Sustainable Wild Whitebait Fishery: habitat mapping in the Waimangaroa, Jones Creek and Whareatea catchments

Technical Report · April 2020

CITATIONS
0

READS
60

1 author:

Shane Orchard
University of Canterbury
86 PUBLICATIONS **199** CITATIONS

SEE PROFILE

Sustainable Wild Whitebait Fishery: Habitat mapping in the Waimangaroa, Jones Creek and Whareatea catchments

Shane Orchard

Prepared for

Department of Conservation
West Coast *Tai Poutini* Conservancy
April 2020

WATERLINK

Cover photograph:
View of the Waimangaroa River tributary near Collins Road.
Photo: S. Orchard

Waterlink Ltd
CONSERVATION PLANNING • RESOURCE MANAGEMENT
439 Marine Parade, Christchurch 8062
Aotearoa / New Zealand
T: +64-3-388 8281 | M: +64-21-318548
E: s.orchard@waterlink.nz

Document revision and status

Revision	Date	Status	Approved by	Issued by
v1	14/04/2020	Draft for client review	S. Orchard	S. Orchard
vFinal	29/05/2020	Final	J. Comrie	S. Orchard

Sustainable Wild Whitebait Fishery: Habitat mapping in the Waimangaroa, Jones Creek and Whareatea catchments

Shane Orchard

Prepared for

Department of Conservation
West Coast *Tai Poutini* Conservancy
April 2020

Report WL20032 prepared for Department of Conservation

.

TABLE OF CONTENTS

1. Introduction

This report summarises the results of habitat mapping completed in March 2020 to support the Sustainable Wild Whitebait Fishery (SWWF) Project on the South Island's West Coast.

Surveys of the tidal reaches of three waterway systems were completed as follows:

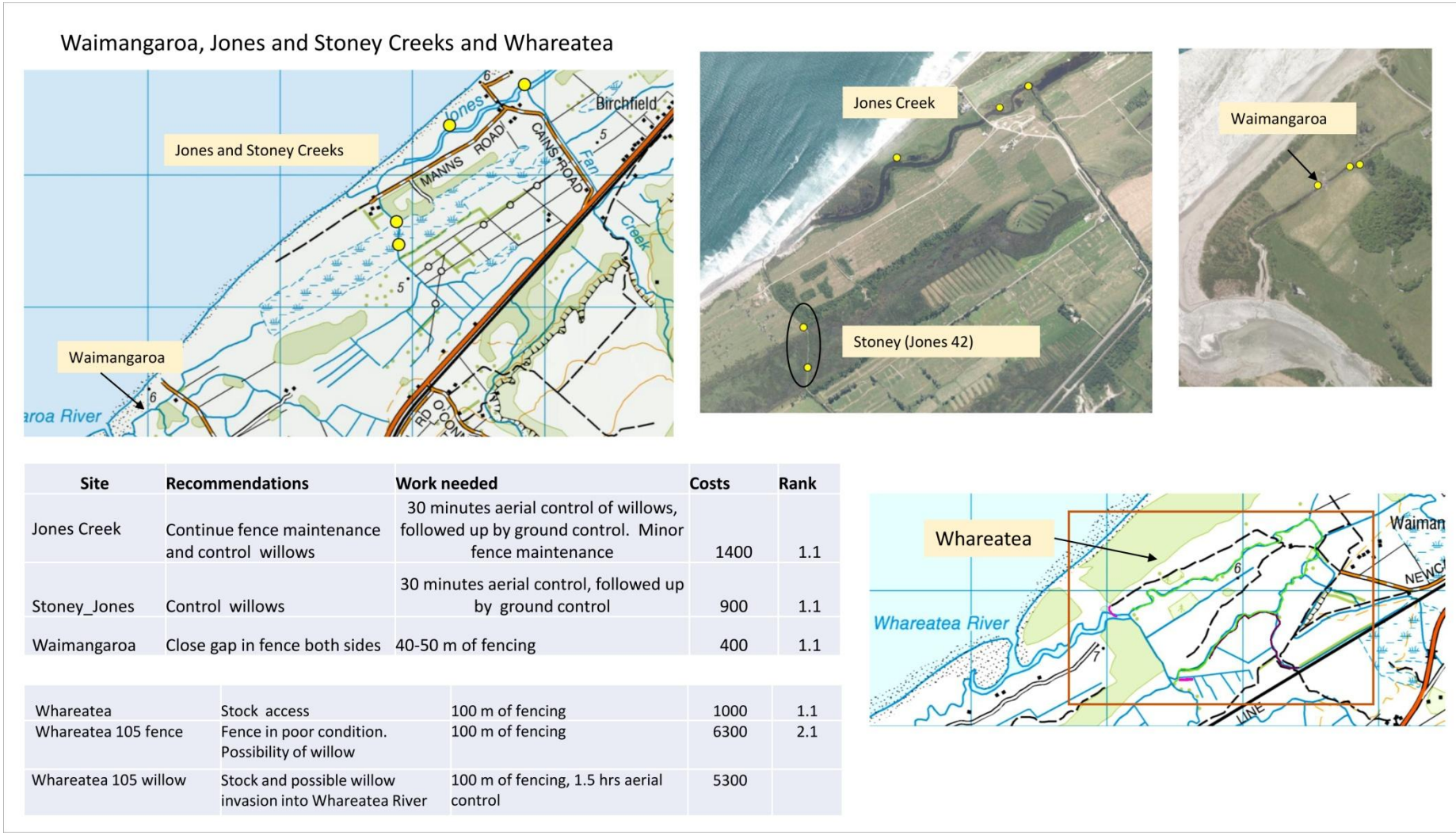
a) the northern tributary stream of the Waimangaroa River from Collins Road to its confluence near the Waimangaroa river mouth.
b) Jones Creek in the vicinity of Cains Road and Stony Creek in the vicinity of Manns Road. Stony Creek currently enters Jones Creek near the mouth of the latter with the confluence located in an active swale on the open beach.
c) two prominent tributaries on the true right of the lower Whareatea River and sections of the mainstem near the confluence of each.

The objectives of each survey included assessment of riparian habitat condition for īnanga spawning using the habitat quality classes of Orchard & Hickford (2018), investigation of potential connectivity barriers for fish movement, and identification of river restoration opportunities that may be beneficial to the whitebait fishery and wider river conservation.

Summary details on the general location of īnanga spawning based on known records, and interventions under consideration for the protection of spawning sites were provided by DOC prior to these surveys (Fig. 1). Information on the latter, including the condition of fencing and distribution of invasive plant species (particularly willow), was also reviewed and updated as an aspect of this project, and recommendations made in view of the above objectives.

The following sections provide results from the īnanga spawning habitat assessment and a set of notes and recommendations based on related observations and information gathered from landowners in the survey areas.

Several site photographs are included in the text and additional photographs are included in Appendices 1 — 3.



Site	Recommendations	Work needed	Costs	Rank
Jones Creek	Continue fence maintenance and control willows	30 minutes aerial control of willows, followed up by ground control. Minor fence maintenance	1400	1.1
Stoney_Jones	Control willows	30 minutes aerial control, followed up by ground control	900	1.1
Waimangaroa	Close gap in fence both sides	40-50 m of fencing	400	1.1
Whareatea	Stock access	100 m of fencing	1000	1.1
Whareatea 105 fence	Fence in poor condition. Possibility of willow	100 m of fencing	6300	2.1
Whareatea 105 willow	Stock and possible willow invasion into Whareatea River	100 m of fencing, 1.5 hrs aerial control	5300	

Fig. 1. Summary information supplied by DOC based on the results of previous surveys. Cross reference numbers refer to information provided by Stengs (2007). Yellow dots show the approximate location of known spawning sites collated from the information provided.

2. Waimangaroa River, Collins Road tributary

2.1 Previous information

Although this sub-catchment is relatively small it may play an important role in the provision of īnanga spawning habitat within the wider Waimangaroa catchment. For example, the following information from Dr. Mike Hickford as reported in Stengs (2007) strongly suggests that this tributary is the major (and perhaps only) location of spawning habitat in the wider catchment:

> *"We have found eggs on several occasions over the last 4 years in the small tributary that enters the Waimangaroa River on the north side of its lagoon. This tributary crosses farmland and has been modified by a mechanical digger. We have found moderately high number of eggs in multiple clumps of fescue along the steep banks of this ditch in the area below the ford. This area of bank is not fenced, but the steepness of the banks makes it unlikely that grazing would occur. We have never found eggs elsewhere in this river despite extensive searching in the main channel and lagoon".*

Since that time no further spawning areas have been found elsewhere in the Waimangaroa catchment.

The main objectives of this survey were to produce updated information on the condition of īnanga spawning habitat, to assess the risks posed by stock damage and to make recommendations on fencing investments if and where required.

