Randomised assessment of atutahi (*Galaxias maculatus*) spawning habitat in the Whanganui Awa

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Mihi

He tokomaha ngā ringaraupā i whakapau kaha ki te whakaoti atu i tēnei rīpoata. Ki a koutou nō roto mai o Tūpoho, tēnei te mihi. Ki ngā kaimahi o Ngā Tāngata Tiaki, o Te Atawhai o te Ao, tēnā koutou. Arā, ki a koutou Shane Tawhitapou, Marilyn Tamakehu, Connor Pauro, Dean Ranginui, ka nui te mihi. Ki te ahi kā o Te Ao Hou, tēnei te mihi ki a koutou i kaha manaaki i a mātou, ā, i hāpai i tēnei kaupapa. Geoffrey Hipango koutou katoa ko ngā ringawera i hora i te kai reka, tēnā koutou. Tēnei hoki te mihi ki a Beryl Miller kōrua ko Jill Sheehy mō ā kōrua mahi whakariterite i ngā āhuatanga o tēnei kaupapa. Tae noa ki ngā kaimahi o Horizons Regional Council i haere tahi mai ki te rapurapu i ngā hua o te atutahi, tēnā koutou e ngā kanohi hōmiromiro. Nā koutou katoa tēnei mahi i ora.

Contents

A note on terminology

In Whanganui, we use the word atutahi for the adult of *Galaxias maculatus*, known in other iwi areas as īnanga. Our word for the whitebait of this species is karohi. In this report, we use the Whanganui word atutahi when referring to the adult.

Introduction

Previous surveys of atutahi spawning in the Whanganui River catchment have shown that spawning occurs from 9.98 km upstream of the river mouth to 28.9 km upstream of the mouth (Rutledge 2019). In the mainstem alone, this is 38 km of potential habitat to survey if both banks are surveyed. The tributaries add further habitat to cover. Undertaking a detailed census in this area would not be possible.

Surveying potential high- or medium-quality habitat provides information on where atutahi have spawned over a certain period, how productive those spawning sites are, and what the quality of the habitat is like at those sites. However, this method does not allow one to extrapolate out to gain an understanding of the wider potential spawning habitat in the whole catchment.

To overcome this, we trialled a method using randomly generated sites to assess spawning habitat condition in the Whanganui Awa.

Methods

Sampling design

The monitoring area was defined as all potential atutahi spawning habitat within tributaries and the mainstem of the Whanganui River below 20 m above sea level. To determine the upstream and downstream limits of the monitoring area, we undertook presence/absence searches for atutahi eggs on 7 April and 5 May, 2021. These were quick searches to determine egg presence in suitable habitat in both the mainstem and the tributaries. Suitable habitat was determined subjectively. Up to six people took part in the searches. Where we found eggs, we recorded the GPS location and moved on to the next site immediately. If no eggs were found within 20 minutes, we again moved to the next site. The extent of our monitoring area was defined by the furthermost up- and downstream sites where we found eggs. We then used the newly found extent and the River Environment Classification (REC2) to create a sample frame. This represents our target population.

We generated sampling sites using Halton Spatial Stratification, a method that balances sampling sites spatially. This produces a hierarchically ordered list of potential sampling sites. We then used satellite imagery and expert knowledge to decide whether each potential site should be accepted or rejected as a sampling site. We rejected sites that were outside our known spawning extent, or were not likely to realistically support atutahi spawning (such as where satellite photos indicated the reach was an ephemeral stream in a paddock). We assessed the sites in the order in which they were generated, assessing 183 sites to arrive at a final sample size of 32.

Parameters assessed

At each site, we measured 100 m downstream from the randomly generated GPS point. This was divided into 10 m blocks. Each block was assessed from 1 m above the known or estimated spring tide mark to 1 m below it, giving an area of 20 m^2 per block and 200 m^2 per site.

Each block was assessed for:

- bank slope
- percent ground cover
- height of ground vegetation
- dominant ground vegetation type
- stem density
- root mat thickness
- ground moisture
- percent overhead vegetation cover
- dominant overhead vegetation type
- egg density (if present)
- egg patch area
- whether eggs had eyespots
- bank aspect.

Threats to the site and notes on any relevant observations were recorded.

Vegetation

For atutahi spawning, the important factors are what vegetation is at spawning level (i.e. ground level), how tall and dense that vegetation is, and the amount of shading affecting that vegetation. For each 10 m block, we therefore recorded the vegetation cover at ground level, the height of the ground vegetation, and what the dominant vegetation was. We also recorded the percentage of overhead vegetation cover and the dominant overhead vegetation to assess shading effects on the spawning vegetation.

Note that for sites 9, 13, 24, 28, 36, 39, 57 and 88, only ground cover vegetation was formally assessed, not overhead cover. However, for some of these sites, we were able to retrospectively add overhead cover from site notes.

Stem density

Stem density was determined by counting the number of stems within a 10 x 10 cm quadrat. This was randomly applied to any area of ground-level vegetation within the block (Figure 1). We considered that data on the stem density (or lack of) on bare ground was already covered by the estimate of vegetation cover, and that the key information needed was stem density in the vegetation present, hence the placement of quadrats within vegetated areas rather than any random area within the block.

We counted only stems that originated within the quadrat. This differs from the method used in other studies (eg, Orchard and Hickford 2017), where any stem within the quadrat is counted, regardless of its origin. To compare the methods, we also conducted counts on 30 quadrats using the Orchard and Hickford method and then the method used in our study.

Figure 1: Using a cut out ice-cream lid as a quadrat was rather effective. Photo: H. Rainforth

Root mat thickness and ground moisture

The root mat is the collection of aerial roots (often mixed with decaying leaf matter) at the base of plants. When thick enough (e.g. > 0.5 cm), it helps to retain moisture and create a humid environment that is good for egg survival. Root mat thickness was recorded as either 0, 0–0.5 cm, or > 0.5 cm, based largely on the spawning habitat classes in Orchard and Hickford (2017). Ground moisture was recorded as a subjective assessment, using the categories ‘dry and dusty’, ‘dry in some places’, ‘damp’, and ‘wet’.

