ŌHAU LOOP PHASE 2:
ENHANCING KNOWLEDGE OF INANGA HABITAT

Manaaki
Taha Moana

MTM Report No. 25
May 2015

ŌHAU LOOP PHASE 2: ENHANCING KNOWLEDGE OF INANGA HABITAT

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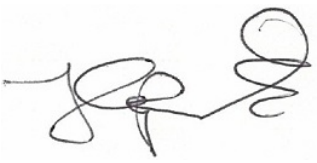

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MIHI

Te ngākau pūaroha ki ngā ōhākī
‘E kore koe e ngaro- te kākano i ruia mai i Rangiātea
Puritia! Puritia! Puritia!

E ngā atua Māori, mō ōu whakaaro whānui mā a tātou, tēnā koutou.

E ngā mana, e ngā reo, e ngā iwi o te motu, tēnā koutou.
E ngā matāwaka, whītiki! Whītiki! Whītiki!
Te hunga ora ki te hunga ora, te hunga mate ki te hunga mate.

E kui mā, e koro mā a Tūkorehe, kia koutou kua ū mai nei ki tēnei mahi nui, ki te atawhai, ki te manaaki i ngā taonga i tukua mai e ngā tūpuna o te takiwā nei a Tahamata, Kuku, tēnā koutou.
E whaea mā, e matua mā, e ngā whānaunga katoa, e hoa mā, e kohikohi ana, e mahi tonu ana me te kaupapa nui mō Te Taiao.

Ko te tūmanako kia whakawhānuitia i ōu mātou tirohanga i roto i te whakatakotoranga kaupapa nei.

Nō reira, tēnā koutou, tēnā koutou, tēnā koutou katoa.

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EXECUTIVE SUMMARY

This latest project in the Ōhau Loop ('the Loop'), has focused on inanga (whitebait) habitat knowledge and restoration, and was built on an existing research relationship between Taiao Raukawa, Manaaki Taha Moana (MTM) project Horowhenua research team and Cawthron Institute (Cawthron). This relationship was forged through the successes of the Manaaki Taha Moana (MTM): Enhancing Coastal Ecosystems for Iwi/Hapū project.

Once a highly valued area for *mahinga kai* (or food gathering area), the Ōhau Loop was part of a meandering tidal section of the Ōhau River. Flood protection works on the lower Ōhau River in 1972–1972 saw this 3.5 km meander cut off from the main flow by the creation of 'the Cut'; a diversion channel which by-passed the Loop. Today the Loop is surrounded by intensive dairy farming by the Māori shareholder's farm Tahamata Incorporation and has poor water quality, degraded biodiversity, and an abundance of aquatic weeds. In 2011 the Loop was targeted for rehabilitation through the MTM project.

In the Phase 1 project under MTM, the ecological state of the Ōhau Loop was assessed and potential restoration measures identified for the benefit of the Tahamata Incorporation farm and the Ōhau Loop ecosystem. The 2011 Ōhau Loop Phase 1 report (Allen *et at*. 2011) led to the installation of a fish-friendly flood-gate at the bottom end of the Loop by Horizons Regional Council (Horizons), supported by Tahamata and Māori shareholders in February 2013.

Preliminary recommendations from Phase 1 included the removal of accumulated fine sediments from the Loop and the re-connection of adjacent lagoons to form a continuous channel connected by fish-friendly culverts. It was also recommended that some (yet to be determined) flow should be diverted from the Ōhau River into the top of the Loop to alleviate poor water quality. Further study is required to calculate the flow requirements for mahinga kai species, whilst maintaining flood protection. More suitable riparian fencing and planting native species was also recommended to provide shade, habitat and filtering of sediments from farm runoff.

For the current study, Cawthron scientists, Horizons staff, and members of Taiao Raukawa, including local kaitiaki and whitebaiters, undertook community environmental monitoring and enhancement of inanga egg-laying (spawning) habitat within the lower reaches of the Ōhau Loop. The aims of the project were to:

- increase local knowledge of inanga egg-laying habitat.
- enhance freshwater fisheries by installing temporary artificial inanga habitat (while replanted harakeke recovers).
- assess effectiveness of artificial habitat via community monitoring with kaitiaki.

An intensive survey of inanga egg-laying habitat was done in the lower reaches of the Loop in March 2014 by local kaitiaki, whitebaiters, Cawthron scientists and members of Taiao Raukawa. The survey included inspection of vegetation from the water's edge to beyond the riparian margin along several hundred metres of the Loop's banks. Salinity measurements were taken in the centre of the channel to look for the presence of a saltwater wedge.

Despite a full day of searching no inanga eggs were found in the Loop itself. However, adult inanga were observed congregating at the entrance to the new fish-friendly flood-gate at the bottom end of the Loop.

Variations in the salinity measurements in the Loop could be the result of several mechanisms such as.

- upwelling groundwater at points along the lower reaches of the Loop.
- pockets of saltwater becoming trapped in riverbed depressions during spring tides, then freshwater running over the surface of this heavier saline layer.

Within the main Ōhau River channel, a significant inanga egg-laying area was discovered approximately 200 m downstream of the new flood-gate. The egg-laying habitat was surveyed and found to be 17 m long × 1 m wide. An egg quantification study found an average egg density of 2,130 eggs per 100 cm^2, which equates to approximately 3.6 million eggs over the whole area.