2.2 Survey overview

This stream drains a small sub-catchment of the Waimangaroa River located on the coastal plain north of the mainstem. The lower stream occupies an incised channel below Collins Road that originates in a large area of swampland over 5 km further north. There are also several tributary waterways within this catchment, many of which are connected to farm drain networks but also include fast-flowing sections through bush remnants and small tributaries associated with riparian wetlands (Fig. 2).

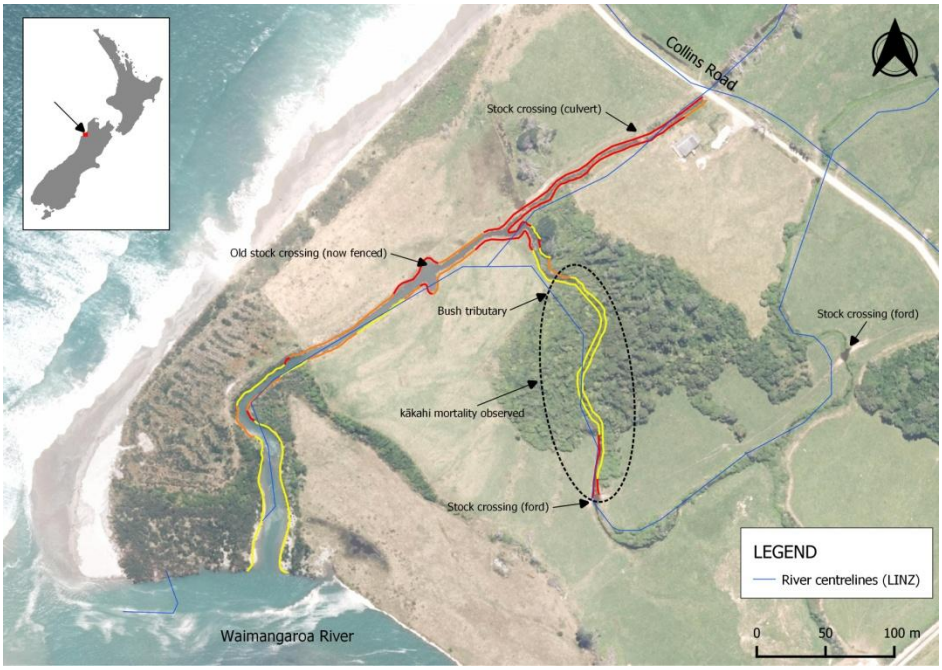
Downstream of Collins Road the stream bank height is ca. 2 m becoming more vertical and/or undercut below its confluence with the bush tributary shown in Fig. 2. Although the waterway is not fully fenced in the vicinity of Collins Road there was no evidence of stock access.

Three active stock crossings were observed:

- a short distance downstream of Collins Road where a farm track crossing is supported by a culvert.
- two open fords on the farm track upstream of the forested section of the bush tributary (Fig. 2a).

An older stock crossing point in the lower stream ('old stock crossing' in Fig. 2a) is no longer used and has been fenced off by the farmer. The fencing here is permanent in nature with no gates present. No obvious fish passage issues were observed in association with the culverts in the study area, though there may be others upstream.

A large number of dead freshwater mussels / kākahi were observed in the bush tributary - both within the waterway channel and scattered throughout the floodplain forest nearby (Fig. 3). Several searches were conducted for living specimens and none found. Although the timing of the mortality event is unknown, monitoring is recommended to establish the severity of impacts and potential for recovery of the population.



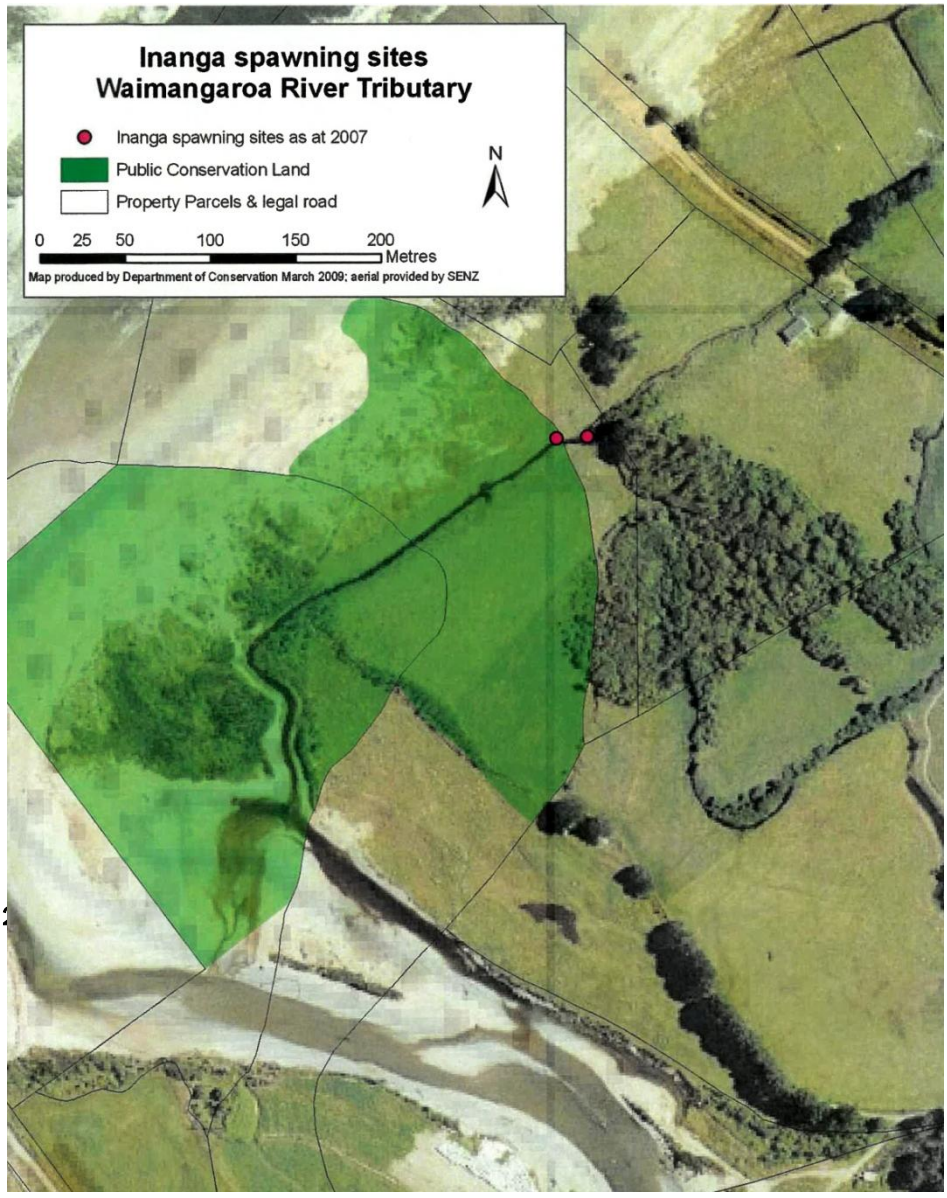


Fig. 2. Overview maps.
(a) recent aerial image showing features mentioned in this report.
(b) 2008 Department of Conservation map showing location of land parcels, Public Conservation Land, and previously recorded īnanga spawning sites.

Fig. 3. (a) large numbers of dead freshwater mussel / kākahi were found in the bush tributary stream. (b) close-up of dead kākahi on the riparian margins of the stream.

2.3 Īnanga spawning habitat

The reach most likely to support spawning was identified with reasonable confidence from field observations (Fig. 4). The best conditions are found in the vicinity of the bush tributary confluence and upstream towards the stock crossing near Collins Road. Suitable vegetation for spawning at the estimated Mean High Water Springs (MHWS) waterline is mainly provided by tall fescue (*Schedonorus arundinaceus*) and creeping bent (*Agrostis stolonifera*). Further downstream the stream banks are mainly vertical in character and largely devoid of vegetation with the exception of *Selliera* turf on some bank faces. These fescue-lined banks have potential to support spawning in high water events but were assessed as being generally unfavourable (habitat quality class 1 or 2) on typical spring tides. Two spawning sites (Fig. 5) were also found at the confluence during the survey, consistent with the above impressions.

