resources/highlights-2017/impact-1-protect-and-restore/building-ecosystem-resilience/highlights/tipping-points

eggs develop and so the spawning events observed were those of March and April spring tides. Full and new moons occurred on 19th April and the 19th May (Figure 2).

The NIWA tide forecaster[5] was used to calculate moon phase and an estimate of the timing of tidal influence up the river was derived from http://tidespy.com/. This information allowed site visits at high tide for salinity measures or low tide for access to conduct spawning searches. Access can be affected by the daily timing of the low tide and tidal ebb where streams are not wadeable at high tide.

Except for Waitati Stream and the Kakanui/Waiareka, which were accessed by kayak, all sites visited were waded. Access for spawning is easiest at low tide, whereas salinity measures for detection of the salt water wedge are optimal at high tide. Generally, the first visit was done at close to high spring tides to assess the saline push and egg searches done on those occasions if and where possible or at low tides. Half a meter tidal push makes most of the lower reaches unwadeable. The lower reaches of spawning areas are generally accessible at low tide, except where it becomes very saline and tidal, and banks are highly undercut and spawning very difficult to locate, if it is occurring at all.

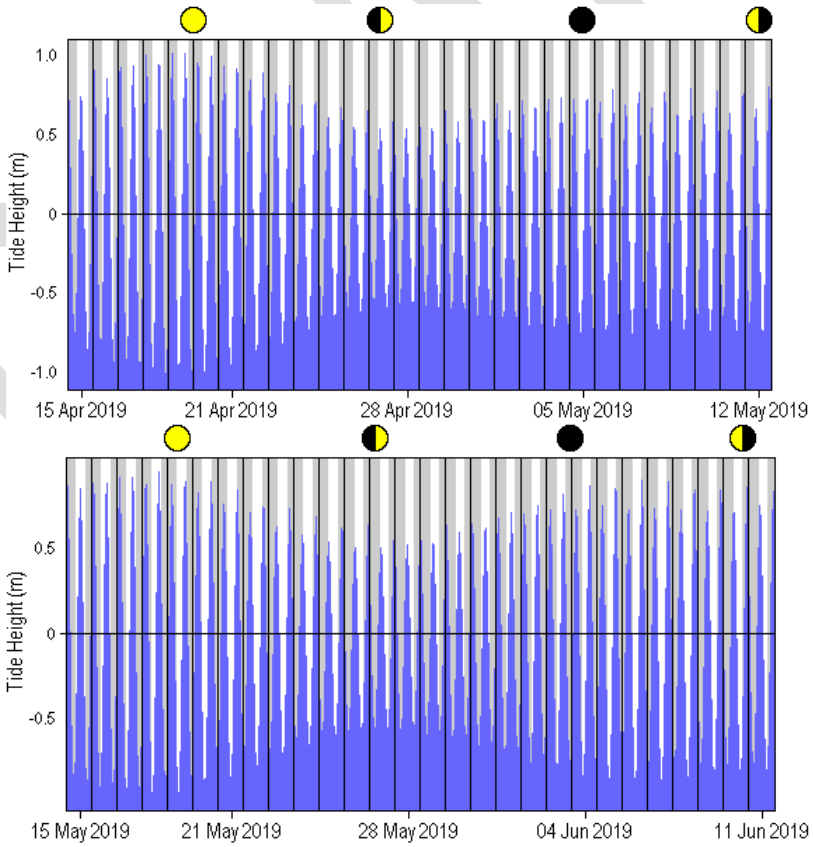


**Figure 2 Tide heights calculated using NIWA's tide forecaster.**

[5] https://www.niwa.co.nz/services/online-services/tide-forecaster

**Egg searches**

Search effort was informed by salinity, tidal effect and habitat type. Once an area was identified as a likely spawning site, generally based on salinity, then searches were undertaken by working along the bank and searching through the base of the vegetation at a probable spawning height. Spawning height is usually judged to be enough that the crowns of the higher tall fescue along the banks are inundated at high tides, in some places it is the roots and this is a subjective judgement based on experience. As the search progresses upstream the vertical proximity to the stream at becomes lower as the tidal amplitude decreases.