Egg density, patch area and eyespots

Where eggs were found, the width and length of the patch was measured. The number of eggs in a randomly placed 10 x 10 cm quadrat was recorded, using the categories of 'none', 'few' (1–10), 'some' (11–100), 'moderate' (101–1000) and 'abundant' (> 1000). This approach was used to reduce the amount of time required to exactly quantify eggs at each site. A check was made on whether the eggs had eyespots, and categorised as 'none', 'some', 'most' or 'all'. Photographs of eggs were checked by experts to ensure identification was correct.

Bank aspect

Bank aspect was recorded as the main direction the bank faced, using the cardinal and ordinal directions of the compass.

Figure 2: Assessing habitat quality at site 60. Photo: H. Rainforth

Habitat quality

Habitat quality was determined by comparing averages from each site against Orchard and Hickford's classification (2017; Table 1). Additionally, each block was also assigned to a class, based on this classification.

Table 1: Orchard & Hickford's habitat quality classification.

Class	Quality of habitat for supporting spawning	Criteria
1	Poor	Vegetation cover < 100% or stem density < 0.2/cm^2
2	Moderate	Vegetation cover 100% Stem density > 0.2/cm^2 Aerial root mat depth < 0.5 cm
3	High	Vegetation cover 100% Stem density > 0.2/cm^2 Aerial root mat depth > 0.5 cm

Because the classification was originally designed to set the physical extent of moderate and high-quality habitat, rather than evaluating habitat within an already set site area (as our sites were), we also assigned each block and site to a modified habitat quality class, with a lower cut-off of 75% cover rather than 100%. This meant that blocks that had good stem density but didn't achieve the 100% cover threshold could still be recognised for the good habitat found within the site. The 75% threshold was derived from an average of percentage cover at blocks (not sites) where atutahi eggs were found, and also aligned with the Whitebait Connection Habitat Assessment (Whitebait Connection 2017).

We also evaluated the sites using a scoring system based loosely on the Whitebait Connection Habitat Assessment (Whitebait Connection 2017). Scores were assigned as per Table 2. Sites with scores of 27 or less were considered poor. Sites scoring between 28 and 44 were considered moderate, and sites 45 and above were considered good.

Table 2: Scoring for habitat quality, adapted from the Whitebait Connection habitat assessment sheet (Whitebait Connection 2017)

	0 points	5 points	10 points
Bank slope (°)	< 7° *OR* > 35°	21–35°	7–20°
Ground cover (%)	< 50%	50–75%	> 75%
Vegetation height (cm)	< 10 cm *OR* > 50 cm	10–20 cm	20–50 cm
Stem density (stems/cm^2)	0 < density < 0.1/cm^2	0.1 < density < 0.2/cm^2	≥ 0.2/cm^2
Root mat thickness (cm)	0 cm	0 < thickness < 0.5 cm	≥ 0.5 cm
Ground moisture	Dry and dusty	Dry in some places	Moist

Results

Extent

Spawning was found around 200 m downstream of the Kōwhai Park boat ramp (see Figures 3 – 6 and Table 3). This is near the previously known most downstream site, which was only 250 m upstream from here (Rutledge 2019). The most upstream site was immediately below Hipango (see Figures 3 – 6 and Table 3). This is 2.5 km further upstream than the most upstream site previously known (Rutledge 2019), increasing the extent of known spawning from a distance along the river of 18.9 km to 21.7 km.

Table 3: GPS co-ordinates for upstream and downstream extent of atutahi spawning in the Whanganui River

	Upstream		Downstream	
	Easting	**Northing**	**Easting**	**Northing**
Previous known extent (Rutledge 2019)	1779172	5590748	1775515	5579822
Current known extent (this report)	1781026	5592310	1775439	5579812

Figure 3: Sites searched to determine atutahi spawning extent in the Whanganui Awa (topo map version).