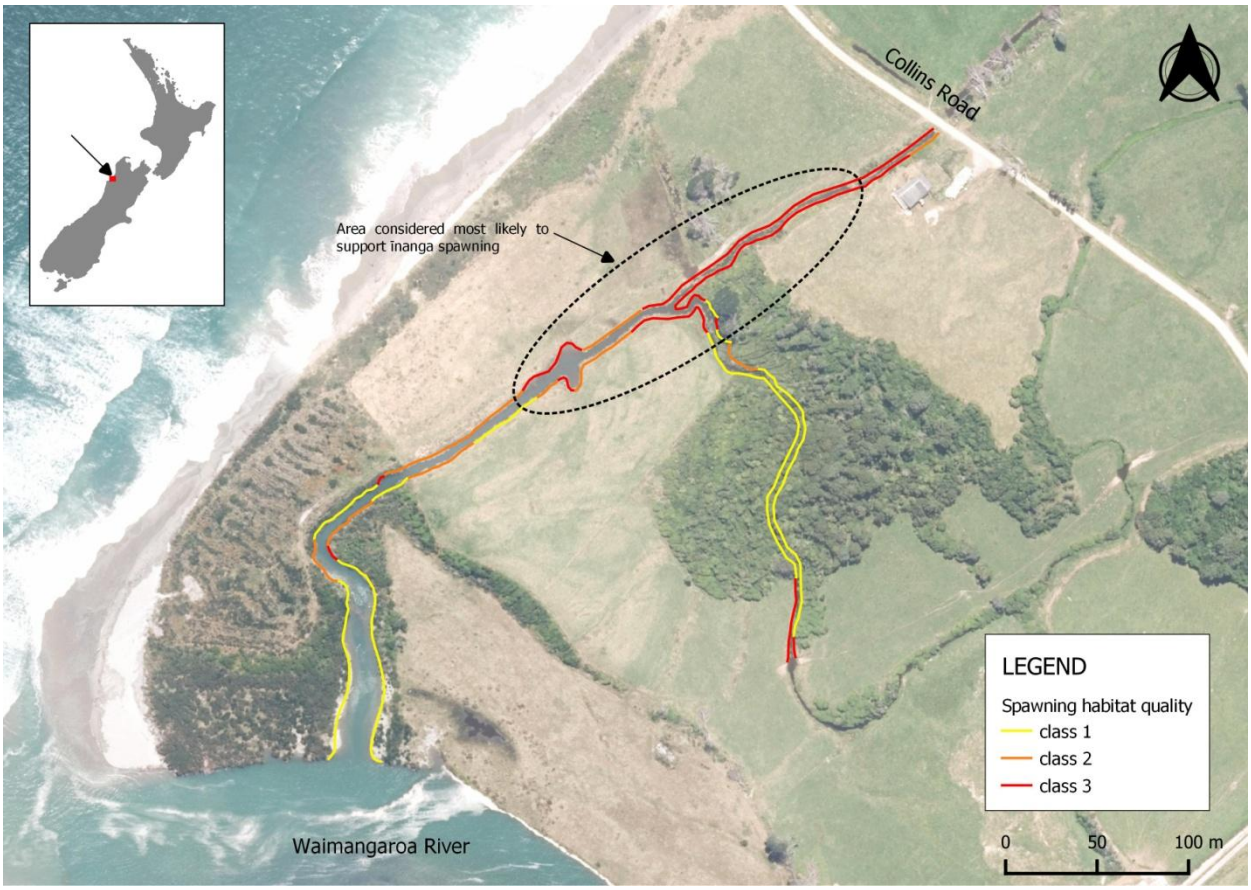


Fig. 4. Results of the īnanga spawning habitat assessment in the Collins Road tributary of the lower Waimangaroa River. High quality habitat is recorded as 'class 3' following Orchard & Hickford (2018).

Fig. 5. Two views of the stream confluence area where two spawning sites were found (arrowed). Both views are looking upstream with the bush tributary on the right.

The key summary points identified from this survey include the following:

Movement / connectivity barriers

- although no hydrological connectivity issues were noted within the survey area, there are a variety of habitats for migratory fish species further upstream, e.g. swamp area to the north, several bush remnants, interconnected farm drains.
- it would be beneficial to evaluate a) distribution, b) population structure, and c) connectivity aspects for migratory fish species in the wider catchment in view of the above habitat types and locations. It is noted that fish species also play a key role in kākahi recruitment and therefore the potential for kākahi recovery at this site (see below).

Īnanga spawning

- no additional fencing is thought necessary to protect īnanga spawning habitat. The old stock crossing point downstream is no longer in use and has been fully fenced.
- monitor potential for stock access from the (unfenced) stock crossing point near Collins Road – however the natural topography of the stream channel is likely to provide sufficient protection.

Kākahi recovery

- monitor recovery of kākahi population.
- ascertain potential role of fish populations in kākahi recruitment, plus the potential for recruitment issues if insufficient adult shellfish have survived.

3. Jones and Stony creeks

3.1 Previous information

The Jones Creek catchment includes an extensive lagoon and wetland system occupying old back-dune swale topography a short distance inland from the present-day coast (Fig. 1). Fan Creek is a prominent tributary that flows alongside Cains Road and originates from steep bush-clad terrain on the lower slopes of Mt Frederick.

Stony Creek originates from similar headwater catchments to the south in the vicinity of the Old Britannia Gold Mine. The lower reaches of Stony Creek have been heavily channelised downstream of State Highway 67 where the former stream channel is now connected to an extensive series of farm drainage channels associated with hump and hollowing. Additionally, the stream passes through a large area of harakeke flax swamp enroute to the sea (Fig. 1). However, the swamp connections have been modified by an embankment that has likely been constructed to improve the upland drainage capacity of the stream. Although these features were mostly outside of the area covered in the present survey, hydrological connectivity between the stream and swamp habitats was severely limited in the areas observed.

Previously reported spawning sites in this area include three sites in Jones Creek as detailed in Stengs (2007), and two in Stony Creek (Fig. 1) The sites in Jones Creek comprise of two locations on Public Conservation Land upstream of Cains Road, and another 500 m downstream adjacent to an area of farm land, all on the true right (Fig. 6). An area of crack willow (*Salix fragilis*) is present in the riparian wetland upstream of Cains Road on the true right. Another infestation is present in the vicinity of the upstream spawning site in Stony Creek (Fig. 6).

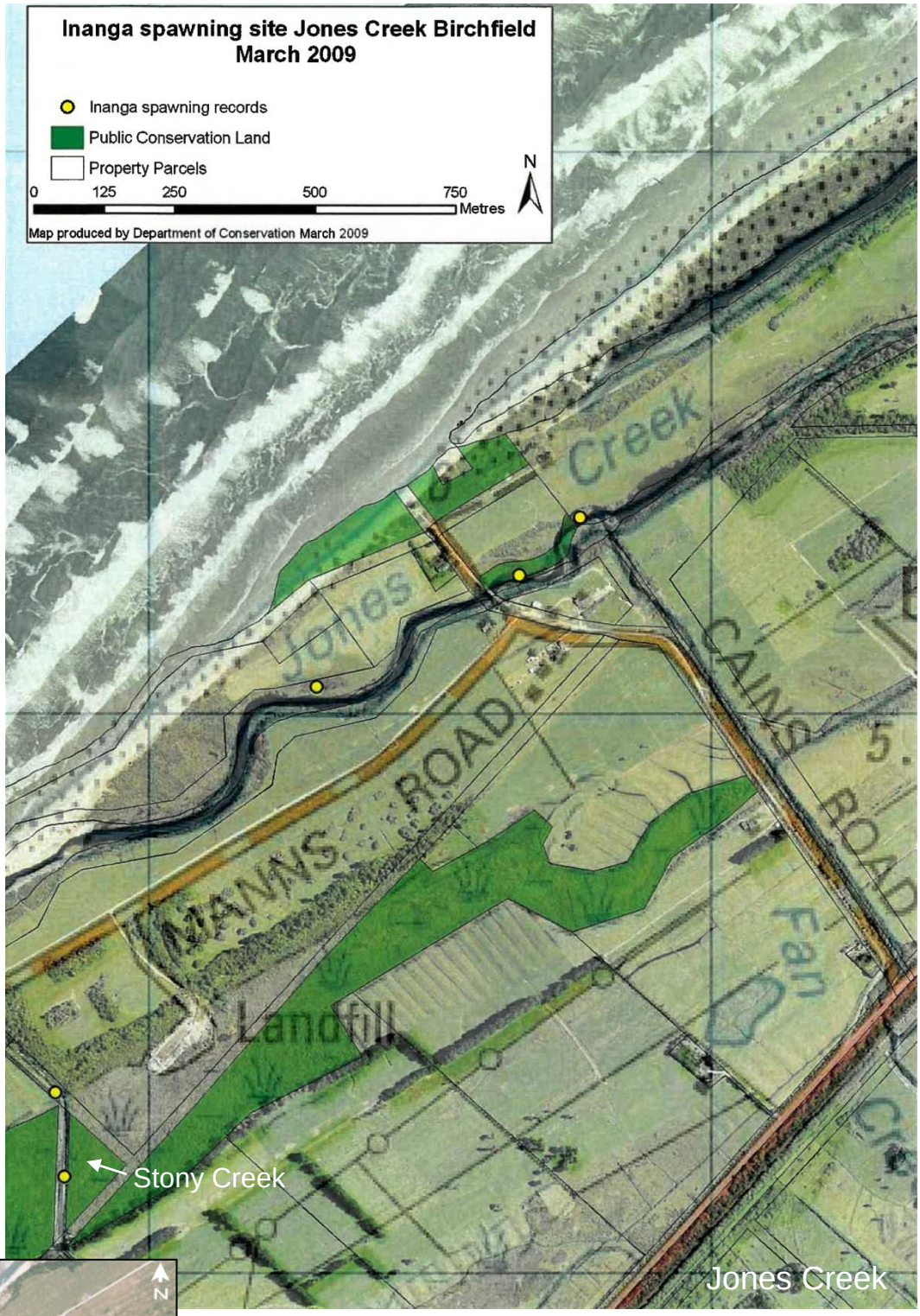
The main objectives of this survey were to produce updated information on the condition of īnanga spawning habitat, and to assess the merits of undertaking willow control to support objectives of the SWWF.

