LAKE ROTORUA

ALUM DOSING MONITORING PROGRAMME 2025 FOR KŌURA AND KĀKAHI

REPORT No. 3 PREPARED FOR BAY OF PLENTY REGIONAL COUNCIL

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Rotorua, New Zealand

December 2025

Lake Rotorua Alum Dosing Monitoring Programme 2025 for Kōura and Kākahi

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Date: December 2025

Status: FINAL

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Citation

Kusabs, I. (2025). Lake Rotorua alum dosing monitoring programme 2025 for kōura and kākahi. Report prepared for Bay of Plenty Regional Council. Kusabs and Associates Ltd, Rotorua, New Zealand.

Cover image

Weed stranding at the Rotorua Lakefront, 18 November 2025. Photo: I. Kusabs.

Acknowledgements

Thanks to Brett & Chloe Bonnington for access to the lower Utuhina Stream through their property and assistance with kōura sampling. Thanks also to Alastair and Penny McCormick for access to Lake Rotorua at Hinemoa's Point and helping with kōura sampling. Thanks to Andy Bruere for project liaison.

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EXECUTIVE SUMMARY

This report presents the results of monitoring kōura (freshwater crayfish) and kākahi (freshwater mussels) populations in Lake Rotorua and the Utuhina Stream, undertaken as part of the alum dosing monitoring programme.

Two complementary sampling methods were used to monitor kōura populations: night-time spotlighting at the Rotorua Lakefront, and minnow trapping in the littoral zone of Lake Rotorua at Hinemoa's Point and the lower Utuhina Stream. Kākahi populations were surveyed at three sites using the established NIWA methodology, involving transects perpendicular to the shore and visual counts using a bathyscope. Surveys were carried out seasonally.

After three years of monitoring, kōura populations exhibit contrasting trends across the study sites. At the Lakefront, kōura abundance is increasing; however, densities remain below pre-development levels, likely reflecting the combined effects of aquatic weed inundation and predation by invasive catfish. Kōura populations at Hinemoa's Point have remained relatively stable, while catches in the lower Utuhina Stream have increased over the monitoring period. In contrast, kākahi densities have remained relatively stable at all three sites, with significantly higher abundances recorded at the Whittaker Road site.

Given the consistently low kōura numbers recorded during winter surveys at Hinemoa's Point and the Utuhina Stream, it is recommended that winter monitoring at these sites be discontinued in 2026. In addition, kākahi monitoring could be reduced to a single annual survey, undertaken in either spring or winter.

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INTRODUCTION

Water quality in Lake Rotorua has deteriorated since the 1960's because of excessive phytoplankton (algae) growths due to increasing phosphorus and nitrogen in the lake waters. The Lakes Rotorua and Rotorua Action Plan (Bay of Plenty Regional Council, 2007)[1] proposes to lower the trophic level index (TLI) of Lake Rotorua from 4.9 to 4.2 by reducing internal and catchment-derived nutrients (nitrogen and phosphorus). The Bay of Plenty Regional Council uses continuous alum treatment to lock dissolved reactive phosphorus in the Utuhina & Puarenga streams.

Monitoring in the Utuhina Stream has been carried out annually from 2006 to 2017 where no evidence has been found of any adverse impacts on fish and macroinvertebrates (Tempero, 2018)[2]. Nevertheless, aluminium can be toxic to fish. Kōura (*Paranephrops planifrons*; freshwater crayfish) and kākahi (*Echyridella menziesii*; freshwater mussels) are considered taonga (treasured) species by Te Arawa iwi. The main purpose of this programme is to monitor the kōura and kākahi populations in Lake Rotorua, near the confluences of the Utuhina and Puarenga streams, that is downstream of the alum dosing plants.

METHODS

Kōura sampling

Night-time spotlighting was used to determine the relative abundance of kōura at the Rotorua Lakefront (Lakefront) while traps were used to monitor kōura in the littoral zone of Lake Rotorua at Hinemoa's Point and in the lower Utuhina Stream (Fig. 1). When conditions were suitable (clear water, no wind) spotlighting proved to be an effective means of counting kōura (Fig. 2). Kōura are nocturnally active and so at night, we used a Fennix PD36R V2.0 Rechargeable Flashlight with a maximum of 1700 lumens and a narrow beam (0.40 m diameter at 5 m distance). Kōura and fish were counted by an observer walking quietly along the boardwalk and scanning the spotlight beam up to 5 m from the boardwalk.