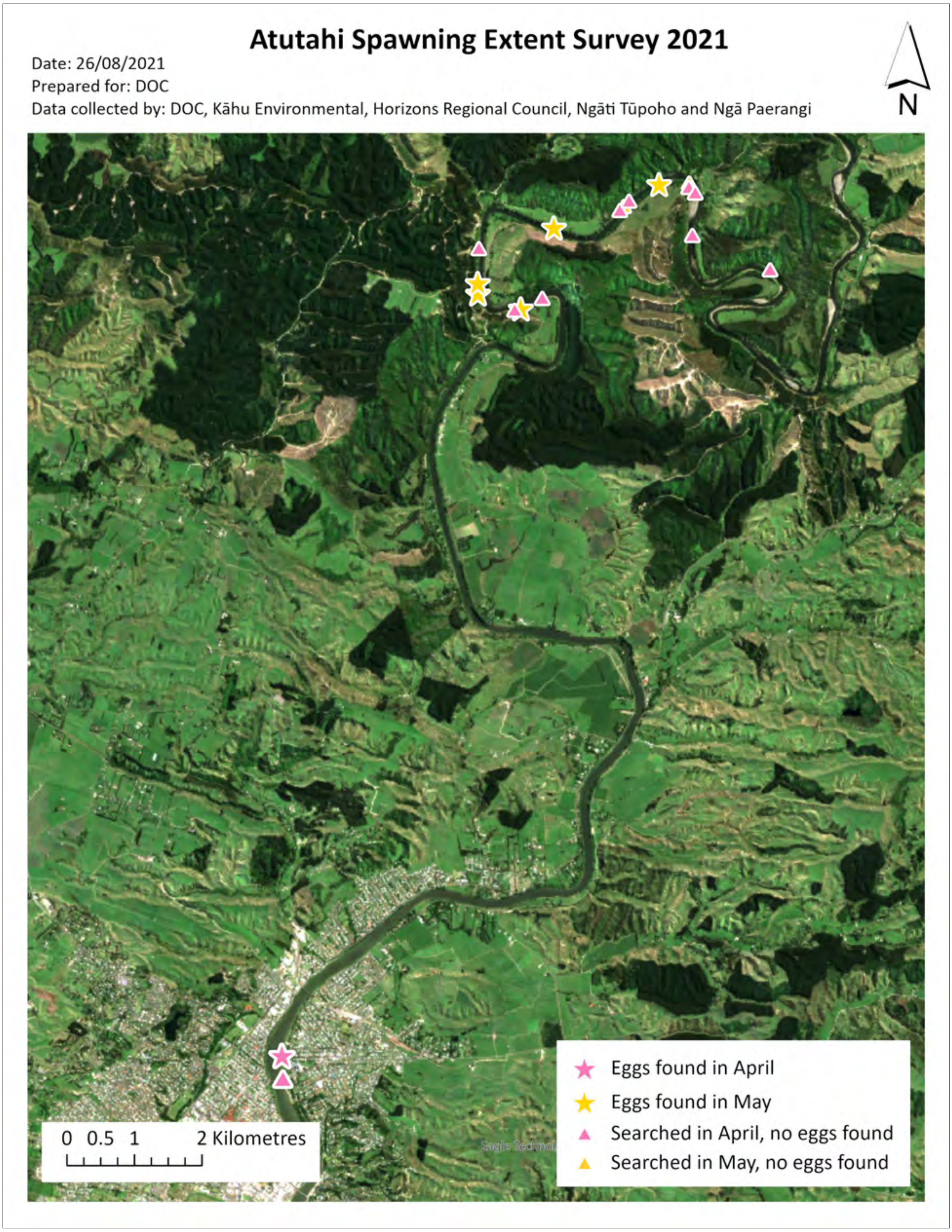

Figure 4: Sites searched to determine atutahi spawning extent in the Whanganui Awa (aerial imagery version)

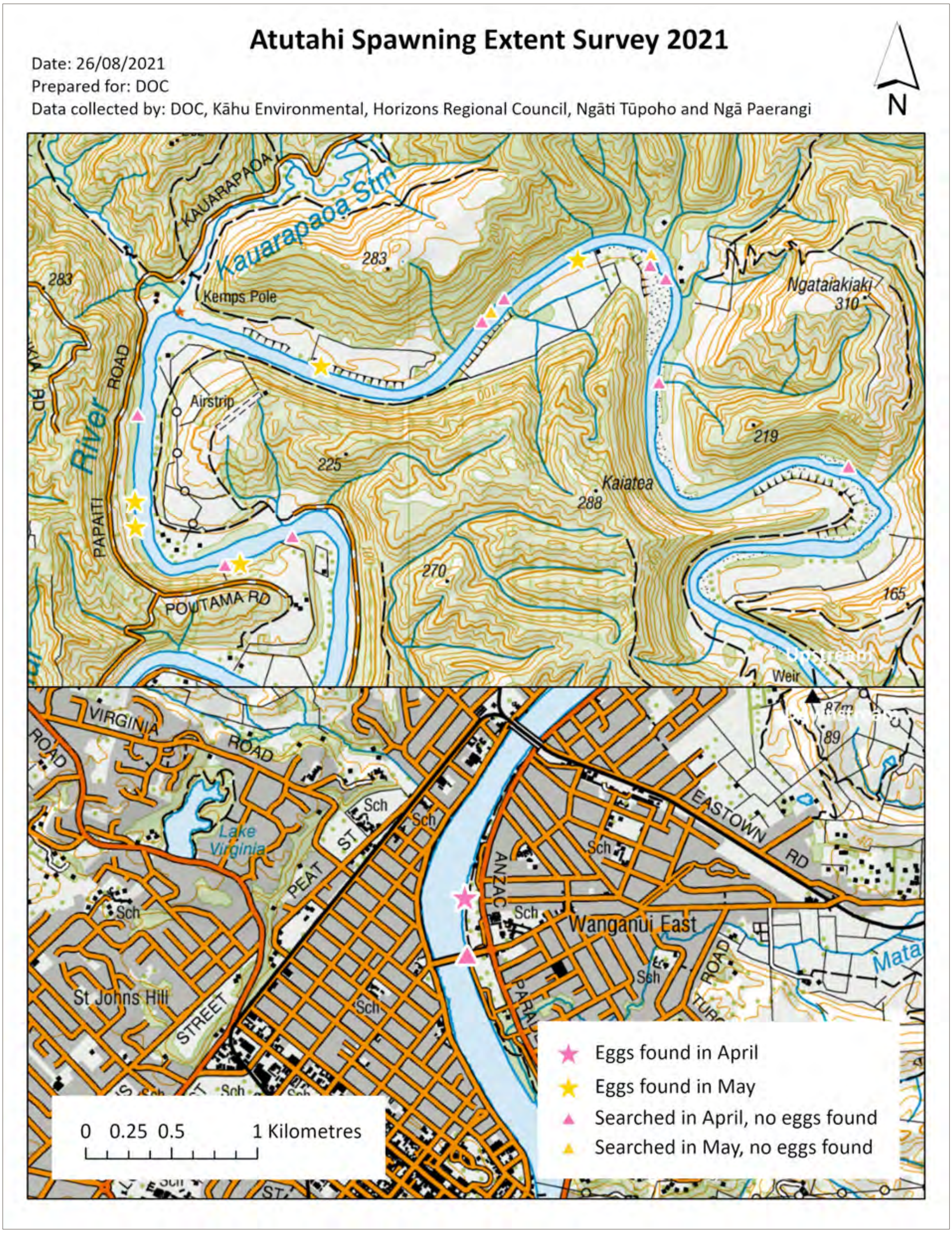

Figure 5: Close up of sites searched to determine atutahi spawning extent in the Whanganui Awa (topo map version)

Figure 6: Close up of sites searched to determine atutahi spawning extent in the Whanganui Awa (aerial imagery version)

Site data

Bank angle

Bank angle ranged from 21–77°, with an average of 50° (Table 4). Only six sites (19%) were classified as having a passable angle (21–35°), using the Whitebait Connection assessment (Whitebait Connection 2017). No sites were in the ideal range of 7–20°.

Figure 7: Site 88, showing the typically steep banks in the lower Whanganui River. Photo: H. Rainforth

Vegetation

Of the 28 sites we assessed for overhead vegetation, there was an average of 37% shading (Table 4). Shading ranged from 0–100%. Only three sites (11%) had no overhead shading, and three had 100% cover. Where overhead vegetation was present, 84% of sites were dominated by willow, and 16% were dominated by other species – mānuka (*Leptospermum scoparium*), taupata (*Coprosma repens*), bamboo (unidentified species) and maple (*Acer* spp.).