Inanga lay their eggs just after the spring tides, from February to April each year. Eggs hatch each month at the next spring tide. Inanga egg densities in the survey area were quantified again in April and May 2014, and in April 2015. There was considerable change in the extent (length, width) and intensity (density) of egg-laying each month.

The other objective of the project was to provide temporary inanga egg-laying habitat while replanted native vegetation, harakeke, established at the bottom end of the Loop. In March and April 2014, and again in March 2015, a huge effort by local kaitiaki saw three to five sets of two straw bales installed just above and below the flood-gate at the bottom end of the Loop. However, despite efforts to place the bales across a range of tidal heights and over several months, no inanga eggs were observed in any of the straw bales in 2014 or 2015.

Although we were unsuccessful in expanding egg-laying habitat artificially, the discovery of previously unrecorded inanga egg-laying habitat in the vicinity of the Ōhau Loop is significant. Furthermore, new knowledge of inanga spawning and the need to protect egg-laying habitat has been passed on to others of the hapū and iwi through local kaitiaki involvement in searching for, monitoring the egg-laying habitat, and sharing these experiences with others.

Future restoration initiatives to remove sediment and increase water flow in the Loop are under consideration. These would expand the habitat of inanga and other mahinga kai species and ultimately help to restore the mauri of the Ōhau Loop.

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GLOSSARY

Term	Definition
cm	Centimetre
GPS	Global positioning system
km	Kilometre
m	Metre or metres
hapū	Sub-tribe
harakeke	Flax
Inanga	Whitebait species
iwi	Tribe
kaitiaki	Guardian, protector
mahinga kai	Indigenous freshwater species that have traditionally been used as food, tools, or other resources
mana	Authority, respect, prestige
taonga	Treasure
tuna	Eel
mauri	Life-force or life-giving principle
whānau	Extended family, family group

1. INTRODUCTION

This study of whitebait habitat and restoration in the Ōhau Loop (known as 'the Loop') was built on an existing research relationship between Manaaki Taha Moana (MTM) researchers, Horizons Regional Council (Horizons) and Cawthron Institute (Cawthron). This relationship was forged through the successes of the Manaaki Taha Moana (MTM): Enhancing Coastal Ecosystems for Iwi/Hapū project (Box 1).

Box 1. Manaaki Taha Moana

Manaaki Taha Moana (MTM) is a 6-year programme, which runs from 1 October 2009 to 30 September 2015. Research is being conducted primarily in two areas:

1. Tauranga moana region
2. Horowhenua coastline between Hōkio Stream, south of Foxton Beach, and Waitohu Stream, just north of Ōtaki Beach.

This programme of research activities has built upon previous research with Ngāti Raukawa ki te Tonga in the lower North Island through the programme, Ecosystem Services Benefits in Terrestrial Ecosystems for Iwi and Hapū (MAUX0502).

Professor Murray Patterson (School of People, Environment and Planning, Massey University) is the Science Leader for the MTM programme.

A number of different organisations are contracted to deliver the research. Caine Taiapa of the Manaaki Te Awanui Trust is Research Leader Māori for the Tauranga Moana case study and Dr Huhana Smith is Research Leader Māori in the Horowhenua coastal case study through Te Reo a Taiao Raukawa, the Ngāti Raukawa Environmental Resource Unit (Taiao Raukawa). Freshwater and marine expertise comes from Cawthron Institute (Nelson), information technology expertise from WakaDigital Ltd (Tauranga), and project management and ecological economics expertise comes from the School of People, Environment and Planning, Massey University (Palmerston North).

Taiao Raukawa (on behalf of hapū of Ngāti Raukawa ki te Tonga and affiliates) is linked with other iwi and groups, particularly Muaūpoko hapū and whanau who have tangata whenua status in the northern Waiwiri to Hōkio case study area. The research team tries to engage extensively with all iwi and hapū, kaitiaki (environmental guardians) and other end-user groups, who have been set up in each case study region.
Manaaki Taha Moana is a collaborative, action and kaupapa Māori research project that uses and bolsters mātauranga Māori or Māori knowledge systems within whenua (lands), awa (waterways), repo (wetlands) and moana (sea and harbours).

The Horowhenua MTM research activity centres on an area of inter-related hapū (collective of multiple whanau groups), within a south-west coastal rohe (region). This area once had extensive coastal forest, with streams, rivers, estuaries, a series of lakes, lagoons and dune wetlands that teemed with freshwater food and fibre resources and kaimoana (tidal and marine resources). The coastal, cultural landscape is bounded by the Tasman Sea and extends from the Hōkio Stream in the north to the dynamic Waitohu Stream, wetland and estuary at Ōtaki Beach in the south. The case study includes awa and awa iti (rivers and streams), repo (wetlands), roto (dune lakes) and moana (seas and estuaries) within the coastal region (Smith *et.al* 2014).

For the current study, Cawthron scientists, Horizons staff, and members of Taiao Raukawa, in liaison with local kaitiaki and whitebaiters (Figure 1), guided community environmental monitoring and enhancement of inanga (whitebait) egg-laying (spawning) habitat within the lower reaches of the Ōhau Loop.

1.1. Inanga spawning

Inanga lay eggs just after the spring tides, from February to April each year. Eggs are laid in the riparian (riverbank) vegetation at the top of the spring tidal extent. They hatch each month at the next spring tide.