Egg masses were measured for where they sat on the bank relative to both the stream depth and height from the stream bed. The length from the bank edge was also measured (where 0 is closest to the river edge). Where spawning was continuous this was also recorded for bank length. A subjective measure of egg density was recorded, sparse, clustered or abundant.

Habitat features where spawning occurred were recorded such as plant species, fencing, stock grazing.

**Tidal amplitude**

Two-metre to one metre stainless steel water level recorders WT-HR 2000, were attached to waratahs and inserted into the stream substrate to measure the semi-diurnal fluctuations in water level with tidal effect. In most streams two recorders were placed a distance apart to capture both the tide height and the tidal extent. The lower recorder giving the tidal height in a spawning area and the upper meter delineating the upstream reach of the tidal push. Water levels were logged every 15 minutes. The data was downloaded using Omnilog software[6] and transferred to excel for analysis. Upstream and downstream hydrographs were synchronised for time and overlain to highlight the relationship between the two amplitudes.

**Saltwater wedge**

Salinity was measured with a YSI EC300 conductivity meter. Salinity measures were generally taken close or on spring tides and as close to high tide as was practicable, to

[6] http://www.trutrack.com/intech/omnilog.html

indicate maximum tidal push. Freshwater is considered to have less than 0.05% dissolved salts (or 0.5 ppt).

**Habitat**

A comparative assessment of catchment scale and development is given to help prioritise restoration effort and provide a basic understanding the adult habitat. The relative proportion of lower gradient in catchments affects the overall amount of adult habitat available since inaka prefer low gradient water. Other issues looked at were passage, which can be impacted by road fords and culverts. The detrimental affect culverts within spawning areas was also noted.

**Community involvement**

I encouraged the involvement of local rūnaka and whitebait fishermen. Emails were sent to the two rūnaka in the area, Moeraki, Puketeraki ki Huirapa whanau. I presented an overview of the work to Roopu Kaitiaki ki Araiteuru and the Komiti Kaupapa Taiao ki Karitane and was accompanied by seven volunteers. I engaged on a student podcast highlighting my aims and the pressures facing whitebait.

# 4. Results

### National Inaka Spawning Database

Twenty-nine records (two were for banded kokopu) across eight locations were recorded for eastern coastal Otago in the National Inaka Spawning Database (accessed 2017, no further work had been submitted to the database).

NZFFD whitebait species records were available for all sites except for the Waiwherowhero and Kuriiti Streams. Inaka were the most common whitebait species sampled (n = 12), followed by banded kokopu (n = 9), koaro (n = 8) and giant kokopu least common (n = 4).