For ground cover vegetation, there was an average of 63% coverage, with a range of 9–99% coverage (Table 4). There was more variation in dominant ground cover than in overhead cover, with 25% of sites dominated by tall fescue (*Lolium arundinaceum subsp. arundinaceum*), 25% dominated mixed pasture grasses, 6% dominated by Kikuyu grass (*Pennisetum clandestinum*), another 6% by Mercer grass (*Paspalum distichum)*, and the remaining 38% by mixed or other vegetation. This last category included wīwī (*Juncus* *edgariae*), *Tradescantia fluminensis*, ivy (*Hedera helix*), unidentified moss species, *Carex geminata*, and umbrella sedge (*Cyperus eragrostis*). Ground vegetation height averaged 45 cm and ranged from 7–99 cm (Table 4). The invasive weed field horse tail (*Equisetum arvense*) was present at many sites.

Stem density

Stem density ranged from 0–0.24 stems/cm^2. The average stem density was 0.08 stems/cm^2. Of all the sites surveyed, only two (6%) met the stem density of 0.2 stems/cm^2 required to be considered moderate- or high-quality habitat using Orchard and Hickford's classification (2017).

Table 4: Site data for potential atutahi spawning sites in the Whanganui River.

Site	Date assessed	Easting	Northing	Aspect	Bank angle (°)	Ground cover vegetation (%)	Vegetation height (cm)	Dominant ground vegetation	Overhead shading (%)	Dominant overhead vegetation	Stem density (/cm^2)	Root mat thickness (cm)	Ground moisture level	Eggs found	Productivity	Habitat quality (Orchard and Hickford 2017)	Habitat quality (modified Orchard and Hickford 2017)	Classification (adapted Whitebait Connection Score)
9	8/04/21	1778425	5581735	S	73	nd	n/d	nd	31	willow	0.00	0.36	1.6	no	0	1	1	Poor
13	8/04/21	1776362	5580712	NW	77	nd	n/d	Mixed pasture grasses, flax, pampas	5	mixed	0.00	0.00	1.0	no	0	1	1	Poor
14	7/05/21	1780224	5583631	NW	59	64	75	tall fescue	21	poplar	0.19	0.08	1.6	no	0	1	1	Poor
24	8/04/21	1781250	5592378	N	44	42	31	Mercer grass; tall fescue	nd	nd	0.06	0.00	1.7	no	0	1	1	Poor
28	8/04/21	1779499	5589850	E	38	61	23	tall fescue	2	none	0.10	0.08	2.6	no	0	1	1	Moderate
31	6/05/21	1775283	5578945	NE	70	97	59	Kikuyu grass	11	willow	0.09	0.93	2.4	no	0	1	1	Poor
36	8/04/21	1779090	5591717	N	40	13	23	umbrella sedge	nd	willow, poplar	0.05	0.00	2.7	no	0	1	1	Poor
39	9/04/21	1777737	5587450	E	59	73	43	tall fescue, willow, Mercer grass	nd	nd	0.08	0.00	1.8	no	0	1	1	Poor
52	21/05/21	1778902	5585750	S	55	70	42	tall fescue, Mercer grass	32	willow	0.11	0.11	2.6	no	0	1	1	Moderate
57	5/05/21	1778363	5590621	E	21	77	56	tall fescue	0	none	0.24	0.05	2.9	yes	82414	1	1	Moderate
60	6/05/21	1780959	5592351	SSE	59	56	35	tall fescue	12	mānuka	0.19	0.08	2.6	no	0	1	1	Moderate
63	4/05/21	1777651	5581600	W	29	50	8	pasture grass (species unknown)	4	willow	0.10	0.00	3.0	no	0	1	1	Poor
68	7/05/21	1778798	5581755	S	34	35	35	mixed	79	willow	0.05	0.00	3.0	yes	10	1	1	Poor
73	20/05/01	1777043	5581468	SE	32	80	40	Tradescantia, ivy	96	willow, poplar	0.07	0.03	2.7	no	0	1	1	Moderate
79	20/05/01	1775577	5578715	SW	63	75	65	tall fescue	6	willow	0.11	0.35	2.2	no	0	1	1	Poor
88	4/05/21	1780111	5585599	S	52	71	61	tall fescue	nd	willow	0.11	0.15	2.5	no	0	1	1	Poor
93	21/05/21	1778283	5589675	NW	55	63	32	Mercer grass	49	willow, poplar	0.09	0.03	2.6	no	0	1	1	Moderate
100	6/05/21	1779213	5590703	SE	47	9	8	moss (unknown species)	85	willow	0.04	0.00	2.7	no	0	1	1	Poor
101	2/06/21	1775670	5578069	NE	60	98	99	Kikuyu grass	4	maple	0.06	0.60	2.4	no	0	1	1	Poor
108	6/05/21	1780460	5591952	SE	41	69	51	tall fescue, Carex geminata	0	none	0.20	0.15	2.8	no	0	1	1	Moderate
109	20/05/21	1776527	5581168	SW	58	80	39	Tradescantia	59	bamboo	0.05	0.25	3.0	yes	Not calculatable	1	1	Moderate
110	2/06/21	1780666	5584684	E	58	57	53	Mercer grass	13	willow	0.05	0.15	2.3	no	0	1	1	Poor
117	21/05/01	1778149	5581784	S	30	82	56	mixed	26	willow	0.11	0.40	2.1	yes	7036	1	1	Moderate
124	2/06/21	1779487	5585701	S	72	62	24	mixed	95	willow, poplar	0.04	0.05	2.6	no	0	1	1	Moderate
133	2/06/21	1775736	5578672	S	37	50	42	mixed pasture grasses	100	poplar	0.09	0.03	2.5	no	0	1	1	Poor
135	3/05/21	1777568	5581658	NW	28	99	94	wīwī, tall fescue	0	none	0.11	0.65	2.8	no	0	1	1	Moderate
148	2/06/21	1779089	5589620	SE	56	41	23	mixed pasture grasses	67	willow, poplar	0.04	0.05	2.4	yes	134	1	1	Poor
167	3/05/21	1774512	5575701	W	35	85	89	tall fescue	5	Taupata	0.08	0.45	3.0	no	0	1	1	Moderate
172	3/06/21	1779462	5589501	NW	65	98	57	tall fescue	10	willow	0.03	0.00	2.3	no	0	1	1	Poor
176	3/06/21	1779840	5581990	SE	45	80	46	mixed pasture grasses	100	willow	0.04	0.05	2.9	yes	125	1	1	Moderate
180	2/06/21	1778710	5591869	N	49	35	27	mixed pasture grasses	56	willow	0.03	0.13	2.5	no	0	1	1	Poor
183	2/06/21	1777730	5588712	W	57	24	7	mixed pasture grasses	100	willow	0.03	0.05	1.9	no	0	1	1	Poor
Average					**50**	**63**	**45**		**37**		**0.08**	**0.2**	**2.4**		**6136**	**1**	**1**	
SD					**23**	**34**	**36**		**43**		**0.1**	**0**	**1**		**19242**			
Range					**21–77**	**9–99**	**7–99**		**0–100**		**0–0.24**	**0–0.9**	**1–3**		**0–82414**	**1**	**1**	**Poor – moderate**