1.2. Aims

The aims of this study were to:

- Increase local knowledge of inanga egg-laying habitat.
- Enhance freshwater fisheries by installing temporary artificial inanga habitat.
- Assess effectiveness of inanga habitat restoration through community monitoring with kaitiaki.

Figure 1. The Ōhau 'Loop' inanga team, including Cawthron Institute scientists, Horizons Regional Council staff, and members of Taiao Raukawa, local kaitiaki, and whitebaiters, March 2014.

1.3. The Ōhau River Loop

The following section has been extracted in part directly from the MTM Phase 1 report (Allen *et al.* 2011) to provide context for the current study.

1.3.1. Location and physical environment

The Ōhau Loop is approximately 80 km north of Wellington on the west coast of the North Island (Figure 2). Today the Loop essentially forms an artificial oxbow lake, situated on the lowland floodplain of the Ōhau River.

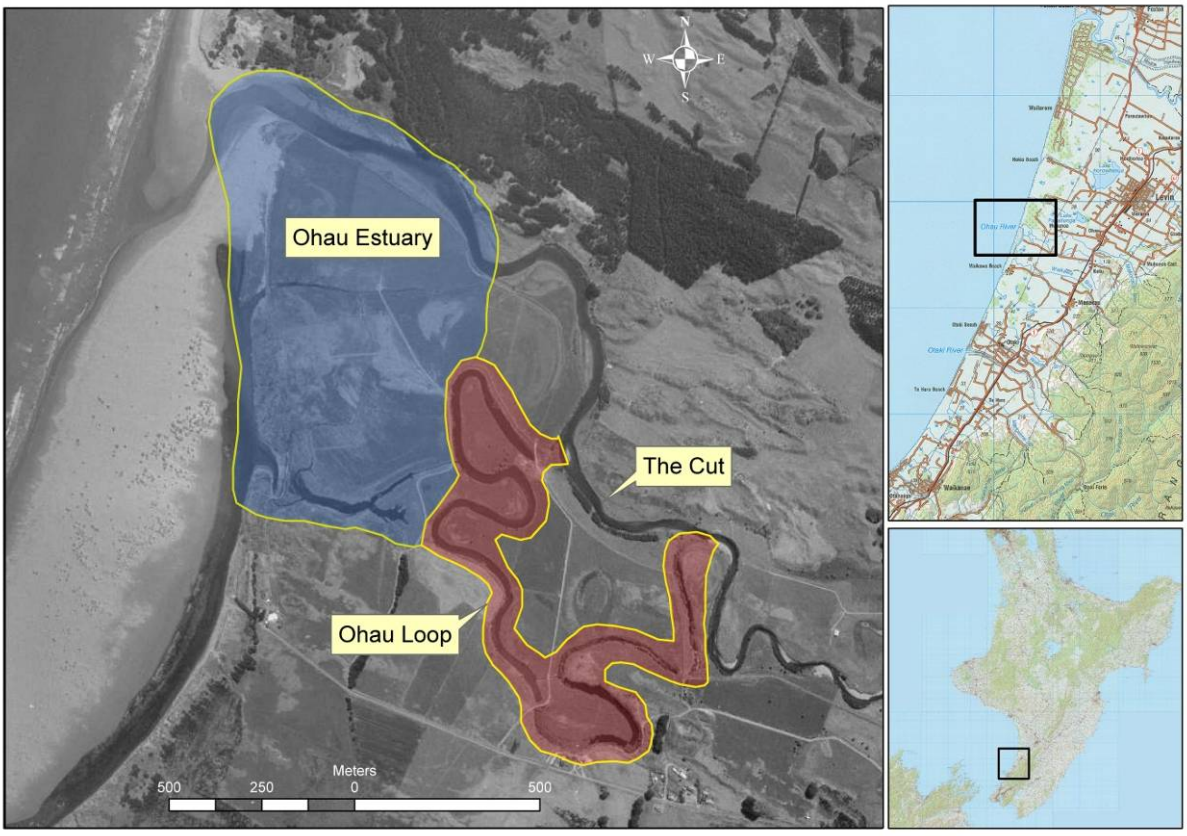

Figure 2. The location of the Ōhau River 'Loop' (pink area), the 'Cut', and the extent of the original Ōhau Estuary that is now partly farmland (blue area). Ōhau Estuary boundaries were drawn using Ravine (1992); from Manaaki Taha Moana (MTM) Phase 1 report (Allen *et al.* 2011)

The Loop lies adjacent to what was the Ōhau Estuary, but is now partly converted to farmland (Figure 2). Despite this modification, the remaining estuarine area is considered the last major estuary on the west coast of the Wellington Conservancy and is afforded "a high priority for conservation by the Department of Conservation" (Department of Conservation 1996). Ravine (1992) surveyed the estuary in 1992 when assessing the suitability of wetlands in the district for inclusion in the Department of Conservation's Protected Natural Areas Programme. The programme aimed to identify and protect a full range of indigenous, biological and landscape features around New Zealand. The 100 hectare estuary was targeted for restoration and protection with 'Priority 2' status, citing good examples of estuarine ecosystems, moderate biodiversity, high naturalness, and special wildlife value (Ravine 1992).

The lower Ōhau River has always been renowned for flooding, as one early anecdote describes: "In a typical year during the late 1940s to 1954, up to a third of the Kidd's one hundred acres, the Saint family farm and flat areas across Ōhau Inland Road (now Kuku Beach Road), and much of the farm between Kidd's and the Ōhau River

would flood once to three times a season as backed up in the tide" (Smith 2007; quoting personal communication with Hon. Douglas Lorimer Kidd, 6 January 2006).