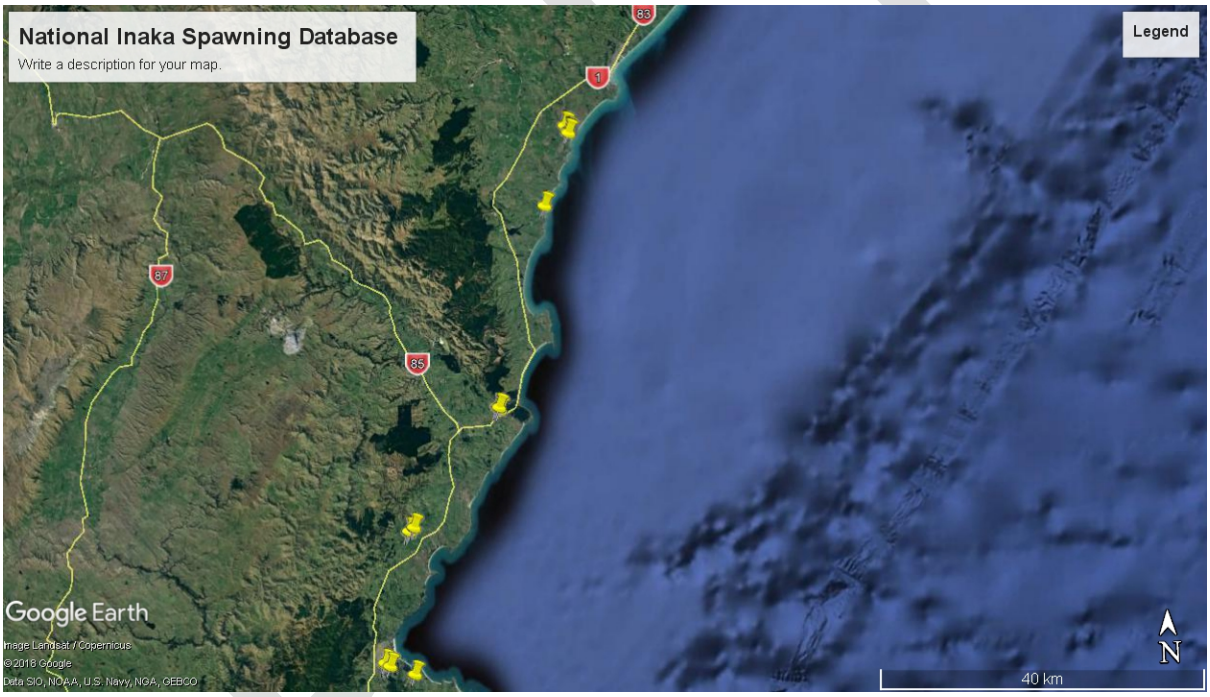


**Figure 3. Results from the National Inaka Spawning Database (yellow icons) across area surveyed 2019.**

### Egg searches

Eggs searches were undertaken at 15 of the 17 sites accessed and located at eight of the 15 (Table 2). Three new stream spawning sites were identified; the Pleasant River, Watkins Creek and Careys Creek, each with a significant inaka population. Expansion of spawning site delineation was achieved in the Waihemo Shag and

Waikouaiti Rivers. In the case of the Waihemo River spawning was identified a further 600 m upstream of that found previously and the newly identified area appears to be the primary spawning location. In the Waikouaiti River spawning was said to not occur upstream of Orbells Bridge, but was subsequently found 300 m upstream of that point. Further spawning sites were found in the Waitati River and Orokonui Stream, where previously there had only been one location in the Waitati River and several in the estuary itself, on near the mouth of Orokonui stream. This survey found spawning in the lower reach of Orokonui Stream for approximately 12 m.

Searches were deferred in the Waianakarua and Kakanui/Waiareka as the river mouths were acting as outflows with no tidal push, diminishing the probability of locating spawning sites. Once the tidal push was re-established a search in the Kakahui A limited bank search was undertaken on the Waianakarua but nothing found. The water level meter shows that there is a very limited but consistent tidal amplitude on the Waianakarua lagoon (approx. 17 mm), however the lagoon is entirely fresh and the signals for where spawning may be occurring muted. In the case of the Waianakarua estuary there is no breaching the beach berm by the tidal wave action indicating the tidal amplitude is occurring from below with hydraulic pressure from the sea.

**Spawning site descriptors**

The majority of eggs were found in clumps of tall fescue, with fewer spawning events found in creeping bent, Yorkshire fog, *Juncus articulatus* and *Eleocharus acuta*. A single observation of spawning in a naturally occurring Phormium tenax. There was very little native habitat, the majority of spawning sites were vegetated in pasture grasses. Spawning did not occur in locations were willows dominated, for example Waihemo Shag upstream of the railway bridge.

**Table 1. Species records from the NZFFD in each of the waterways surveyed (BD and RJC know observation not in the NZFFD.**

| Catchment number | Waterway | NZFFD Records | Galaxias maculatus | Galaxias brevipinnis | Galaxias argenteus | Galaxias fasciatus | Unidentified galaxias |
|---|---|---|---|---|---|---|---|
| 717 | Kakanui River | Yes | Yes | Yes | BD | Yes | |
| 717.01 | Waiareka Stream | Yes | Yes | | | | |
| 720 | Waianakarua River | Yes | Yes | Yes | | | |
| 722 | Kurinui Creek | Yes | | | | | |
| 723 | Kuriiti Creek | No | | | | | |
| | Waiwherowhero | No | | | | | |
| 726 | Shag River | Yes | Yes | Yes | | RJC | Yes |
| 729 | Pleasant River | Yes | | | | | |
| 729.1 | Watkin Creek | Yes | Yes | | | | |
| 731 | Waikouaiti River | Yes | Yes | Yes | | RJC | Yes |
| 733 | Careys Creek | Yes | Yes | Yes | | Yes | Yes |
| 733.5 | Blueskin Bay | Yes | Yes | Yes | Yes | Yes | |
| 734 | Waitati River | Yes | Yes | Yes | Yes | | |
| 734 | Orokonui Estuary | Yes | Yes | Yes | Yes | Yes | Yes |
| 734.5 | Purakaunui Creek | Yes | | | | | |
| 734.5 | Drivers Creek | Yes | Yes | | | Yes | Yes |
| 734.5 | Mabel Creek | Yes | | | | Yes | |
| 734.5 | Whareakeake | Yes | Yes | | | Yes | Yes |