Root mat thickness

Root mat thickness ranged from 0–0.9 cm, with an average thickness of 0.2 cm (Table 4). Only three sites (9%) had a root mat thickness of 0.5 cm or more.

Ground moisture

The ground at most sites (59%) was moist (Table 6). Three per cent of sites were dry and dusty, with the rest (38%) dry in some places. No sites were classified as wet. Proportionally fewer sites were moist in April than in the later months of May and June.

Table 5: Number of sites by moisture level and month

	Dry and dusty	Dry in places	Moist	Wet	Sites searched
April	1	3	2	0	6
May	0	4	12	0	16
June	0	5	5	0	10
Total	1	12	19	0	32

Table 6: Percentage of sites by moisture level and month.

	Dry and dusty	Dry in some places	Moist	Wet
April	17	50	33	0
May	0	25	75	0
June	0	50	50	0
Total	3	38	59	0

Egg presence and productivity

A total of 32 sites were searched, with eggs found at only 19% of all sites (Figure 8 and Table 7). No eggs were found at any of the randomly generated sites searched in April. At an individual block level, only 4.7% of searchable blocks had eggs (Table 8). When calculated as a percentage of the total area searched, only 0.3% of the area had eggs present.

Figure 8: Randomly assigned sites in the Whanganui Awa assessed for habitat quality and searched for atutahi egg presence.

At sites where eggs were found, productivity ranged from 10 to 82,414 eggs per site (Table 9). Overall, this was lower than the productivity found by Rutledge (2019; Table 9). No sites in our study had egg densities in the moderate (1–10 eggs/cm^2) or the abundant (> 10 eggs/cm^2) categories.

Table 7: Sites searched by month and presence of eggs.

	April	May	June	Total
Sites with eggs	0	4	2	**6**
Sites searched	6	16	10	**32**
Sites with eggs present (%)	0%	25%	20%	**19%**

Table 8: Blocks and area searched and where atutahi eggs found.

Number of blocks searchable for eggs	Blocks with eggs	Blocks with eggs (%)	Area searched (m^2)	Area where eggs found (m^2)	Area where eggs found (%)
317.5	15	4.7	6,350	20.4	0.32

Table 9: Range of productivity compared with Rutledge's 2019 study – number of eggs per site.

	March	April	May	June
Ranges this study	n/a	0	10 to 82414	125 to 134
Ranges Rutledge (2019)	598 to 1,049,686	243 to 1,049,988	Only general observations, but levels similar to April	n/a

Habitat quality

When assessed against Orchard and Hickford's (2017) habitat criteria, 100% of sites fell into the poor category (Table 4). For individual blocks, 97.5% were poor, 1.9% were moderate, and 0.6% were high quality[1]. Using a modified threshold of 75% vegetation cover, 92.8% of individual blocks were poor, 5.9% moderate, and 1.3% high quality. At a site level, all sites again fell into the poor category using the modified threshold. Of the blocks where eggs were found, 100% were poor using the unmodified threshold, and all but one block (at site 57) fell into the poor category using the modified threshold (that is, 94% of blocks where eggs were found were classified as poor habitat using this system).

Using the adapted Whitebait Connection assessment system, 59% of sites were classified as poor habitat and 41% as moderate. Of the sites where eggs were found, two of six (33%)

[1] Note that we have not presented the individual site data in this report as it is too lengthy. However, we are happy to provide it to anyone who requests it.

were sites classified as poor and the remaining four (66%) were at sites considered moderate. Conversely, of the sites considered poor, only 11% had eggs, whereas 31% of the sites considered moderate had eggs.

Discussion

Bank angle

In general, the bank angle in the Whanganui is too steep for good quality atutahi spawning. Given that any angle over 35° is considered poor (Whitebait Connection 2017), the average of 50° in this catchment demonstrates the need to address bank angle to improve spawning habitat. Atutahi seem to be relying on small, slumped areas, such as that seen at Site 57 (Figure 9) of this study and at many of the sites in Rutledge (2019).

Figure 9: Site 57, showing slumped area where atutahi eggs were found. Photo: H Rainforth

Vegetation

Overhead shading is an issue in the Whanganui catchment, with an average of 37% of the area assessed shaded. Willow was by far the most dominant form of shading, at 84% of the dominant vegetation. The impact of shading by willows on spawning habitat in general is discussed in Taylor (2002) and was also identified as an issue for this catchment by Rutledge (2019), who stated that:

> In the mainstem the common feature of areas where eggs were found was their location in riverbank areas free of the extensive areas of large shading trees (mostly willows and alders) that typify the river's riparian zone. The stronger light environment away from heavy shading allowed rank grasses (typically mercer grass, tall fescue and creeping bent), some *Juncus* and herbaceous species (commonly *Ranunculus* and lotus) to develop and provide suitable habitat for īnanga to spawn in.