In the early 1900s, large areas of contiguous wetland were drained to create pasture for livestock (Lucas Associates 1998). This had the effect of "accelerated obliteration of the beautiful, natural, moisture-conserving water features of our landscape" (Adkin 1948). Early aerial photos (Figure 3) show the meandering section of the lower Ōhau River before 'the Cut' was constructed. Clearly visible are sediment bars deposited on the inside berms of the meanders. Once the Loop was cut off from the main stem in 1972, there could be no more deposition of larger sediment (*i.e.* cobbles and gravels) or flushing of fine sediment, hence the Loop is now filled with organic detritus and silt from surrounding farmland. The resulting loss of mahinga kai from the lower Ōhau and Ōhau Loop, eventually led to the recent projects aimed at restoring habitat and mahinga kai species.

Figure 3. The Ōhau Loop in the 1940s before 'the Cut' was made (Smith 2007). From Manaaki Taha Moana (MTM) Phase 1 report (Allen *et al.* 2011).

2. METHODS

2.1. Egg-laying habitat surveys

Field sampling was conducted on 10–11 March 2014, 14 April 2014, 8 May 2014 and on 14 April 2015.

Egg-laying habitat surveys involved local kaitiaki, whitebaiters, members of Taio Raukawa, Horizons staff, and Cawthron scientists searching for inanga eggs beneath vegetation from water-level up to 1.5 m above the waterline (Figure 4).

Figure 4. Inanga egg-laying habitat surveys with kuia/whitebaiter Yvonne Wehipeihana-Wilson and Anna Retigen, Horizons Regional Council staff.

10–11 March 2014:

On 10 March 2014, inanga egg-laying habitat surveys were conducted from the Ōhau estuary up the diversion stream, also known as 'the Cut', and through the Loop down to the new fish-friendly flood-gate, and down the main channel of the Ōhau River. Salinity measurements were made within the Loop from the fish-friendly flood-gate to 1 km upstream. On 11 March 2014 an extensive search for inanga egg-laying habitat

was done on the true left bank main Ōhau River channel down-stream of the fish-friendly flood-gate.

14 April 2014

An extensive search for inanga egg-laying habitat was done on both banks of the main Ōhau River channel downstream of the fish-friendly flood-gate at the bottom end of the Loop. A thorough search was also undertaken through the restoration areas above and below the flood-gate.

8 May 2014

An extensive search for inanga egg-laying habitat was done on the true left bank of the main Ōhau River channel 200 m downstream of the fish-friendly flood-gate at bottom the end of the Loop. A thorough search was also undertaken through the restoration areas above and below the flood-gate.

14 April 2015

An extensive search for inanga egg-laying habitat was done on the true left bank of the main Ōhau River channel 200 m downstream of the fish-friendly flood-gate at the bottom end of the Loop. A thorough search was also undertaken through the restoration areas above and below the flood-gate.

2.2. Inanga egg quantification

Once inanga eggs were found, egg quantification was done using standardised techniques (Hickford & Schiel 2014). GPS marks were taken along the egg-laying habitat. At each egg-laying site, 50–100 m transects were laid out and the extent of the egg-laying estimated. Within individual egg patches, the number of eggs in 10 randomly chosen 1 cm square areas was counted within 10 cm × 10 cm quadrats. The root mat height, vegetation height, aspect, and vegetation were also recorded.

2.3. Straw bale installation

The other objective of the project was to provide temporary inanga egg-laying habitat while replanted native vegetation, harakeke, establishes at the bottom end of the Loop. Straw bales are a common method to provide temporary artificial spawning habitat for inanga by offering suitable egg-laying conditions *(i.e.* warm and moist) within and between the bales (Hickford & Schiel 2014).

In March and April 2014, and again in March 2015, a significant effort (5–8 people over 12 hours) by local kaitiaki saw three to five sets of two barley straw bales installed just above and below the flood-gate at the bottom end of the Loop. The bales were held in place by metal stakes (waratah posts) and in some cases high-tensile wire was used to hold the bales down (Figures 5 and 6).

Figure 5. Straw bale installation within the Ōhau Loop with local kaitiaki.

Figure 6. Straw bales at the entrance to the Ōhau Loop, 2014.

Straw bales were examined for inanga egg-laying one and, in some cases, two months after installation. Bales were moved apart and individual bale slices were also prized apart to look for eggs (Figures 7).

Figures 7. Examining straw bales for inanga eggs, 14 April 2014.

3. RESULTS

3.1. Inanga egg-laying habitat monitoring

Differences in numbers of eggs between each monitoring occasion are the result of the new spawning that occurs each month (Section 1.1).

10 March 2014

Despite a full day of searching inanga eggs, no eggs were found on the first day. However, 20–30 adult inanga were observed congregating at the entrance to the new fish-friendly flood-gate at the bottom end of the Loop.

Salinity measurements upstream of the flood-gate found that salinity varied considerably along the Loop. This variation may be caused by mechanisms such as:

- upwelling groundwater at points along the lower reaches of the Loop.
- pockets of saltwater becoming trapped in riverbed depressions during spring tides, then freshwater running over the surface of this heavier saline layer.

It may be necessary to determine the cause of these salinity changes, through further investigation and modelling of groundwater flows, prior to any future large-scale restoration within the Loop.