Black, vinyl-coated steel traps with 11 mm by 5 mm diamond-shaped mesh (hereafter, minnow traps), were used to capture kōura. The assembled traps were 42 cm long and 22.5 cm in diameter with a funnel entrance tapering to the opening of 25 mm in diameter. Traps were baited with pre-frozen trout flesh. Traps were typically set in the afternoon and then retrieved the following morning (soak time was 14–18 h) so that they were fishing at night when kōura were most active.

[1] EBOP (2007) Proposed Lakes Rotorua and Rotoiti Action Plan: A programme for the long-term restoration of Lakes Rotorua and Rotoiti's water quality. Environmental Publication 2007/11. Environment Bay of Plenty, Whakatane, New Zealand. 165 pp.

[2] Tempero, G.W. 2018. Ecotoxicological Review of Alum Applications to the Rotorua Lakes: Supplementary Report. ERI Report No. 117. Client report prepared for Bay of Plenty Regional Council. Environmental Research Institute, Faculty of Science and Engineering, University of Waikato, Hamilton, New Zealand.

Kōura measurements

Kōura were counted, measured (orbit carapace length - OCL), sexed and reproductive and shell state recorded. All fish captured were identified and counted. Koura observed spotlighting were counted and size estimated, while fish were identified and counted. CPUE was defined as the number of kōura per minnow trap. After processing, all kōura were returned live to the water near the tau kōura. Total sample handling time for two people to retrieve and process the samples from each tau was typically 2 to 3 hours. Catch per unit effort (CPUE) was defined as the number of kōura per whakaweku and biomass per unit effort (BPUE) as estimated wet weight (g) of kōura per whakaweku.

Water clarity

Water clarity was assessed in the lower Utuhina Stream site on each sampling occasion using a water clarity tube (Fig. 5). The average of three readings was recorded. Water clarity was not assessed at Hinemoa's Point due to the extreme fluctuations in turbidity caused by water emanating from Puarenga Bay.

Kākahi

The NIWA kākahi monitoring methodology[3] that has been used to monitor kākahi populations in Lake Rotorua since 2017 was also used in this study[4]. Transects were located at three sites in Lake Rotorua (Fig. 1). At each site 100 m transects, 0.5 m wide, and perpendicular to the shore, were inspected out into the lake from standard points to a depth where the water was regularly wadeable. All kākahi in an area of 0.5 m wide running parallel to and up current from a weighted survey line were counted using an underwater viewer (Fig. 6). An "L" shaped measuring device constructed of 25 mm PVC pipe (1.2 m long x 0.5 wide) was used to measure water depth and to maintain the 0.5 m distance from the survey line. Counts were summed for each 1 m interval. Sediment type was visually assessed along the transect lines as mud, mud-sand, clean sand, gravely sand etc.

Where possible, surveys were carried out when weather conditions and water clarity allowed good visual observations to be made. Water clarity was deemed suitable when numerals on the tape measure were clearly visible at a water depth of 1 m. On some occasions, multiple visits were required to complete the surveys. Kākahi surveys were carried out on 20 January, 14 April, 8/22 July and 3 November 2025.

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[3] Nuri, S. H., Kusabs, I.A. and Duggan, I. C. 2020. Comparison of bathyscope and snorkelling methods for iwi monitoring of kākahi (*Echyridella menziesi*) populations in the shallow littorals of Lake Rotorua and Rotoiti. New Zealand Journal Marine and Freshwater Research. Published online: 17 December 2020.

[4] Kusabs, I.A. 2024. Lake Rotorua kōura and kākahi monitoring programme 2024. Report number 8 prepared for Bay of Plenty Regional Council. Ian Kusabs and Associates Ltd, Rotorua, New Zealand.

Figure 1 Approximate locations of kākahi (1, 2, 3) and kōura (Utuhina Stream, Lakefront & Hinemoa's Point) monitoring sites for the Lake Rotorua alum dosing monitoring programme.