An example of the impact of overhead shading is site 100 (Figure 10) – the only ground vegetation even vaguely suitable for spawning at this site was found in the final block, which had no shading. The remainder was either bare mud or isolated patches of moss.

Sitting at an average of only 63%, ground cover could certainly be improved. This sits well below the 100% threshold that Orchard and Hickford (2017) use for either moderate- or high-quality habitat, and only in the 'ok' band for the Whitebait Connection assessment (Whitebait Connection 2017). Controlling willows and other invasive shading trees will help improve ground cover vegetation.

Most of the area assessed (62%) is dominated by some form of pasture grass, which is suitable for spawning. Ground vegetation *type* doesn't need to be improved – only its cover and thickness.

At an average of 45 cm, vegetation height is one of the few parameters that is in the 'good' category of the Whitebait Connection habitat assessment.

As noted, field horsetail (*Equisetum arvense*) was present at many sites. The impact of this species on atutahi spawning site selection and egg survival is not known. However, we were concerned that this species would make for poor spawning habitat and would outcompete other species better suited to spawning success.

Figure 10: Site 100, showing the lack of ground cover under willows. Photo: H. Rainforth

Stem density

Stem density is generally very poor in the Whanganui Awa atutahi spawning area, with only 6% of sites reaching the 0.2 stems/cm^2 density threshold. Given the importance of stem density for atutahi egg survival, this should be a focus for future restoration work. Actions might include stock exclusion, goat control, and creating gentle-gradient spawning bays where grass can establish without risk of slumping. For urban areas, such as Matarawa Stream, discussing mowing regimes with the District Council will be useful. This stream was previously known as a good spawning area, but the right bank appears to have been mowed, perhaps for planting purposes.

Root mat thickness

Orchard and Hickford (2017) consider any root mat less than 0.5 cm to result in moderate atutahi egg mortalities. Given the average root mat thickness across all sites was only 0.2 cm, we can expect only moderate to low survival of atutahi eggs in this catchment under current spawning habitat conditions. Only 9% of sites had a root mat thickness that would support good egg survival. Work is needed to improve root mat thickness in the Whanganui Awa.

Ground moisture

Unlike many other parameters, ground moisture levels in the spawning areas surveyed were predominately favourable and would generally support atutahi egg survival, if other aspects could be improved.

Egg presence and productivity

Only a very small area of the total area searched (0.3%) had eggs present. Considering the assessed the habitat quality, this is unsurprising. Overall, there is a strong need for work to improve atutahi spawning habitat and presence in the Whanganui Awa.

None of the randomised sites assessed in April had eggs present. This is possibly because fewer sites were searched in April (6 sites) than in May and June (16 and 10 sites respectively). Alternatively, it could be the effects of a flood event that occurred in the river prior to our April searches. We note that we did find eggs in a lower river tributary on a training day immediately prior to the April searches; flooding does not appear to have affected this tributary to the same extent as the mainstem was affected. We would otherwise expect to find eggs in April, as Rutledge (2019) found good numbers of eggs in March, April and May of 2019.

Productivity at our sites was generally lower than that at sites surveyed by Rutledge in 2019. This is most likely a result of the methods. Rutledge targeted areas of moderate to good habitat, where there is a greater chance of finding eggs, and finding higher numbers of eggs. Our methods, by design, meant we sought to look in all and any levels of habitat quality (although in truth no areas were of high quality).

Figure 11: Atutahi eggs at site 57, one of the few sites where eggs were found. Photo: H. Rainforth

Habitat quality

In this study we aimed to evaluate the overall state of potential atutahi spawning habitat in the Whanganui Awa – that is, the state of the habitat between the upper and lower extent of known atutahi spawning in this catchment.

Both assessment criteria we used showed that spawning habitat condition in this area is generally poor and needs improvement. Even at the scale of individual blocks, only 0.6% of the area assessed was classified as high quality, or 1.3% using a lower vegetation cover threshold of 75%. This habitat condition is reflected in the low percentage of blocks that had eggs present (4.7%) and the very small area in total where eggs were found (0.3%). Clearly, there is a strong need for improvement of spawning habitat in this awa.

In general, sites in a moderate condition (according to the adapted Whitebait Connection assessment) had a better chance of having eggs present than those in a poor condition (31%

compared with 11%). This indicates that the adapted scoring system is a useful approach to assessing the habitat condition.

A small number (11%) of the sites where eggs were found are poor quality using the adapted Whitebait Connection assessment system. We suspect that the eggs at these poor condition sites were in very small, isolated spots of better habitat within the wider block, although this level of detail wasn't assessed.

Reflections on the methods

Our surveys were a new way of assessing atutahi spawning habitat. As with all new approaches, there were some useful aspects and some aspects that could be improved. Below are some reflections on the methods for anyone wishing to conduct similar surveys.

Dominant vegetation

Most atutahi surveys take detailed recordings of vegetation present at the site. This is useful when building an understanding of the plants atutahi prefer to use for spawning. Given the extensive data already collected on this aspect, and our need to assess as many sites as possible in a limited time, we decided to only record the dominant vegetation in each 10-m block, as opposed to all vegetation. This also helped expand the number of people able to conduct the surveys, as one of the most time-consuming aspects of atutahi spawning surveys is observers becoming familiar with all the different plants. This is particularly the case for introduced grasses, which can be hard to tell apart. In terms of functionality from an atutahi's point of view, we didn't consider there was much gain in distinguishing Mercer grass from creeping bent, unless the observer was already familiar with the difference. Hence, at times, we just used the coverall description of pasture grass. In general, we found this approach useful.

Useful vegetation height

We measured maximum height of the ground vegetation (as opposed to the overhead vegetation). One question that arose, however, was whether it would be more useful to measure the average height of the ground vegetation, rather than the maximum height. This is particularly relevant for blocks where there were small clumps of tall fescue interspersed with mosses or other low-growing vegetation. Measuring maximum (excluding seed heads) at these sites gave a skewed impression of the vegetation. Average height might be more useful, however this should be tested.

We also wondered whether it might be more useful to measure only the height of the dominant vegetation, as opposed to the height of all the vegetation. As above, this would avoid situations where there are isolated clumps of taller grasses skewing the data. Again, this should be tested.