3.2 Survey overview

Due to the extensive area of potential interest in the Jones Creek catchment, the survey area was restricted to the vicinity of Cains Road and with a focus on assessing habitat conditions in the reach where spawning has been previously recorded. Throughout this area there were no obvious signs of stock damage and the riparian margins were in generally good condition in terms of vegetation cover.

Assessment of the crack willow infestation above Cains Road (Fig. 7) showed that a considerable die-off of trees has occurred naturally. Information received from the landowner provided useful on these events which were observed to occur shortly after the Cyclone Fehi storm and may be associated with salinity effects. Very high water levels and tidal surges were observed in Jones Creek at that time. Currently, many of the willows are in the early stages of resprouting.

In Stony Creek, the survey area extended from the confluence of Jones Creek (which is currently located on the open coast beach) to the furthest upstream of the two previously reported īnanga spawning sites. Above the Manns Road culvert the banks are typically steep with extensive blackberry patches on the true left adjacent to the farmland area (Fig 8a). The previously reported willow infestation is located further upstream adjacent to the flax swamp and consists mostly of a line of willows on the stream margins (Fig. 8b).



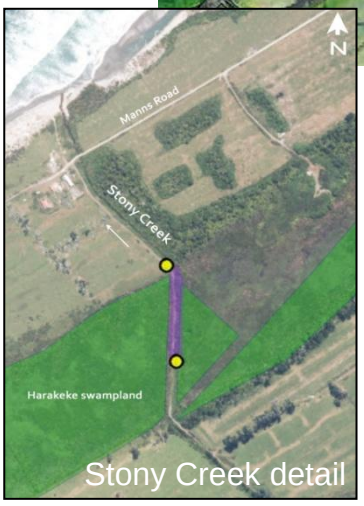


Fig. 6. 2009 Department of Conservation maps showing location of Public Conservation Land, and previously recorded īnanga spawning sites at Jones and Stony creeks. Yellow dots show the approximate location of previously reported spawning sites. Purple shading in Stony Creek denotes an area of willow control completed March 2019.

Fig. 7. Two views of the area of crack willow (*Salix fragilis*) infestation upstream of Cains Road on the true right.

Fig. 8. Two views of the lower reaches of Stony Creek. (a) the reach upstream of Manns Road is heavily channelised with abundant blackberry (*Rubis fruticosus*) patches on the true left bank. This view is looking downstream from a small clearing. (b) typical view of the section adjacent to a large area of flax swamp (to the right of the frame) showing crack willow (*Salix fragilis*) trees lining the waterway. The grassed area is an embankment. The location of a previously reported spawning site is in this vicinity.

3.3 Īnanga spawning habitat

Jones Creek

There are extensive areas of riparian vegetation suitable for īnanga spawning in Jones Creek, particularly on the true right bank (Fig. 9). These include tall fescue dominated sections adjacent to farm land but also riparian wetland areas that support a high diversity of other species. One of the previously reported spawning sites is located within an extensive area of tidal wetland upstream of Cains Road (shown in Fig. 9) and there is an abundance of high quality habitat in this vicinity. Habitat quality was mostly poor on the true left bank within the area surveyed due to the presence of limited vegetation cover on the bank faces at the estimation position of MHWS. Despite this there is well established vegetation cover on the adjacent terrace (for example, dense flax and scrub cover downstream of Cains Road). However, there may be other areas of suitable habitat beyond the area covered in this survey including on the true left further downstream. There is also a large area of potentially suitable habitat upstream of the Fan Creek confluence although it is difficult to estimate its contribution without further information on the upstream extent of tidal influence.

Overall, there is an abundance of high quality habitat within Jones Creek catchment and there is likely to be considerable spawning activity within the area as a whole. However, the relative importance of specific locations

within this area is difficult to ascertain at the present point in time. The considerable distance between the three previously reported spawning sites is broadly consistent with this interpretation.

The most useful further information is considered to be:

i) establishing the upstream and downstream extent of spawning, and

ii) spawning area and egg production data that would help to identify the areas that support the bulk of spawning activity.

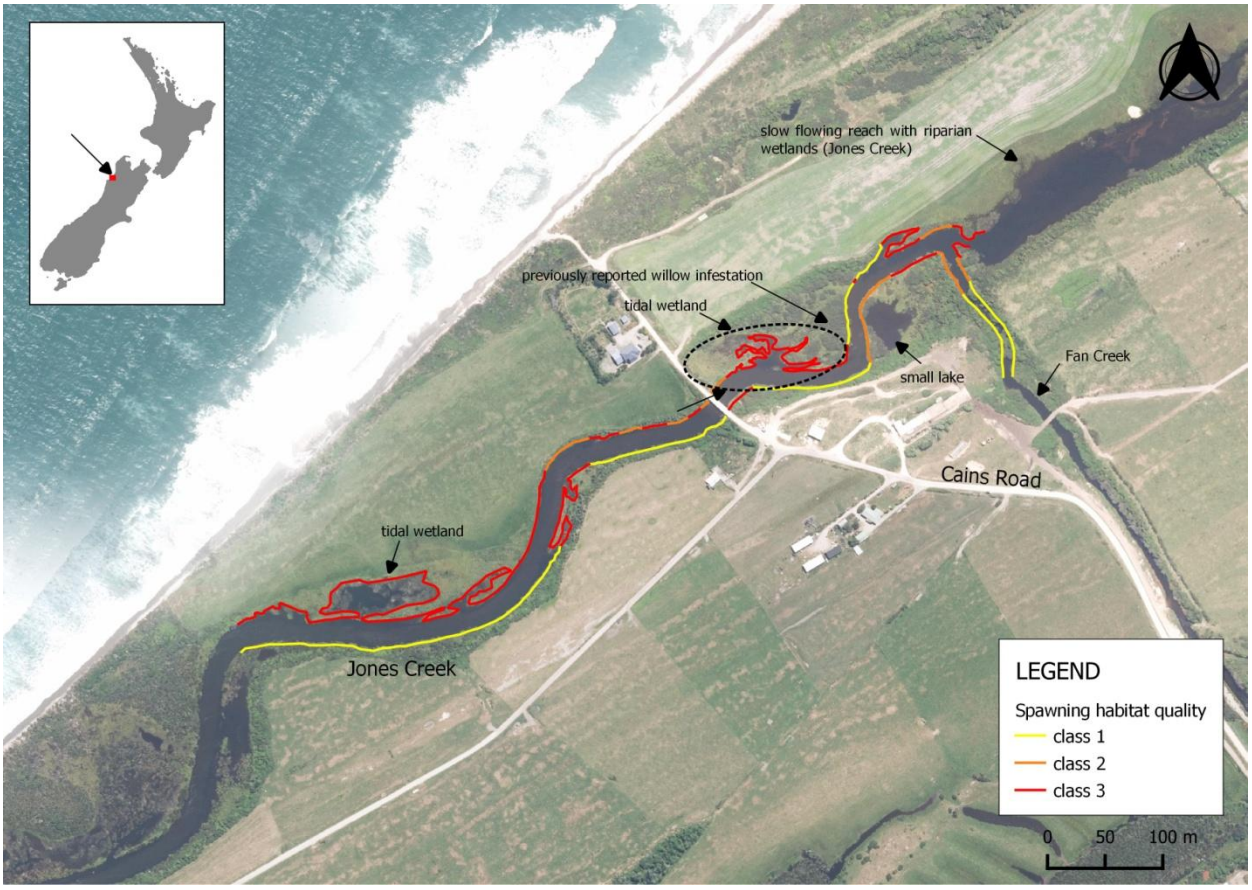


Fig. 9. Aerial view of Jones Creek in the vicinity of Cains Road showing key features and the results of the īnanga spawning habitat assessment. Note that there are additional areas that may provide suitable habitat for īnanga spawning both upstream and downstream of the area covered in this survey.