Data analysis

ANOVA with post hoc Bonferroni-Holm comparisons were used to determine whether there were any statistically significant differences between mean kākahi densities at the seven survey sites. Data analysis and visualization was performed using Daniel's XL Toolbox add in for Excel, version 7.3.2 (Kraus 2014).

RESULTS

Kōura

Rotorua Lakefront

Four spotlighting surveys were carried out at the Lakefront from 25 January 2025 to 30 October 2025. A total of 74 kōura were counted in this year's survey an increase of 61% on the 46 recorded in 2024 and 252% on the 21 recorded in 2023 (Table 1).

Common smelt (*Retropinna retropinna*), common bully (*Gobiomorphus cotidianus*) and morihana/goldfish (*Carassius auratus*) were the most abundant fish species observed (Table 2). While pest fish species, mosquitofish (*Gambusia affinis*) and catfish (*Ameiurus nebulosus*) were common (30 to 50 individuals; Table 2). Brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*) and tuna (*Anguilla australis*) were present in low numbers on occasions (Table 2; Fig. 3). The slow rate of colonisation by kōura at the Lakefront is most likely due to regular aquatic weed inundation (cover photo) and the establishment of brown bullhead catfish (Fig. 2) in Lake Rotorua, major predators of juvenile kōura, that are now common at the lakefront (Fig. 3).

Table 1 Survey date, number, and estimated size of kōura observed at the Rotorua Lakefront from 28 June 2016 to 30 October 2025. Kōura size classes - extra-large (>40 mm), large (30 – 39 mm), medium (16-29 mm) and small (< 15 mm). # Kōura were collected with spotlights and dipnets and translocated to Kawaha Point prior to the commencement of redevelopment works at the Rotorua Lakefront. Note: construction works were largely completed by July 2021.

Date	Kōura (n)	Extra large	Large	Medium	Small
28 June 2016	99	5	61	16	17
25 October 2019#	57	3	20	22	12
31 August 2022	0	0	0	0	0
20 March 2023	1	0	1	0	0
4 August 2023	3	0	1	2	0
8 November 2023	17	0	11	5	1
8 February 2024	17	6	8	3	0
4 June 2024	4	0	3	0	1
28 August 2024	4	0	3	0	1
23 October 2024	21	3	8	8	2
25 January 2025	21	0	14	6	1
4 May 2025	29	0	13	5	11
23 July 2025	9	0	4	1	4
30 October 2025	15	1	5	6	3

Table 2 Survey date, number, and numbers of kōura, brown bullhead catfish (catfish), trout (rainbow = RT, brown = BT), tuna (Sf= shortfin, LF = longfin eel), goldfish, smelt (common smelt), bullies (common bullies) and gambusia (mosquito fish) observed at the Rotorua Lakefront from 31 August 2022 to 30 October 2025. Abundance classes = Abd – abundant, Com – common, Pst = present.

Date	Kōura	Catfish	Trout	Tuna	Goldfish	Smelt	Bullies	Gambusia
31 August 2022	0	0	1 BT	0	Abd	Abd	Abd	Com
20 March 2023	1	0	0	0	Abd	Abd	Abd	Com
4 August 2023	3	0	1 BT	0	Abd	Abd	Abd	Com
8 November 2023	17	18	1 RT	0	Abd	Abd	Abd	Com
8 February 2024	17	6	0	0	Abd	Abd	Abd	Com
4 June 2024	4	23	1 BT, 1 RT	0	Abd	Abd	Abd	Com
28 August 2024	4	13	1 BT	1 SF	Abd	Com	Com	Com
23 October 2024	21	23	1 BT	0	Abd	Abd	Abd	Com
25 January 2025	21	0	0	0	Abd	Abd	Abd	Com
4 May 2025	29	1	0	0	Com	Com	Com	Abd
23 July 2025	9	0	0	0	Pst	Pst	Pst	Pst
30 October 2025	15	56	0	1LF, 1 SF	Abd	Abd	Abd	Com

Figure 2 A kōura and large catfish observed at the Rotorua Lakefront in a nighttime spotlighting survey, 8 November 2023.

Figure 3 A tuna (longfin eel) observed at the Rotorua Lakefront during a nighttime spotlighting survey, 30 October 2025.