Stem density methods

After counting stems using both the approach of including stems from outside the quadrat and excluding them, we concluded that excluding stems from outside the quadrat may lead to a more consistent stem density count. It appears easier to get an accurate count by parting vegetation right down to ground level and using your fingers to follow any stems you are unsure of to the base of the plant to determine whether they originate within the quadrat or not. This also avoids the issue of having to decide whether a stem that is rooted outside the quadrat would qualify as a stem that's relevant to atutahi spawning, or whether it's too high along that stem to be of use, and only ended up in your quadrat because it was pressed down to ground level by the quadrat itself. It also avoids double counting – i.e., counting two or more stems that come from the same base, but have split off outside of the quadrat and are therefore hard to distinguish as being from the same plant, or of miscounting stems by not being able to view stems trapped underneath others by the quadrat. Furthermore, it reduces the risk of accidentally including dead stems, as you can easily follow a stem upwards to check whether it is live. Because grass stems are sometimes sheathed in dead outer material, it can be hard to tell live from dead when they're squashed down by the quadrat.

We suggest the following method for stem density counts in the future:

- Part the vegetation down to ground level, where atutahi would spawn. Place your quadrat on the vegetation. Gently pull stems that originate within the quadrat through the inside of the quadrat, so that they are upright. For taller plants such as rushes, you can place the vegetation through the quadrat before moving the quadrat to the ground. This will make it easier to ensure the vegetation is upright without too much disturbance. You will inevitably miss some that should be inside the quadrat and include some that should not. Adjust these as necessary when your quadrat is at ground level.
- Count all *living* stems within the quadrat – discount any dead material. A stem is one rooted plant, counted from its base where it emerges from the soil. If you're unsure about whether a stem is rooted within the quadrat, use your fingers to follow it to its base. If it splits off into leaves close to the ground, still count it as only one stem. Grasses will often look like one stem, when they are in fact multiple stems rooted very closely together. Be diligent about counting all grass stems. Count all rush stems individually. For creeping species such as *Tradescantia* and buttercup, stems can be defined as any point where creeping stems have become rooted within the quadrat.
- Take note of whether there is much leaf litter separately, including dead and decaying grass leaves.

Lastly, we placed the quadrats randomly within vegetation in each block. It may be better to place the quadrat within a randomly selected area of the *dominant* vegetation in each block.

This would better represent the stem density present in the block. Adding more stem density samples per block could also be useful.

Lack of consideration of flow influence

The randomised method we used does not account for the influence of flow preferences on spawning site selection by ripe atutahi, which have been shown to school in areas of quiet flow (Richardson and Taylor 2002). For example, bank habitat might be in good condition, but the site itself might be in an area where the river flow is moderate or fast. The flow might prevent atutahi selecting this site for spawning, but this aspect would not be shown in the data or factored into the site selection – although it could be through ground-truthing once on site. In future randomised surveys of large catchments, it would be useful to discard sites with faster flows.

Micro-habitat factors not well covered

In any single 10-m block, the bank angle could vary from a small slumped, flat area at the bottom, to nearly vertical straight above. Or it could be near vertical for a width of 4 m and taper off to 20° for the remaining 6 m. Taking one bank angle measurement for the whole 10 m fails to reflect this internal variation. For an atutahi, this makes a big difference. It may mean there is some small amount of useful habitat available in a block, but this is not reflected well in the data. The same issues apply at a site level. On the converse, it may mean the amount of useful habitat in one block is over-estimated.

On the other hand, atutahi will still lay on vertical slopes. It just means the area available to lay their eggs is reduced. It may be that average bank angle is not a particularly useful parameter to include. Alternatively, it may be better to assess what percentage of each block falls into predetermined categories. The (Whitebait Connection 2017) categories may be useful:

- < 7° *or* > 35°
- 21–35°
- 7–20°.

Aspect

We initially intended to only record aspect at sites where eggs were found. However, as we progressed, we noted that where overhanging trees were present, aspect seemed to affect the density of the grass underneath. Specifically, it seemed that southern and western-facing slopes had less grass underneath than eastern and northern facing slopes. However, analysing this finding was beyond the scope of this report. This may be a useful parameter to collect and analyse in future work.

Survey timing

Timing for the surveys is a matter to consider. We went to each site only once. This meant that some sites were surveyed a full two months apart from other sites, with a corresponding (but unmeasured) difference in humidity and ambient temperature. This may have affected our success in finding eggs at some sites. It may have been better to do repeat visits to each site, so that every site was visited every month to ensure an even chance of finding eggs. If taking this approach, one could undertake the habitat assessment just once, then return each month to check for eggs. However, given that the main aim was to assess the state of the habitat, rather than the presence or absence of eggs, this may not be an issue. Returning to each site each month would place increased time pressure on field workers and may be logistically difficult.

Photographs

It would be useful to take panoramic photographs of each site (see Figure 12 for an example), with brightly marked stakes showing the start and finish of each block. This would help with any checks needing to be made on site data after the survey date.

Because of the number of sites we needed to cover and the time needed at each site, our field team included multiple people, many of whom were new to atutahi spawning surveys. This made collecting and dealing with the photographs after the surveys time-consuming. It would be useful to dedicate one or two photographers, or to set up a photo sharing and management system prior to embarking on fieldwork.

We also ran into problems doing checks on egg identification after the surveys. All eggs found should be photographed. When photographing eggs, it is necessary to include a ruler for scale, and to take shots from multiple angles to avoid distortion. For those who are new to atutahi egg identification, Orchard, West et al. (in preparation) has a useful guide for how to tell the difference between slug and atutahi eggs.

Figure 12: An example of a panoramic that can be used for later data verification. Photo: L. Whitehead, DoC

Categories versus specific numbers

We recorded specific numbers for many of our parameters (e.g., the average bank angle, percent cover etc.) We then assigned scores to these after we had collected the data. This meant a retrospective assignment of scores. It would be quicker and easier to change the field sheet so that data is recorded in pre-assigned categories. For example, percent ground cover would be recorded as less than 50%, between 50 and 75%, or more than 75%, rather than, say, ‘37%’.