Stony Creek

High quality īnanga spawning habitat is found in the relatively short section of waterway between the Manns Road culvert and the open beach. There are also a few additional patches of suitable spawning habitat interspersed with flaxes on the true right of the stream as it meanders across the open beach towards its confluence with Jones Creek (Fig. 10).

Due to the relatively limited extent of the areas that were thought to provide the most likely spawning locations, all of the above were searched systematically for eggs following Orchard & Hickford (2018). However, none were found, and this was an unexpected result. No adult īnanga were observed anywhere in the waterway despite the presence of suitable fish habitat and good water clarity at the time. Additionally, the stream environment at the location of the previously reported spawning sites (Fig. 6) is not typical of īnanga spawning habitat in tidal streams. This section of the stream appears to be well above the reach of the tide as judged by observation of the overall gradient and stream flow. Potential explanations include that Jones Creek is a more favourable environment for īnanga, though their absence from Stony Creek would appear unusual.

Information received from the landowner, representing decades of whitebaiting experience in Stony Creek, highlights further interesting aspects. He reports that the whitebait typical of Stony Creek are a different species than those found in Jones Creek. Together, these observations suggest that Stony Creek may be particularly important for other whitebait species such as *G. fasciatus* and *G. argenteus*, and further information-gathering to address these aspects is recommended.

In the reach upstream of Manns Road, the crack willow infestation (subject to control work in March 2019) was considered to pose little risk to īnanga spawning habitat, partly as a result of the above observations (Fig. 11a). Some re-sprouting was observed. There is an abundance of indigenous biodiversity in close proximity to these willows, and therefore ground-based methods would be preferred for any follow-up control work. A lack of hydrological connectivity between the stream and large flax swamp (Fig. 11b) was also noted in this vicinity. Information provided by the landowner suggested that connections may be present further upstream. Establishing the current status of these is recommended for potential relevance to objectives of the SWWF.

Fig. 10. Two views of Stony Creek from the point at which it emerges onto the open coast beach. (a) looking north towards its confluence with Jones Creek. (b) looking upstream towards the Manns Road culvert. This area is considered to be the most likely location of īnanga spawning in the Stony Creek catchment.

Fig. 11. Two views of Stony Creek near the upstream limit of the area surveyed in this project. (a) typical view of the crack willow (*Salix fragilis*) infestation in the Stony Creek channel showing close proximity of indigenous vegetation. The grassed area to the right is an embankment that separates Stony Creek from an extensive area of flax swampland (looking upstream). (b) view of the boundary drain between farm land and the large flax swamp (looking southwest) taken from the embankment beside Stony Creek.

4. Whareatea River tributaries

4.1 Previous information

The survey area for this project was restricted to two prominent waterways based on information provided by DOC (Fig. 12).

The best known spawning site within the survey area was identified by Sutherland (undated) at a farm drain confluence with Rapid Creek, a short distance upstream from the Rapid Creek – Whareatea confluence (Figs. 12 and 13). A second spawning site has been recorded in the Whareatea mainstem further downstream based on observations of spawning activity by the landowner (Stengs 2007). This location is characterised by a tidal saltmarsh and small side channel that connects with a drainage swale in the adjacent farmland (Fig. 14). There is a short unfenced section of riverbank at this point that currently allows stock access to the saltmarsh, though there were no obvious signs of stock damage at the time of the field survey.

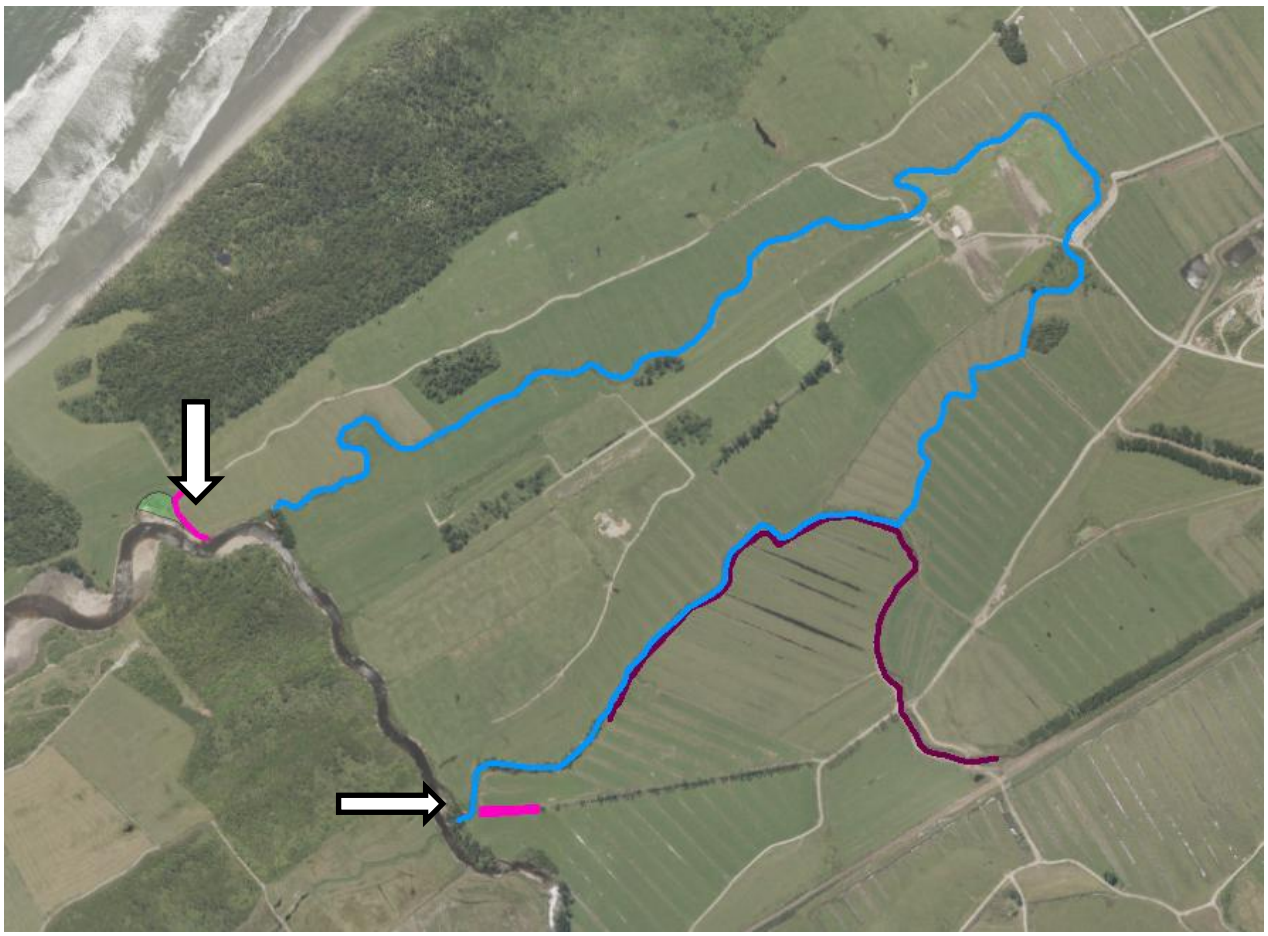


Fig. 14. Location of the Whareatea River tributaries that were identified for this survey (blue lines). The pink lines (arrowed) show locations of the two previously reported īnanga spawning sites. The approximate extent of crack willow recorded in Rapid Creek is shown by the purple line. Information and diagram supplied by Henk Stengs, Department of Conservation.