Hinemoa's Point

The kōura population at Hinemoa's Point was surveyed on 31 January, 14 April, 22 July and 4 November 2025 (Table 3; Fig. 4). All surveys were conducted during calm weather conditions (Kusabs 2023[5]). A total of 40 kōura were captured in 2025, with a mean CPUE of 0.50 ± 0.80 koura per trap (± 1 SD; Table 3). This was similar to 2024, when 42 kōura were captured at a mean CPUE of 0.53 per trap, and slightly lower than 2023, when 57 kōura captured at mean CPUE of 0.81 per trap (Table 3). There were no significant differences among years ($P > 0.05$).

The lowest catch was again recorded in winter (July) with only three kōura captured, similar to the two caught in July 2024 (Table 2). Below 10°C, food intake is low, and individuals show little to no growth. However, unlike in 2024, 15 kōura were captured in summer 2025 compared with just three kōura in summer 2024.

The mean OCL of kōura in 2025 was 25.5 ± 4.8 mm (±1 SD), compared with 24.7 mm in 2024 and 29.1 mm in 2023. Kōura were significantly larger in 2023 than in either 2024 or 2025 ($P < 0.05$); however, there was no significant difference between 2024 and 2025 ($P = 0.49$). Across the three years, kōura ranged from 13 mm to 43 mm OCL (Table 3). The proportion of females was 43.2% in 2025, compared to 40.4% in 2024 and 36.8% in 2023.

[5]Kusabs, I. A. 2023. Lake Rotorua alum dosing monitoring programme 2023, kōura and kākahi. Report number 1 prepared for Bay of Plenty Regional Council. Ian Kusabs and Associates Ltd, Rotorua, New Zealand.

Table 3 Survey date, sampling site, number of traps deployed, number of kōura collected, mean catch per unit effort, mean orbit carapace length, size range, and percentage female (n) from 10 - 20 minnow traps deployed at Hinemoa's Point, Lake Rotorua and retrieved from 15 March 2023 to 4 November 2025. Note: The first kōura survey was carried out at the McKay's property, however, owing to low catches all subsequent surveys have been carried out at the McCormick's property. * 3 kōura not sexed.

Date	Water Temp (ºC)	Traps	Kōura (n)	Mean CPUE	Mean OCL (mm)	Range OCL (mm)	Female %
15 March 2023#	20.0	20	4	0.20 (0.41)	28.8 (2.8)	26 - 32	50.0 (2)
3 April 2023	16.0	10	18	1.80 (2.15)	27.2 (6.5)	14 -39	44.4 (8)
4 August 2023	11.0	20	19	0.95 (0.94)	31.6 (7.1)	19 - 42	10.5 (2)
13 November 2023	17.5	20	16	0.80 (1.10)	28.3 (7.5)	18 - 43	56.3 (9)
12 February 2024	20.5	20	3	0.15 (0.37)	23.0 (8.9)	13 - 30	67.0 (2)
16 April 2024	18.0	20	31	1.55 (2.41)	25.7 (5.8)	14 - 38	38.7 (12)
9 July 2024	9.5	20	2	0.10 (0.31)	17.0 (2.8)	15 - 19	50.0 (1)
7 November 2024	18.0	20	6	0.30 (0.66)	22.8 (5.6)	15 - 30	33.3 (2)
31 January 2025	22.0	20	15	0.75 (0.79)	26.9 (5.3)	17 - 34	33.3 (5)
14 April 2025	16.0	20	9*	0.45 (0.95)	25.3 (3.8)	19 - 33	44.4* (5)
22 July 2025	9.5	20	3	0.15 (0.37)	28.0 (6.9)	20 - 32	33.3 (1)
4 November 2025	17.0	20	13	0.65 (0.88)	23.5 (3.8)	20 - 31	38.5 (5)

Lower Utuhina Stream

A total of 92 kōura were captured in the lower Utuhina Stream in 2025, compared with 56 in 2024 and 55 in 2023 (Table 4; Fig. 5). The mean CPUE in 2025 was 1.16 ± 1.10 (±1 SD) kōura per trap, which was significantly higher than in 2024 (0.70 kōura per trap; $P < 0.01$), but not significantly different from 2023 (0.96 kōura per trap; $P = 0.23$). There was also no significant difference between 2024 and 2023 ($P = 0.20$). The lowest catches were generally recorded in winter (Table 4).