**Table 2. Waterways surveyed 2019 with numbers of water levels in place, salinity records (ppt), number of records in the National Inaka Spawning Database (NISD), fenced, receiving waterbody, egg search undertaken, spawning found, stock access the sites and known impacts on passage.**

| Stream | Water level meters | Salinity ppt | NISD records | Fenced by DOC 1990s | Receiving waterbody | Eggs search | Eggs found | Stock access at spawning site | Passage issue |
|---|---|---|---|---|---|---|---|---|---|
| Waianakarua River | 1 | Yes | 2 | Yes | Waianakarua Estuary | Yes | No | No | No |
| Drivers Creek | | Yes | | | Open coast | No | No | Yes | No |
| Waikouaiti River | 2 | Yes | 7 | | Waikouaiti Estuary | Yes | Yes | Yes | No |
| Kakanui River | | Yes | 2 | Yes | Kakanui Estuary | Yes | Yes | Yes | No |
| Waiareka Creek | 1 | Yes | 4 | Yes | Kakanui Estuary | No | No | No | No |
| Purakaunui Creek | 1 | Yes | 2 | | Purakaunui Estuary | Yes | No | No | No |
| Whareakeake Creek | 1 | Yes | | | Open coast | Yes | No | Yes | No |
| Pleasant River | 2 | Yes | | | Pleasant Estuary | Yes | Yes | Yes | No |
| Waihemo River | 2 | Yes | 9 | | Shag Estuary | Yes | Yes | No | No |
| Alexanders Creek | | Yes | | | Blueskin Bay | Yes | No | No | No |
| Muddy Creek | 1 | Yes | | | Shag Estuary | Yes | No | No | Yes |
| Orokonui Creek | 1 | Yes | 1 | Yes | Blueskin Bay | Yes | Yes | No | No |
| Waitati Creek | 1 | Yes | 2 | | Blueskin Bay | Yes | Yes | No | No |
| Watkins Creek | 1 | Yes | | | Pleasant Estuary | Yes | Yes | Yes | Yes |
| Careys Creek | 2 | Yes | | | Blueskin Bay | Yes | Yes | No | No |
| Waiwherowhero | 1 | No | | | Open coast | No | No | No | Unknown |
| Kuriiti | 2 | Yes | | | Open coast | Yes | No | No | No |
| Kurinui | 2 | Yes | | | Kurinui estuary | Yes | No | No | Yes |

**Figure 4. Flat area of bank with Juncus articulatus where the largest area of eggs was found Waikouaiti 2017.**

**Figure 5. Waikouaiti River clumps of tall fescue were favoured spawning habitat. After floods sands and silts are deposited in the heads of these grasses which render them unsuitable for spawning.**

**Figure 6. Waikouaiti River true left bank to right of photo looking upstream, area below bridge. No spawning occurs.**

**Figure 7. Location of spawning (yellow line) up banks on the Waihemo River 2019.**

## Saltwater wedge

Most of the salinity measures were taken during high spring tides. The most complete sets were taken for the Waihemo, the Waikouaiti, the Pleasant and Waitati Rivers and Careys Creek. Spawning was present at high bottom salinities of (e.g., 29.3 ppt Careys Creek and 28.6 ppt Waitati River). The highest salinity (26.7 ppt) which overlapped with spawning was at Waitati River but most were close to or below freshwater 0.5 ppt (Figure 8).