11 March 2014

A significant inanga egg-laying area was discovered approximately 200 m downstream of the new flood-gate and within the main Ōhau River channel on the true left (Figures 8). The egg-laying habitat was surveyed and found to be 17 m long × 1 m wide. Average egg density was 2,130 eggs per 100 cm^2, which equates to approximately 3.6 million eggs over the whole area (Figure 9).

Inanga egg densities were measured at the same location in April and May 2014, and in April 2015.

14 April 2014

Egg densities were measured along an 85 m long x 1.5 m wide stretch with an average of 1,063 eggs per 100 cm^2, which equates to approximately 13.6 million eggs over the entire area (Figure 10).

8 May 2014

Inanga eggs covered an area 43 m long × 1 m wide along the same stretch of bank monitored in April 2014. Average egg density of 524 eggs per 100 cm^2 were recorded, which equates to approximately 2.2 million eggs over the whole area (Figure 11).

14 April 2015

On the final monitoring occasion, no eggs were found in the egg-laying habitat used in 2014. Instead, a new area (10 m long × 0.5 m wide) was discovered approximately 100 m further downstream on the banks of a side channel (Figure 12). Egg densities in April 2015 were considerably lower than in 2014, averaging 10 eggs per 100 cm^2 or approximately 5,000 eggs over the whole area.

Figures 8. Inanga egg density quantification within a 10 cm × 10 cm (100 cm^2) quadrat. Arrows highlight location of eggs.

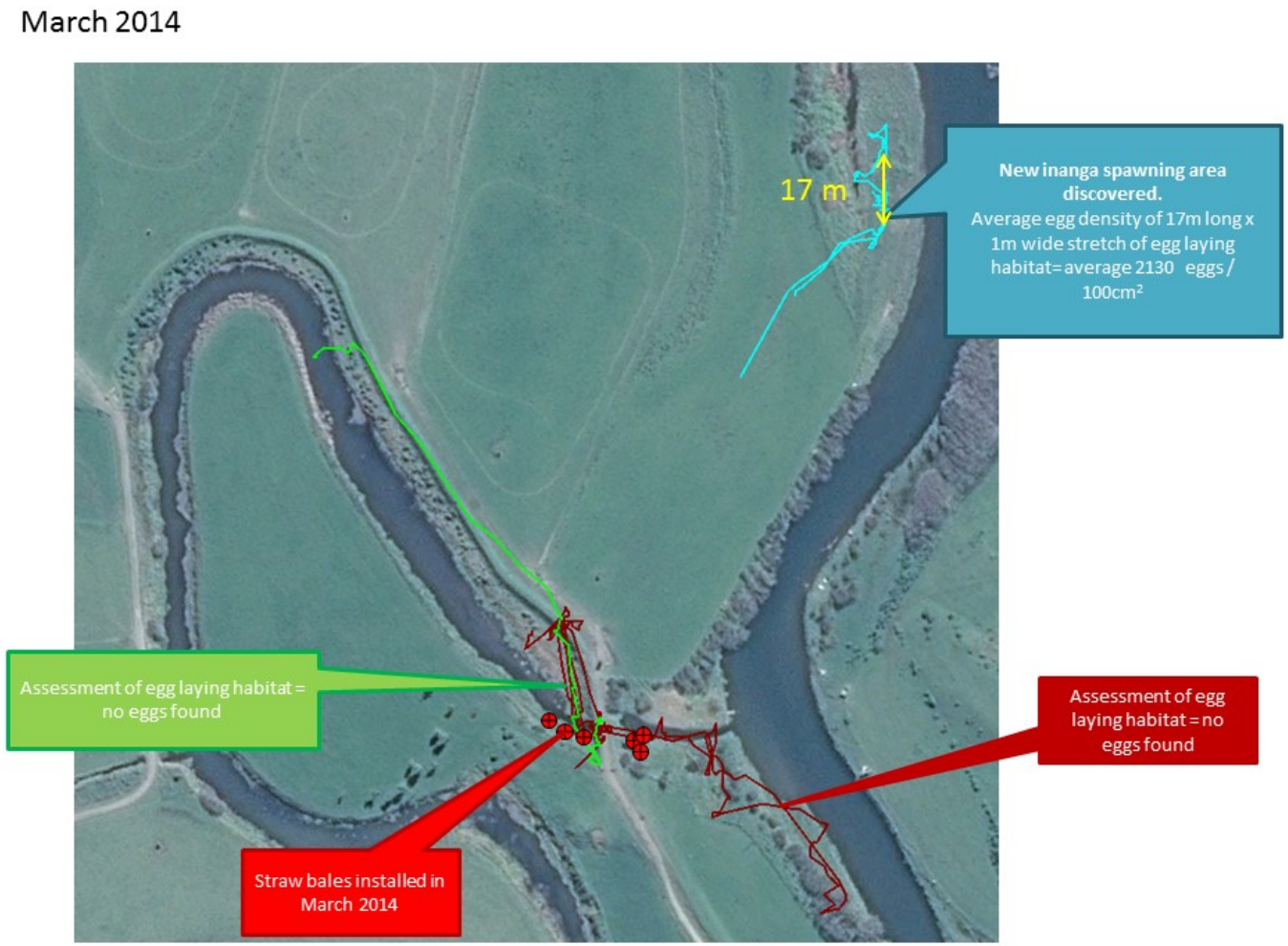

Figure 9. Sampling in the Ōhau Loop 11 March 2014.