The mean OCL of kōura in 2025 was 29.2 ± 6.7 mm (± 1 SD) compared to 30.6 in 2024 and 29.3 in 2023, with no significant differences among years (P=.23; Table 4). The smallest kōura recorded over the three years was 13 mm OCL and the largest 46 mm (Table 3). The mean percentage of female to male kōura was 45.1%, compared to 51.8% in 2024 and 59.2% in 2023.

Interestingly, three kōura collected in February 2025 were infected with *Astathelohania sp* commonly known as whitetail disease, along with one individual each in July and November. The infected kōura included two females and three males, ranging in size from 19 to 25 mm OCL. No infected kōura have previously been recorded at Hinemoa's Point or in the Utuhina Stream.

Table 4 Survey date, sampling site, number of traps deployed, number of kōura collected, mean catch per unit effort, mean orbit carapace length, size range, and percentage female captured in 9 to 20 minnow traps deployed at three sites in the lower Utuhina Stream and in Lake Rotorua at the mouth of the Utuhina Stream, 4 April 2023 to 18 November 2025. * 1 kōura not sexed. # the true right side of the stream was sampled on 9 November 2023 & true left on 12 November 2023.

Date	Temp °C	Water clarity (cm)	Site Description	Traps	Kōura (n)	Mean CPUE	Mean OCL (mm)	Range OCL (mm)	Female %
4 April 2023	-	-	Utuhina mouth	19	11	0.4 (0.7)	24.9 (5.4)	17 -35	72.7 (8)
18 August 2023	-	-	Utuhina mouth	9	5	0.6 (0.5)	29.0 (6.8)	20 - 38	40.0 (2)
18 August 2023	13	78	Lower Utuhina	9	9	1.4 (1.2)	28.0 (6.2)	18 - 38	44.4 (4)
9/12 Nov 2023#	16	85	Lower Utuhina	20	26	1.3 (1.3)	31.8 (5.7)	20 - 41	57.7 (15)
8 February 2024	17.5	83	Lower Utuhina	20	11	0.6 (0.7)	33.5 (5.5)	24 - 43	36.4 (4)
16 April 2024	14.5	75	Lower Utuhina	20	20	1.0 (1.1)	32.0 (5.3)	18 - 39	40.0 (8)
9 July 2024	11	84	Lower Utuhina	20	6	0.3 (0.5)	23.3 (5.0)	18 - 32	80.0 (4)
4 Nov 2024	16	81	Lower Utuhina	20	19	1.0 (0.9)	29.7 (5.7)	14 - 37	63.2 (13)
4 February 2025	17.5	86	Lower Utuhina	20	27	1.3 (1.2)	27.8 (5.3)	22 - 42	55.6 (15)
23 April 2025	16	87	Lower Utuhina	19	29	1.53 (1.22)	30.0 (7.4)	13 - 46	34.4 (10)
24 July 2025	13	76	Lower Utuhina	20	12	0.63 (0.83)	29.5 (7.7)	21 - 42	16.7 (2)
17 Nov 2025	17	42 - 85	Lower Utuhina	20	24	1.20 (1.01)	29.6 (6.8)	20 - 44	60.9* (14)

Figure 4 Kōura captured in a black minnow trap at Hinemoa's Point, 3 April 2023. Note: the trout flesh in the minnow trap.

Figure 5 Local kaitiaki Brett Bonnington and his grandson Jacob Martin measuring water clarity and sampling kōura using minnow traps set in the lower Utuhina Stream, 9 and 13 November 2023.

Figure 6 Surveying kākahi at Hinemoa's Point, 28 April 2022.

Kakahi

Kākahi mean density for the 2025 survey was 2.8 (± SD 2.8) kākahi m^{-2} compared to 2.1 in 2024 and 2.7 in 2022/23 with no significant differences among years (P = 0.43[6]). Once again, the highest densities of kākahi in 2025 were recorded at Whittaker Road with a mean density of 6.6 kākahi m^{-2}, followed by Hinemoa's Point (1.2 kākahi m^{-2}) and St Faith's (0.8 kākahi m^{-2}) (Table 5). Across the three survey years, kākahi were significantly more abundant at Whittaker Road (5.8 kākahi m^{-2}) than at the other two sites (P < 0.001). However, there was no significant difference between St Faith's (0.9 kākahi m^{-2}) and Hinemoa's Point (0.9 kākahi m^{-2}; P = 0.996).