Recommendations

Spawning habitat restoration

Spawning habitat for atutahi in the Whanganui Awa is poor. Urgent work is needed to improve spawning habitat. This work should largely focus on willow removal, bank reshaping where possible, stock exclusion and reducing mowing, and measures to address sediment inputs from upstream.

Nearly 40% of the spawning area is shaded. Willows make up most of this overhead shading and prevent growth of both native and introduced spawning vegetation. We recommend an intensive programme of willow removal in the range of atutahi spawning – roughly from above Dublin Street Bridge up to Hīpango Park. Although written for another catchment, Denyer (2015) provides some practical advice on willow removal.

The type of vegetation present did not appear to be an issue, only its cover and thickness. Rank grasses are as good as native vegetation for atutahi spawning (Hickford, Stevens et al. 2018). Therefore, deliberate planting of native species may not be necessary. Rather, allowing introduced grasses to grow in areas cleared of willows should be sufficient.

Overall, stem density was low, including in areas clear of overhead shading. This may be due to stock access and mowing, or to bank angle and flood flows affecting grass growth. Given stock impacts on both spawning vegetation and egg survival (Richardson and Taylor 2002, Hickford and Schiel 2014), stock exclusion should be the first action taken. We note that one of the randomised sites surveyed (site 63) overlapped with a site assessed by Rutledge (2019). He found high numbers of eggs at this site, but in the period between surveys vegetation was eaten down by stock – habitat was poor during our assessment, and no eggs were found (Figure 13). The landowner is now aware of the issues and is planning to keep stock out of this area in the future. We include this as an example of how vulnerable known spawning sites are to stock access, and how important stock exclusion is. In urban areas of Whanganui where mowing still occurs, discussions with landowners and land managers are needed to alter mowing regimes (Hickford and Schiel 2014). Goat control in the upper section of the spawning zone may also be necessary. Stem density should then be monitored to determine whether it has improved sufficiently following these changes, or whether further action is needed. If stem density is still below that needed for good atutahi egg survival, we recommend trialling bank rebattering (where possible) and the creation of spawning bays and backwaters to test whether this improves stem density.

Sea-level rise due to climate change is likely to push both the saltwater wedge and the tidal extent further inland. To build resilience into the system, future spawning habitat restoration work, such as willow control, should extend beyond the current upstream extent and into the zone likely to be used by atutahi in future. Climate models should help to identify how far upstream to focus these efforts. Similarly, spawning areas currently at the lower extent should receive less attention, if modelling shows that these will become too salty in the future.

Figure 13: Mateongaonga Stream - stock access meant the vegetation at this site, where atutahi spawning has occurred previously, was low. The landowner is now planning to exclude stock. Photo: H. Rainforth.

With much of the spawning zone hemmed in by housing and roads (both urban and rural), and the remainder comprising large, steep banks composed of soft, fine sediment, addressing bank angle may be difficult. However, where possible, rebattering banks to a gentler angle of 7–20° and/or creating embayments and backwaters would be beneficial (Richardson and Taylor 2002, NIWA 2010, Stengs 2019). It may even be possible, in areas such as along Anzac Parade, to design the backwaters to also act as flood protection. See the Living Streams Handbook (Environment Canterbury date unknown) or the Cobdem Island restoration project (Stengs 2019) for more information on bank rebattering and backwater creation, and note that this work may need a resource consent.

Given the extensive length of the potential spawning zone in the Whanganui Awa, we do not recommend targeting areas of hard engineering (such as rip rap) for restoration. There are many other areas that can be improved first, at a lower cost and without extensive engineering.

Weed control, including for the reinvasion of willow, will be necessary on an ongoing basis in the Whanganui atutahi spawning zone (see for example the learnings in Stengs 2019).

Catchment restoration

This report focused on spawning habitat quality. However, the habitat for the entire lifecycle of the atutahi needs to be considered. There is little point restoring spawning habitat if juveniles and adults have poor upstream habitat to live in. Richardson and Taylor (2002) state that, ideally, the average summer temperature for all atutahi life stages – i.e., karohi through to atutahi – should be around 20° C. Karohi avoid temperatures above 22° C, meaning they will avoid migrating upstream if temperatures reach this (ibid). The average summer temperature in the Whanganui Awa at Te Rewa is 20.47° C (data supplied by Horizons Regional Council, March 2022). However, the average summer temperature for the last decade is 21.26° C, compared with 19.93° C for the decade before that, indicating possible climate change impacts. Addressing temperature will be crucial for atutahi health and long-term survival, especially as climate change impacts increase.

Further research and trials

This study was a first step in assessing atutahi spawning habitat at scale in a large catchment, using a randomised approach. Further work is needed to refine the methods, including research into which parameters contribute most greatly to an overall assessment of habitat quality, and whether and how to weight the parameters assessed. Hickford, Cagnon et al's paper (2010) goes some way to understanding this, with a finding that stem density and root mat thickness are correlated with egg survival, whereas the species of vegetation or vegetation height did not. More work is needed in this area.

Other matters to consider when refining the methods would be:

- whether to measure stem density only in the dominant vegetation in each block, or in any vegetation as we did
- whether to measure average vegetation height
- whether to only measure the height of the dominant vegetation.

The impact of field horsetail on atutahi spawning habitat seems to be unknown. Given its invasive nature and presence in the spawning zone, understanding how it impacts on spawning site selection and egg survival is very useful for future restoration efforts.

In the Whanganui Awa, the work of restoring atutahi spawning habitat will take several years. We recommend repeating this research in around ten years, to allow enough time for meaningful change to occur. The same sites should be resurveyed at that point and more added if possible. When planning where to undertake restoration actions in the catchment, the survey sites will need to be disregarded. If actions are focused around survey sites, rather than where the need is greatest, results of the reassessment will be skewed. New randomised sites would need to be generated if restoration efforts are focused on the sites surveyed in this research.

It would be useful to seek assistance from a geomorphologist to understand where in the mainstem or lower catchment that bank rebattering can be safely undertaken, and how this work can be conducted in a way that also helps to reconnect the awa to the floodplain. See, for example, the work undertaken by Burgess-Gamble, Ngai et al. (2018) on Natural Flood Management practices.

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