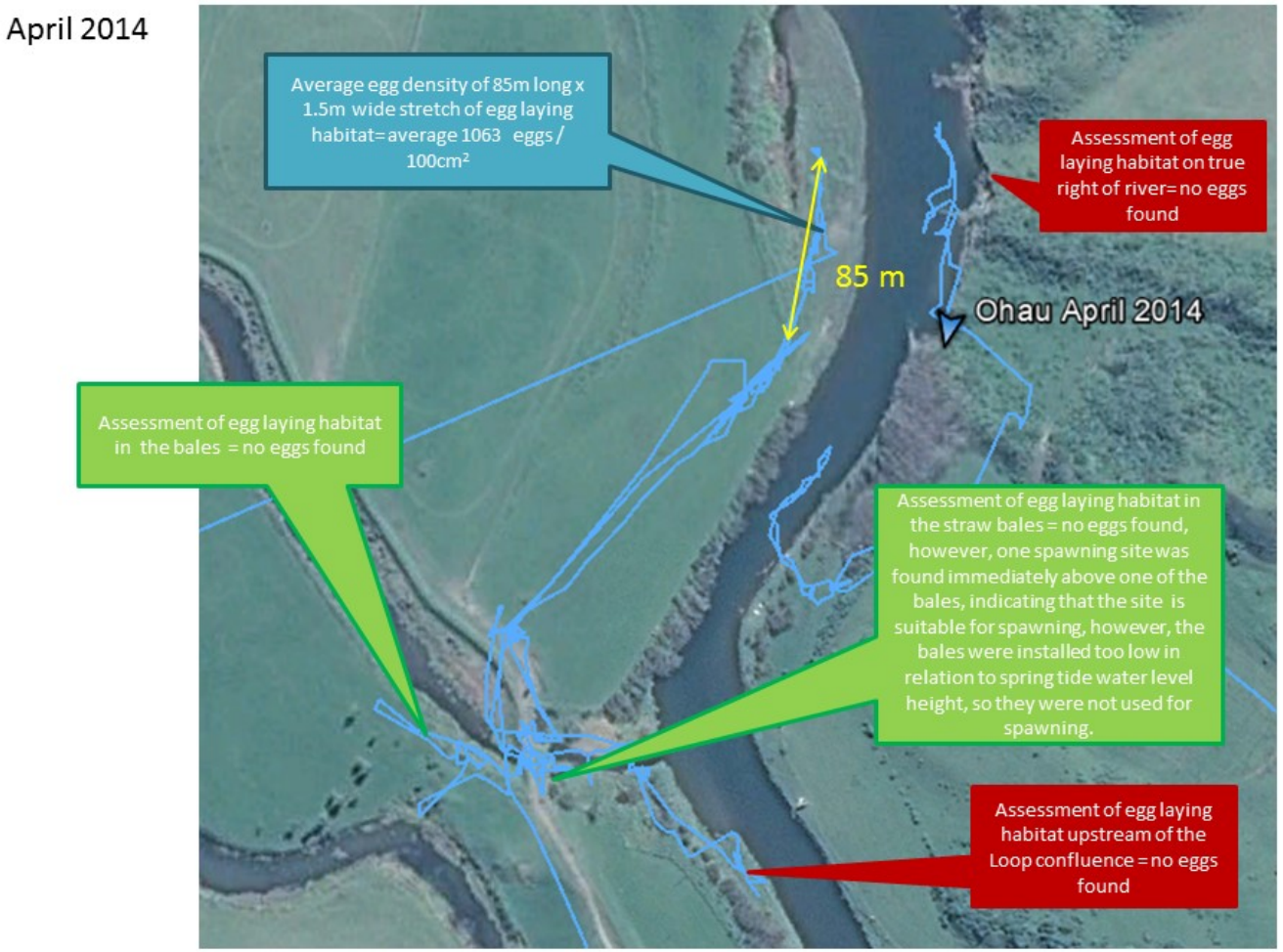

Figure 10. Sampling in the Ōhau Loop 14 April 2014.