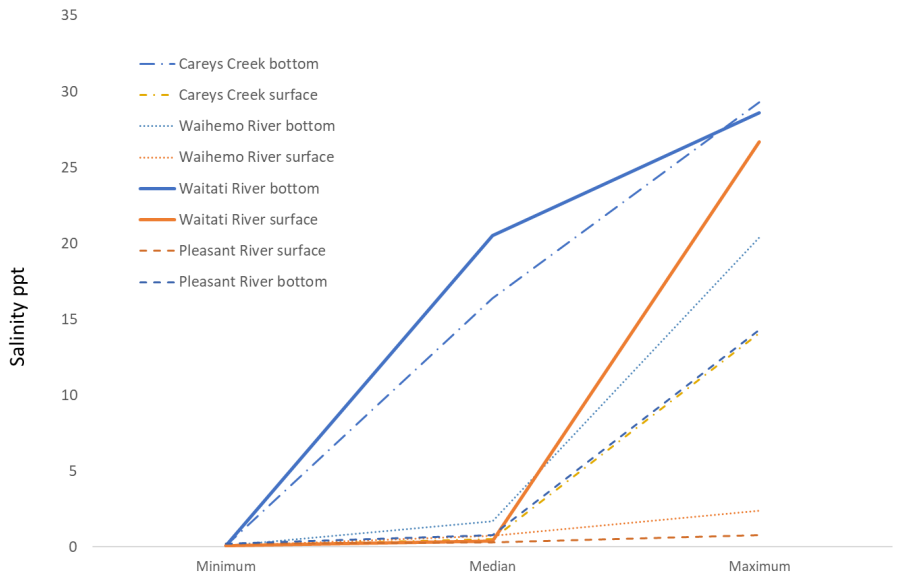


**Figure 8. Salinity Minimums, maximums and medians for the Pleasant River, Careys Creek, the Waitati and Waihemo Rivers.**

## Tidal amplitude

There is a range of tidal effects in the streams surveyed. Whareakeake Creek was a shut off from the sea by the beach berm. The stream itself disappeared into the sands so there was neither and outlet or an inlet. The rivers emptying into the open embayments such as Purakaunui, Blueskin bay, Waikouaiti and Pleasant Estuaries are continuously open and this provides a pronounced tidal push up their channels and spawning areas that are readily demarcated by both the tidal amplitude and the salt water wedge. Depending on the size of the water body these vary from 8 km inland as

with the Waikouaiti River to 550 m in Watkins Creek. The rivers further north empty directly out onto beaches and these are inclined to be blocked by gravel bars. The Waianakarua did not appear to have a tidal push being entirely fresh, however there was a small consistent amplitude of approximately 17 mm detected. Not enough to assist with egg searches.