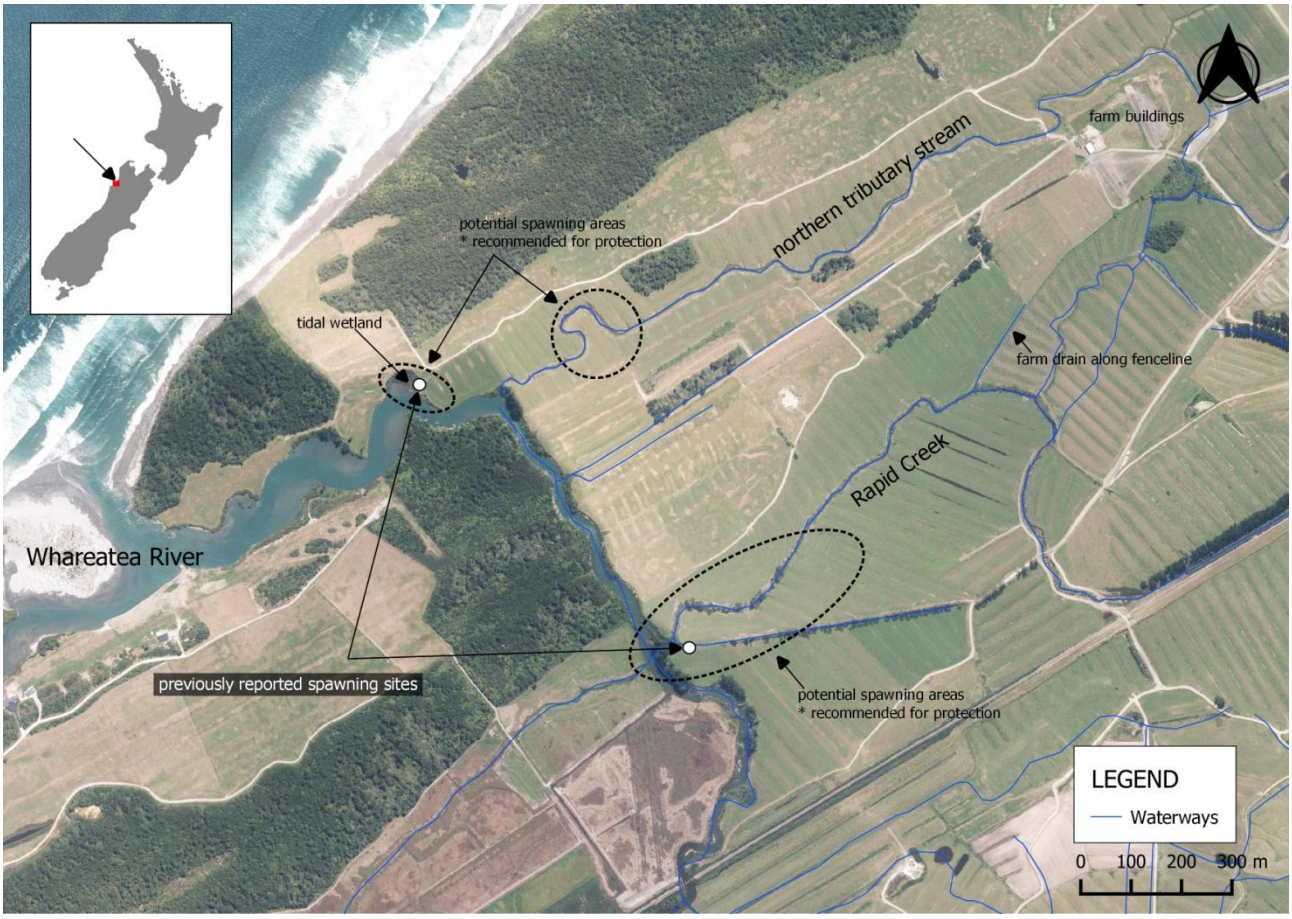


Fig. 13. Overview of the Whareatea survey area showing key features mentioned in this report.

Fig. 14. Two views of tidal wetland on the true right of the Whareatea mainstem where spawning activity was reported by Stengs (2007). (a) view of the saltmarsh area looking upstream with location of the tidal channel and stock access point arrowed. (b) short tidal channel located at the back of the wetland.

4.2 Survey overview

The study area is characterised by a complex network of lowland waterways. Many of these turn back on themselves through prominent meanders across the lowland plains with dairy farming being the prevalent land use. Most of the stream channels are incised with steep banks except at intersections with drainage swales that are typically associated with low points in the stream banks. These are relatively commonplace in areas with hump

and hollowing. However, there are relatively few places where there has been obvious stock access to waterways even in unfenced areas. Small riparian wetlands are found scattered throughout the area in addition to several bush remnants.

The 'northern tributary stream' (shown in Fig. 13) drains an area of relatively open farmland that is generally characterised by narrow riparian strips featuring gorse and scattered *Carex* with a mixture of fenced and unfenced sections (Fig. 15). Rapid Stream drains a network of sub-catchments originating on the Denniston Plateau and foothill terraces. In many places the riparian margins support overhanging vegetation cover and regenerating forest (Fig. 16).

No obvious fish passage issues were observed in association with these waterways. However, there are few culverts and active stock crossing points within the survey area.

Fig. 15. Two views of northern tributary stream a short distance from the farm buildings shown in Fig. 12.

Fig. 16. Two views of Rapid Creek within the survey area showing typical riparian vegetation.

4.3 Īnanga spawning habitat

Relatively well defined sections were identified as potential īnanga spawning habitat in both waterways (Fig. 17). However, the upstream extent of tidal influence was difficult to determine with confidence during the field survey and therefore the upstream limits of the areas mapped for spawning habitat quality in Fig. 17 are somewhat imprecise. In both waterways, high quality spawning habitat is provided by pasture grasses and *Carex*. Many of these locations are unfenced low spots on the stream banks.

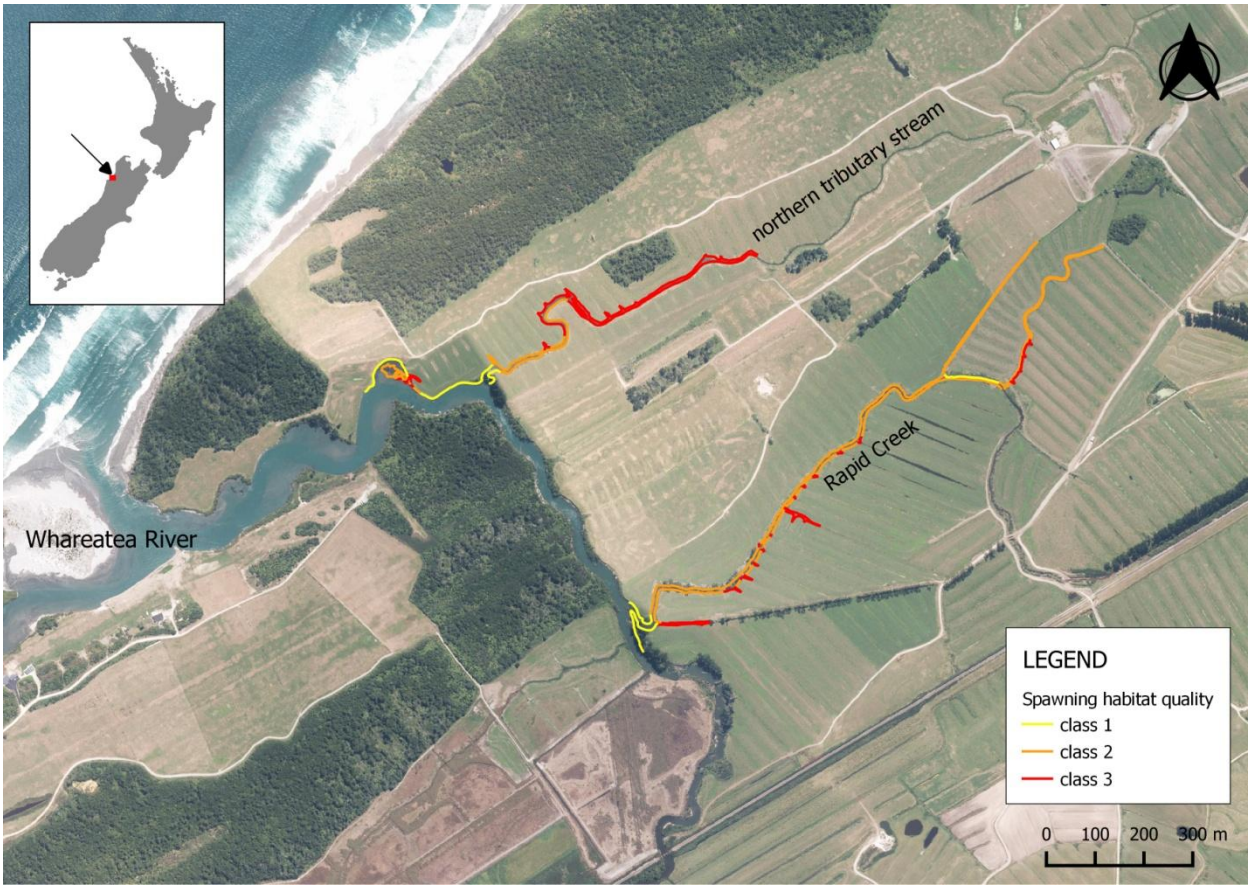


Fig. 17. Aerial view of the Whareatea survey area showing results of the īnanga spawning habitat assessment.