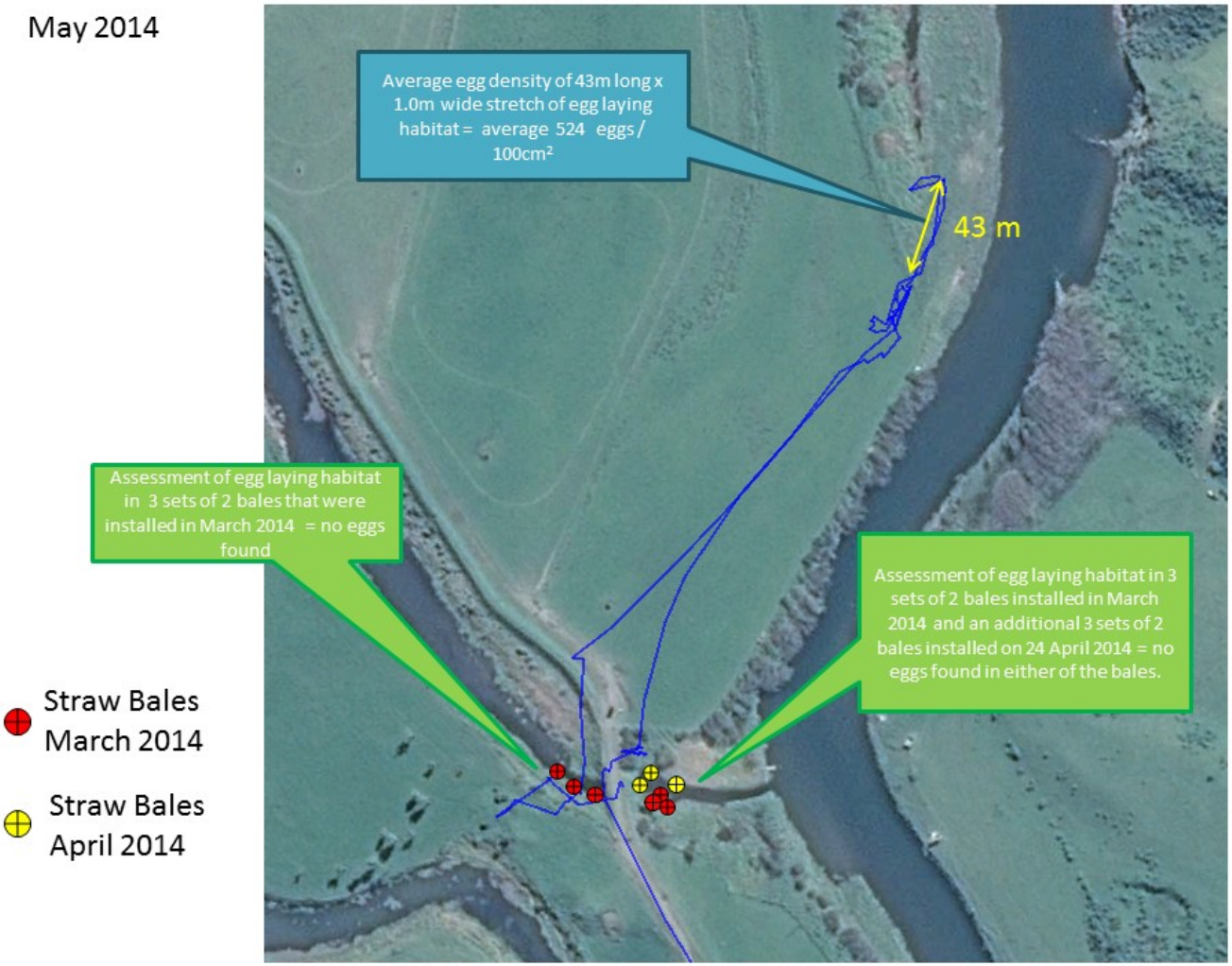

Figure 11. Sampling in the Ōhau Loop 8 May 2014.