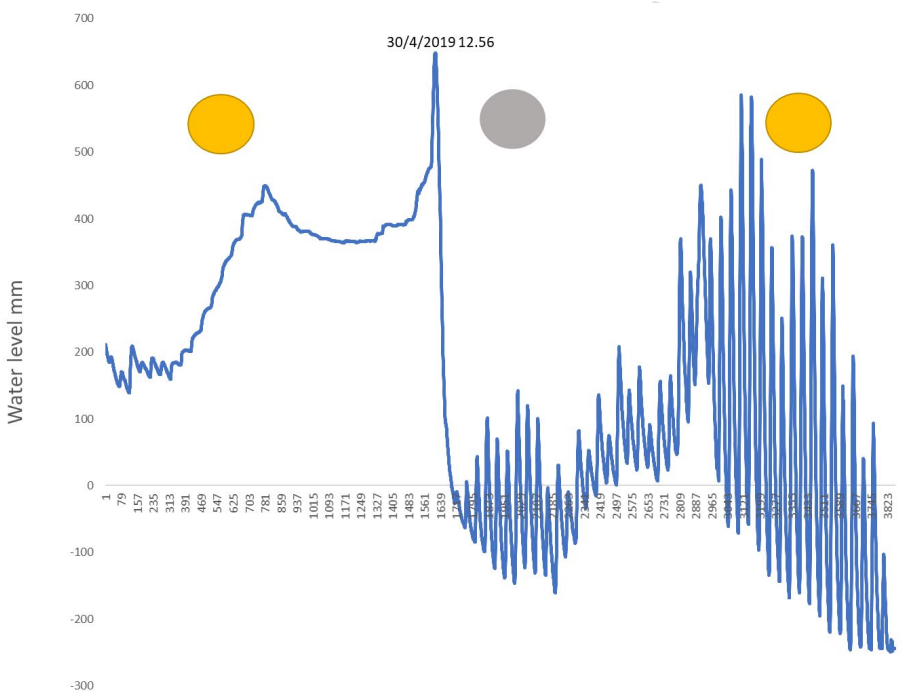


**Figure 9. Water level meter 18/04/2019 - 24/05/2019. Tidal amplitude is present and was measured during the April full moon (19/4/2019) as 17 mm.**

The Kakanui and Waiareka are blocked by a gravel beach berm. On the initial April visit the mouth was blocked. On the second visit (May) the mouth was open (according to a local it is opened by whitebaiters to assist with whitebaiting) and the opening was detected on the water level recorder (Figure 9). On that visit we undertook an egg search on kayaks and found spawning where prior records were recorded. The meter dropped on the 30/4/2019, we took the meter out and searched for eggs on the 23/5/2019 and so saw the results of the May springtide spawning event. It is therefore unknown the extent to which that site was used prior to the tidal amplitude being present. It may be that spawning was delayed or had a search been undertaken they would have been difficult to find given the lack of cues. There was ample spawning in the Kakanui River spawning site, though more focus could occur here to delineate the entire site. The identified spawning site in the Kakanui River is 2

km from the mouth and on the true left runs the 230 km to the confluence with the Waiareka. From the confluence of the Waiareka, spawning runs 1.8 km to the first upstream riffle. More intensive searching would also be necessary in the Waiareka Stream for that to be better delineated, however records show that spawning occurs throughout the Waiareka to 1.8 km upstream. The steep banks and fully fenced nature of the Waiareka Stream means the stream is protected from grazing.

**Fencing and fish passage**

Grazing of riparian margins and impediments to fish passage are the greatest impacts on inaka. Fencing is required on the Watkins and Pleasant spawning areas. These are priorities for any restoration focus. Watkins Creek has had willows removed from the straight channel above SH 1 which is great for reducing sediment accumulation, however replanting is now required. The lower reach of the stream is still in original wetland cover dominated by *Plagianthus divaricatus* and is a remnant of the original cover. This is in private ownership and requires investigation into stock incursions and ongoing protection given there has been a recent change in ownership. The drainage channels of Watkins Creek are long straight grazed channels. The only spawning occurring in the grass along the channels protected by a boundary fence. Fencing and replanting in *Carex spp.* and *Phormium tenax* would improve spawning habitat significantly.

The Pleasant River is unfenced throughout. This stream requires fencing through the mainstrem and along the true left in the spawning area. Cattle were grazing throughout the stream during the survey work and hence throughout the spawning period. The landowner is concerned about flooding across his paddocks and does not want to maintain fences and plantings. The true right of the Pleasant River is fenced and spawning is primarily found on that side. Cattle are coming down and bank and have destabilised the banks so that there is high erosion, slumping and poor vegetative cover. Although cattle are accessing the true left bank and accessing the true right there is still adequate cover for spawning. Removal of cattle from the true left would however improve the habitat quality.

Two culverts were found in Watkins Creek through which are barriers to inaka passage (Figure 10). The road ford at Brooklands Road on the Pleasant River is a possible barrier and requires further assessment, possibly in spring to monitor whether inaka are gathering below and not seen above.

Several other sites are impacted by the presence of road bridges; Alexander Creek and Kuriiti. There is a ford in Muddy Creek which interrupts passage completely, unless under flood conditions.

**Figure 10. Track culvert in Watkins Creek perched above the stream. No passage upstream can occur as the overhanging lip would prevent even most climbing species.**

## *5. Discussion*

The outstanding inaka spawning populations exist in the Waikouaiti River, the Waihemo Shag River, Kakanui Waiareka and the Pleasant River. Except for the later these sites are protected by fencing. Fencing of the Pleasant and the Watkins are a priority.