Northern tributary stream

Overall, there is an abundance of high quality spawning habitat in this waterway, primarily provided by tall fescue and creeping bent. There is a considerable area of high quality spawning habitat that is situated on a prominent bend within the area of tidal influence (Fig. 18). Although actual spawning in this location is yet to be unconfirmed it is considered to be highly likely. This area is recommended for further investigation with a view to establishing a potential intervention such as a protected area under the auspices of the SWWF. Downstream of this area the lower stream (near the Whareatea confluence) is characterised by high banks that are often undercut with sparse vegetation in the vicinity of the high tide waterline (Fig. 19).

The most important next steps are considered to be:

i) confirming the nature of spawning activity (if any) this site, including the upstream and downstream extent of spawning if possible.

ii) discussing options for a collaborative project with the local landowner. The key protection mechanism involves fencing as the area is open to stock access. However, stock damage was not observed at the time of the field survey and as a result the riparian vegetation is currently in good condition. In this

case fencing of the site appears to be relatively straightforward and the primary objective would be to isolate tidally inundated area from the adjacent farmland (Fig. 18).

Fig. 18. (a) Approximate location the area of potential spawning habitat that is recommended for further investigation. (b) view looking upstream from point A showing the boundary with farmland. A few old fence posts are present in this vicinity though no fencelines are currently in place. (c) view looking downstream from point B.

Fig. 19. The lower section of the northern tributary stream a short distance upstream from the Whareatea confluence showing typically steep banks within the tidal range.

The saltmarsh in the Whareatea mainstem further downstream also provides high quality spawning habitat though it is expected to be of less importance than the area detailed above. Further investigations there should focus on landowner preferences for fencing the stock access point, which could include the small tidal channel that connects with a drainage swale in the adjacent paddock. The orientation of these features is shown in (Fig. 20).

Fig. 20. Orientation of a small tidal channel (circled) that enters farmland behind a saltmarsh area on the true right of the lower Whareatea**.**

Rapid Creek

Several discrete areas of high quality īnanga spawning habitat were identified on the true left bank. Most of these are located at the confluences of drainage swales (Fig. 21). In some cases the swale itself is likely to support spawning depending in inundation levels. In addition to the prominent drain where spawning has been previously recorded, most of drain confluences upstream for over 500 m have the potential to support īnanga spawning. There are also few small sections of bank and bank slumps that may support spawning elsewhere in Rapid Creek (including on the true right). However, most of the stream bank is relatively steep with sparse vegetation within the range of tidal inundation. As a consequence, the drain confluences are considered to be the most important locations and they have the potential to support substantial spawning activity (though noting that this is also dependant on the size of the fish population and degree of movement within the Whareatea system as a whole).

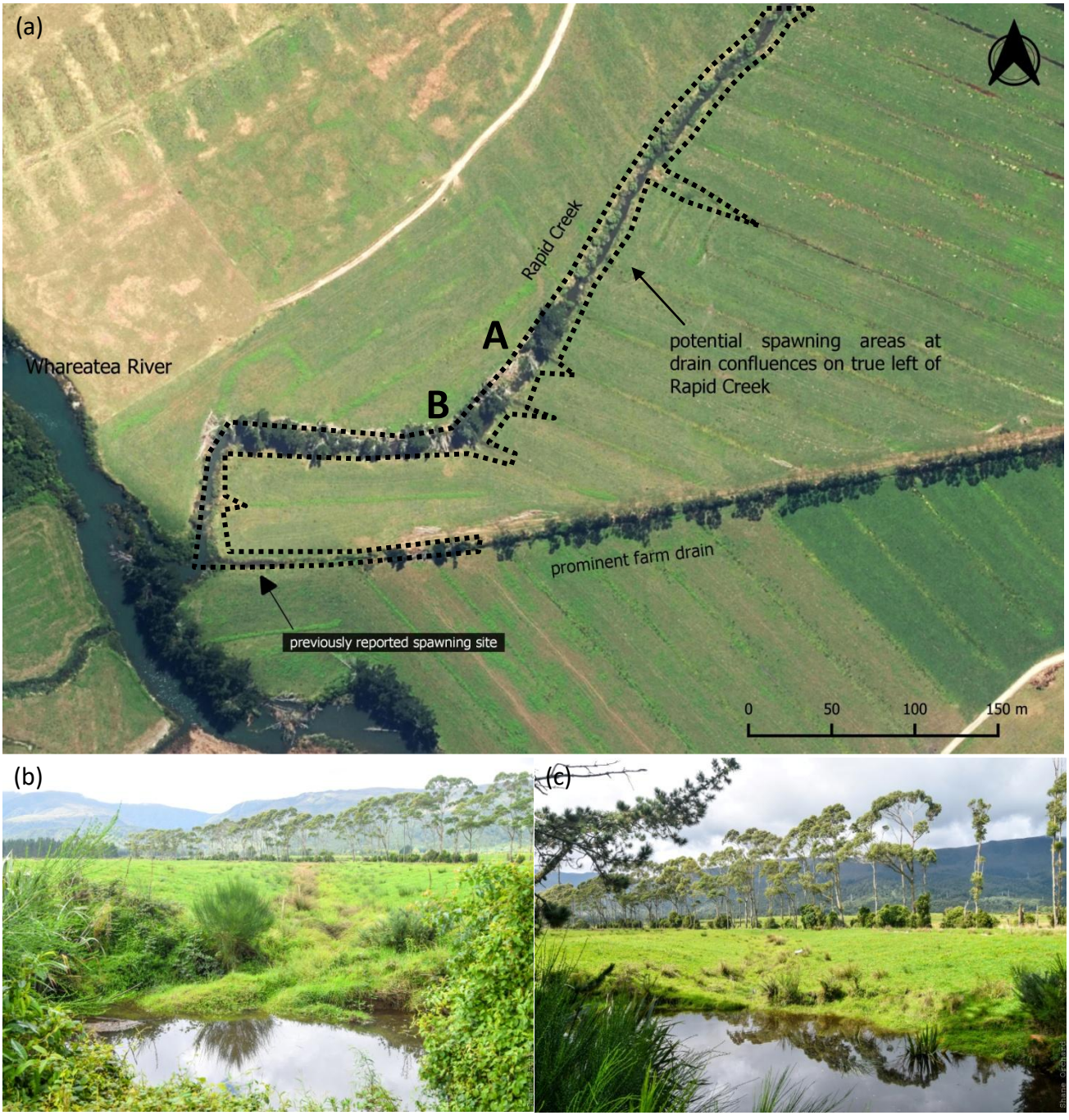


Fig. 21. (a) Location the area of potential spawning habitat that is recommended for further investigation in lower Rapid Creek. (b) view looking across Rapid Creek from point A showing on the drain confluences. (c) view of the drain confluence opposite point B.

The most important next steps for progress a SWWF project in this section of Rapid Creek are similar to the recommendations made for the northern tributary stream. They include:

i) updating and improving knowledge of spawning activity at these locations, including determining the upstream and downstream extent of spawning in Rapid Creek, number of tidal side channels involved, and their relative importance.

ii) discussing options for a collaborative project with the local landowner. The key protection mechanism involves fencing to isolate tidally inundated areas from adjacent farmland. This could potentially take the form of several small protected areas at the confluences of the drainage channels and for variable distances upstream. In many places these may be effective without the need for additional fencing along the Rapid Creek bank due to the presence of steep banks that create natural barriers to stock access.

The previously reported crack willow infestation is considered to pose little risk to the abovementioned areas of potential spawning habitat. In general, the willow trees present are scattered amongst other woody riparian vegetation that is providing shade and overhanging cover in the stream. However ground-based control would be relatively easy to achieve as there is only a modest number of willow trees current presently in this area (approximately 35 mature trees).

5. Conclusions

The habitat surveys completed in this project have been informative in various ways. Key recommendations for SWWF to consider in each of the survey areas may be summarised as follows:

Waimangaroa

- monitor current fencing provision, especially those relying on hotwires or where fencing is not present.
- confirm the upstream limit of īnanga spawning, as this has an important interaction with the above.
- assess hydrologic connectivity and potential migration barriers higher in the catchment.

Jones Creek

- confirm the upstream and downstream limits of īnanga spawning to help guide decisions on riparian spawning.
- monitor regrowth of the previously reported crack willow infestation. Although control is thought unnecessary for the purposes of whitebait conservation (due to the abundance of riparian habitat elsewhere), control may be desirable for other biodiversity objectives.
- assess hydrologic connectivity and potential migration barriers higher in the catchment.

Stony Creek

- gather further information to explain the apparent absence of īnanga spawning in this waterway.
- investigate the apparent discrepancy between the location of previously reported spawning sites and local knowledge that suggests this waterway may be of particular importance for other (non-īnanga) whitebait species.
- assess hydrologic connectivity and potential migration barriers higher in the catchment, with a particular focus on fish access to the extensive areas of potential habitat provided by wetlands in this area.
- avoid willow control in the affected reach for the time being, pending outcomes of the above.