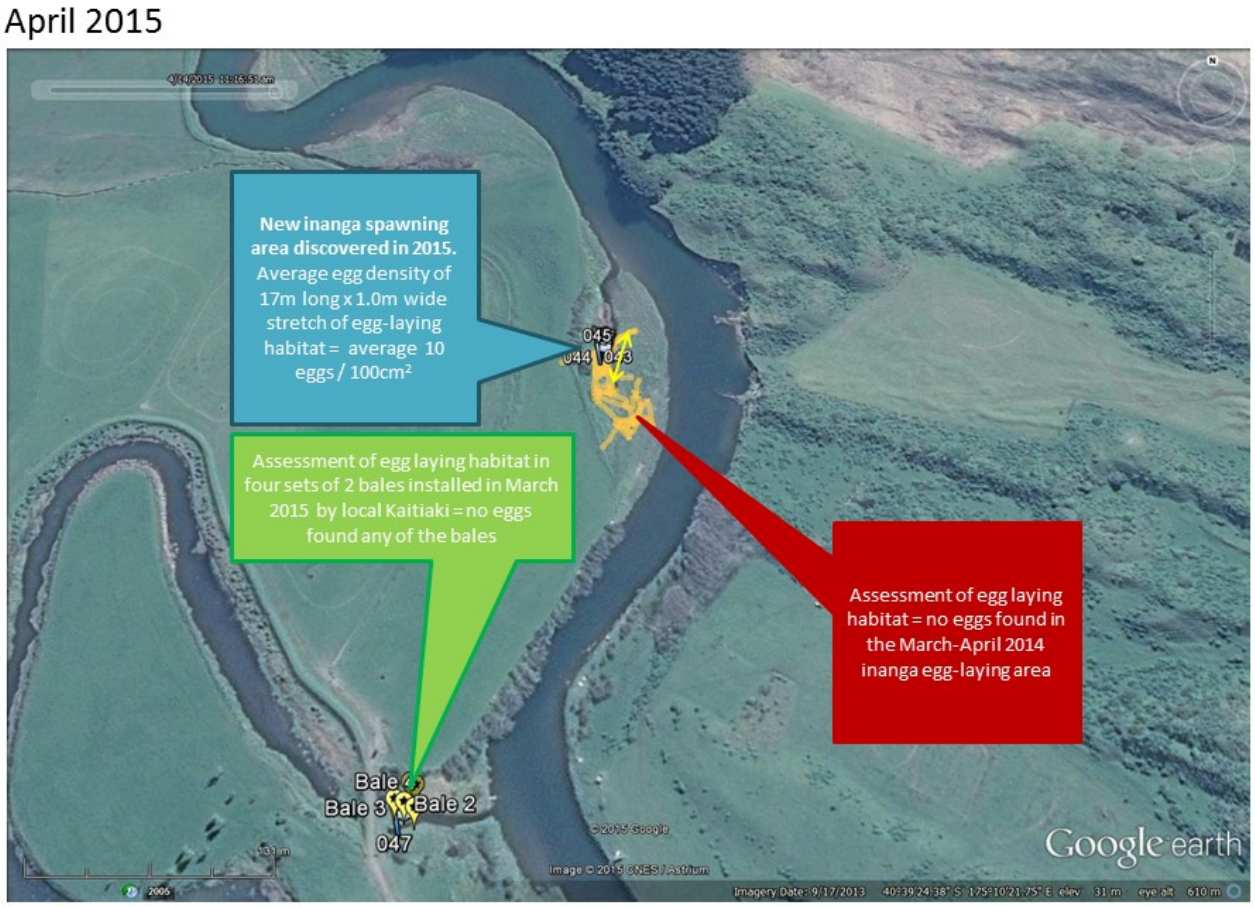

Figure 12. Sampling in the Ōhau Loop 14 April 2015.

3.2. Temporary egg-laying habitat—straw bales

Despite the considerable effort involved in placing and examining straw bales across a range of tidal heights and over several months, no inanga eggs were observed in any of the straw bales in 2014 or 2015.

4. DISCUSSION

4.1. Mātauranga Māori

Prior to this study and before the 'Cut' was put in place; there was local knowledge of inanga abundance in the whole Ōhau meander and Ōhau River. Pinpointing exactly where inanga egg-laying in the vicinity of the Ōhau Loop or in the main Ōhau River channel after the Cut, was perhaps not something that white-baiters searched for, or if they did, they talked about it amongst themselves.

Long-term white-baiters definitely knew of the times before the Cut. There are many stories of these experiences. An example when whitebait were running is that a flour sack was very quickly filled to bursting at various sites along the river meander. In those times inanga could be so plentiful that excesses were fed to chickens or used as fertilizer on domestic vegetable gardens.

In the past, when the lands were long-term leased to non-Māori farmers, cattle were allowed to graze down to the waters edge in both areas throughout autumn, when inanga lay their eggs high on the river banks. As Tahamata was not officially formed until 1974, the coastal flood plain around the Ōhau River and the Loop and adjacent outlet areas had previously been under a number of separate titles with individual or collective Māori owners. The paddocks closer to where the Ōhau River turns south to the estuary and the wet areas around the 'blind creek' were where tides and siltation flowed over the lands. Together the combined effects of the engineered 'Cut' on the river, the stop banks (1972–1974) and constructed culverts prevented tidal river waters flowing back into the 'blind creek' and loop areas (Smith 2007).

It is important to remember that the coastal area of the farm today does not look like it did then. There were many more areas that had not been converted for dairying, which were covered in large stands of old man gorse and boxthorn with many ti kouka (cabbage trees), manuka, and some other intermittent native forest cover.

4.2. Current study

Despite considerable effort by all involved, the use of straw bales was not successful in extending inanga egg-laying into the Loop. However, the discovery of significant inanga egg-laying habitat just down-stream of the Loop, and the knowledge passed to local kaitiaki about the importance of protecting this critical habitat, is a significant outcome for this study. These areas have been fenced-off and with the help of the Tahamata Incorporation farm will be protected for the benefit of future generations. Possible reasons for the lack of inanga spawning within the Loop are the low flows and minimal water exchange with the main channel during large tides (when inanga spawn). Currently, the only flow within the Loop is provided by groundwater and land run-off, and over the past 35 years approximately 104,000 m^3 of fine sediment has built up within the Ōhau Loop (see MTM Phase 1). While the fish-friendly flood-gate at the bottom of the Loop allows some exchange of fresh and brackish water during high-tide, during the highest tides the gate shuts, reducing cues for spawning (related to the salt water influx) and possibly preventing inanga from reaching the Loop during this critical period.

4.3. Recommended process for future restoration

Increased flow, improved water quality and riparian re-vegetation within the Loop will be required in order to increase the habitat for mahinga kai species (e.g. Allen *et al.* 2011). To achieve this, the following process is recommended:

1. Calculate the augmentation flow that is required to provide suitable habitat and water quality for mahinga kai species.
2. Determine the sediment chemistry of accumulated sediments in the Loop to check that no toxic substances are present, which might exclude the option of spreading the excess sediment on farm land.
3. Block-off the end to the Loop while restoration occurs to protect inanga spawning habitat downstream of the Loop in the Ōhau River.
4. Remove accumulated fine sediment from the Loop, reshape banks and re-instate gravel beaches. The bed of the Loop should be re-graded as closely as possible to the original Loop gradient to accommodate plans to introduce flow at the top of the Loop.
5. Excavate areas where farm tracks currently inhibit flow and re-connect the Loop with bridges or fish-friendly culverts (such as box culverts).
6. Re-plant banks with native riparian vegetation.
7. Install an engineered intake and flow regulation system that links the Loop with the main Ōhau River flow. It may be necessary to by-pass the top 500 m of the Loop and link directly to the main channel at red line in Figure 13. The 500 m section

above the intake could be designed to provide habitat for adult inanga, such as swamp land.

8. Re-open the bottom end of the Loop once restoration is complete and ideal flow has been reinstated.

Figure 13. Aerial photograph of the Ōhau Loop showing the potential Ōhau River intake location (red line).

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