Whareatea

- initiate collaborative work with the landowner to establish protection for īnanga spawning habitat in the two priority locations identified. Conduct more detailed surveys of these areas to improve understanding of the areas actually utilised and the relative importance of each.

- consider extending protection to saltmarsh site on the Whareatea mainstem. Although this site is thought to be less important than the above for provision of īnanga spawning habitat, stock are able to freely access the estuary through gaps in the fenceline at present.
- willow control work is not expected to enhance the quality of spawning habitat in the areas surveyed. However, the modest number of individual trees present suggests that ground-based control would be relatively easy to achieve and is recommended.

Finally, the process of scoping, delineating and completing the survey programme has highlighted the potential benefits of taking a more catchment-based approach in future investigations to support the SWWF.

For example:

- in the Waimangaroa survey area, riparian management was generally good in the lower reaches of the two major waterways and there were no obvious barriers of concern for migratory species. However, stock access to the waterways was observed further upstream.. Applying a wider catchment approach within the scope of the SWWF could involve extending the survey extent to assess habitat degradation and connectivity issues in all of the major areas of adult fish habitat. In this case, there is an extensive network of small streams, wetlands, and interconnected farm drains higher in the catchment. Following up on leads that may produce useful information for the conservation of non-īnanga species is also recommended.
- similarly, at Jones Creek, the dimensions of the area of potential interest suggest that a coarse-scale assessment that considers the wider catchment may offer the most effective approach for identifying potential issues. In general, there was little evidence to indicate the need for whitebait conservation interventions in the area surveyed.
- in Stony Creek, high quality īnanga spawning habitat was present but other issues came into focus through observations made in the field survey and information received from the landowner covering aspects of both the local fishery and landscape. These suggested that an expanded focus might be warranted that is further borne out by failure to find īnanga spawning in the locations expected, uncertainties in relation to the previously reported spawning sites, and the status of hydrological connections further upstream. Overall, these results suggest the presence of information gaps that are currently unresolved and yet are likely to be of relevance to whitebait conservation in the catchment.
- the Whareatea survey was successful in reviewing and updating previous assessments of riparian condition from which several specific recommendations could made. Although these are expected to result in conservation gains for īnanga spawning habitat, further investigations would be needed to establish their relative importance. Additionally, there is an extensive network of other waterways in the wider catchment creating the opportunity to take a wider view of potential issues for whitebait conservation and prioritise interventions accordingly.

6. References

Orchard, S., & Hickford, M. J. H. (2018). Census survey approach to quantifying īnanga spawning habitat for conservation and management. *New Zealand Journal of Marine and Freshwater Research, 52*(2), 284-294. doi:10.1080/00288330.2017.1392990.

Stengs, H. (2007). *West Coast Tai Poutini conservancy inanga spawning site assessments with recommendations for restoration and protection*. Greymouth: Department of Conservation. 256 pp.

Sutherland, D. (undated). *Review of the West Coast whitebait fishery*. Report prepared for the Department of Conservation, Hokitika.

Appendix 1. Additional site photographs, Waimangaroa River tributaries near Collins Road.

Fig. A1.1 Two views of the tributary downstream of Collins Road (a) looking upstream from the stock crossing culvert. (b) looking downstream.

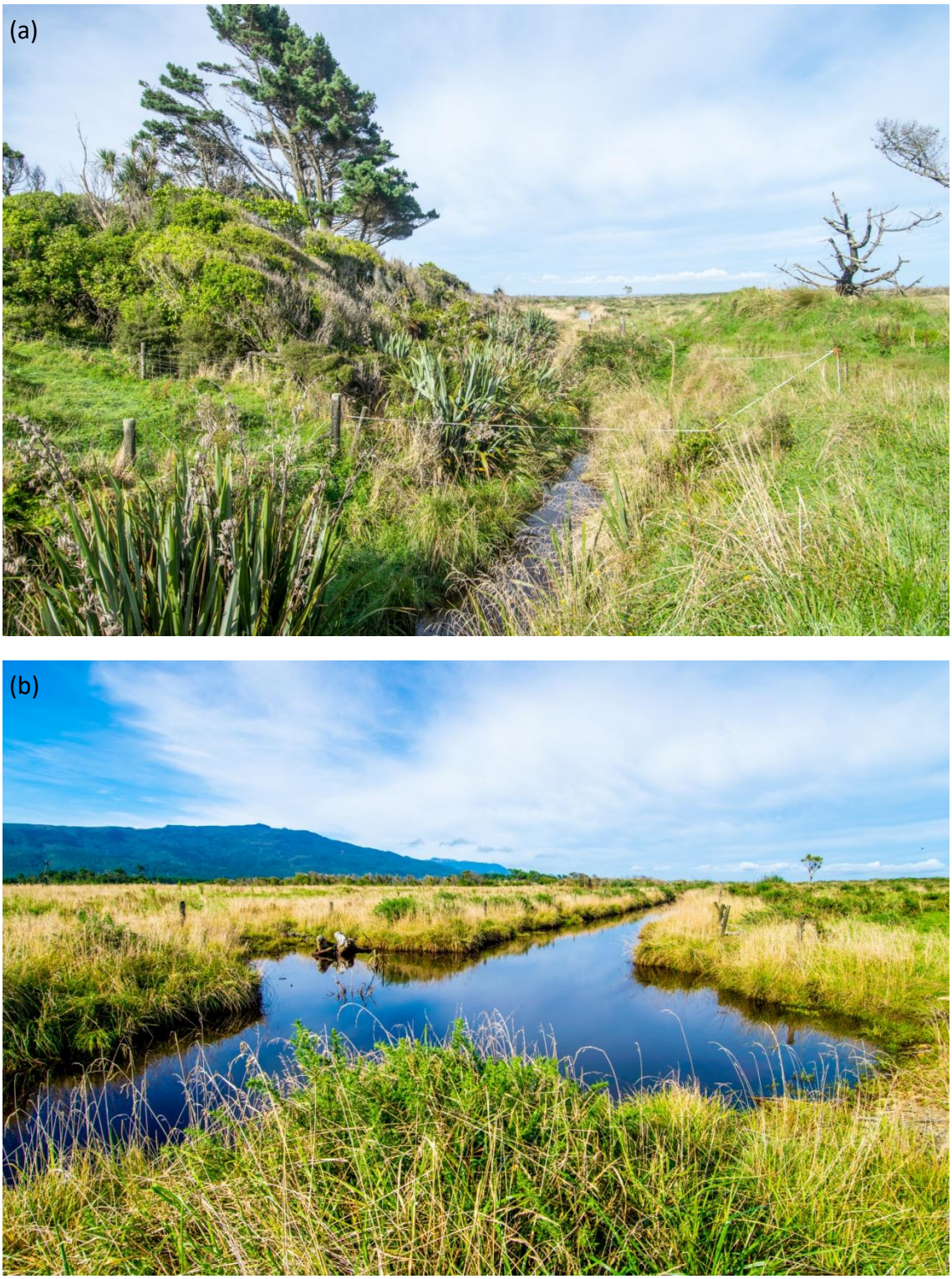


Fig. A1.2 Tributary downstream of Collins Road. (a) looking downstream towards the forest remnant and confluence with the bush tributary. Note hotwire in place. (b) old stock cross point (now fully fenced) looking downstream.

Fig. A1.3 (a) lower section of stream downstream of the old stock crossing point. (b) view of the lower stream and confluence with the Waimangaroa River.

Fig. A1.4 (a) bush tributary where it enters the forest remnant. (b) stock crossing in farmland upstream of the forest remnant.

Appendix 2. Additional site photographs, Jones and Stony creeks**.**

Fig. A2.1 Jones Creek as viewed from the Cains Road bridge. (a) looking upstream with the area of tidal wetland visible centre left. (b) looking downstream showing steep banks and scrub cover on the true left bank, and fenced margins adjacent to farmland and the true right.

(a)

(b)

Fig. A2.2 (a) Fan Creek near its confluence with Jones Creek. (b) Jones Creek a short distance below the fan Creek confluence (looking upstream) in the vicinity of a previously reported īnanga spawning site on the far bank.

Fig. A2.3 (a) Stony Creek looking downstream from the culvert at Manns Road. (b) established forest cover on the true right bank of Stony Creek upstream of Manns Road.

Appendix 3. Additional site photographs, Whareatea River survey area.

Fig. A3.1 One of the farm drains that connects to the Rapid Creek catchment. Many of these established drains are protected from stock grazing and are likely to support fish populations. (b) view of the Whareatea River mainstem looking upstream from its confluence with Rapid Creek (left foreground).