[6] Kruskal-Wallis

Kākahi densities varied little among seasons (Table 6). Mean densities were highest in spring and winter and lowest in autumn and summer; however, these seasonal differences were not statistically significant (P = 0.78[7]).

Table 5 Mean (± SD) densities of kākahi (m^{-2}) at four sites (50 m^2) in Lake Rotorua, July 2022 to October 2024. ns – no survey. * Lakefront counts excluded from analysis. Note: In June 2023, abnormally high lake levels shortened transect lengths – 40 m at Whittaker Road, 50 m at St Faith's – and prevented surveying at Hinemoa's Point. Note: counts at Rotorua Lakefront were discontinued in 2023 due to the very low numbers of kākahi recorded and regular, large shoreline strandings of weed after storm events.

Date	Whittaker Road	St Faith's	Lakefront	Hinemoa's Pt	Mean ± SD
July 2022	4.9	0.6	0.02	1.6	2.4 ± 2.2*
November 2022	5.9	1.3	0.04	1.3	2.8 ± 2.7*
January 2023	2.7	0.7	ns	0.3	1.3 ± 1.3
April 2023	4.7	0.7	ns	1.0	2.1 ± 2.2
June 2023	6.8	2.6	ns	ns	4.7 ± 3.0
October 2023	9.4	1.0	ns	0.8	3.7 ± 4.9
February 2024	4.8	0.6	ns	0.8	2.1 ± 2.4
April 2024	3.4	0.9	ns	0.5	1.6 ± 1.6
July 2024	5.3	0.6	ns	0.3	2.1 ± 2.8
October 2024	6.6	1.3	ns	0.5	2.8 ± 3.3
January 2025	7.0	0.7	ns	1.2	3.0 ± 3.5
April 2025	5.1	0.6	ns	2.0	2.6 ±2.3
July 2025	7.8	0.8	ns	1.0	3.2 ± 4.0
November 2025	6.3	0.9	ns	0.6	2.6 ± 3.2
2022/23	5.7 ± 2.2	1.1 ± 0.8	0.03 ± 0.01	1.0 ± 0.5	2.7 ± 2.7*
2024	5.0 ± 1.3	0.9 ± 0.3	ns	0.5 ± 02	2.1 ± 2.3
2025	6.6 ±1.2	0.8 ± 0.1	ns	1.2 ± 0.6	2.8 ± 2.8

Table 6 Mean (±1 SD) seasonal densities of kākahi (m^{-2}) at three sites (50 m^2) in Lake Rotorua, July 2022 to November 2025.

Season	Number of surveys (n)	Mean kākahi density)
Spring	12	2.99 (3.12)
Summer	9	2.09 (2.32)
Autumn	9	2.12 (1.86)
Winter	11	2.93 (2.75)

[7] One way ANOVA

DISCUSSION AND RECOMMENDATIONS

This report marks the third year of the Lake Rotorua alum dosing monitoring programme. The sampling was carried out successfully and the methodology appears sound, albeit dependent on calm weather and/or water clarity.

At the Rotorua Lakefront, kōura abundance appears to be increasing, with 74 individuals recorded in 2025—a 61% increase from 2024 and a 252% increase from 2023. Despite this encouraging upward trend, kōura numbers have not yet returned to pre-development levels, when 99 individuals were observed in June 2016 and 57 were collected in October 2019. The slow rate of recolonisation at the Lakefront is likely influenced by regular aquatic weed inundation as well as predation pressure from invasive catfish, a major predator of juvenile kōura that is now common in this area.

At Hinemoa's Point, kōura abundance has remained relatively stable over the past three years. The mean CPUE was 0.50 koura per trap in 2025, similar to the 0.53 kōura per trap recorded in 2024 and lower than the 0.81 kōura per trap recorded in 2023. As in previous years, the lowest catches occurred during winter, with only three kōura caught in 2025. This pattern is consistent with low water temperatures typically recorded during winter (<10°C), when food intake and growth rates in kōura are greatly reduced (Hammond et al 2006[8]).

In the lower Utuhina Stream, kōura mean CPUE in 2025 was 1.2 kōura per trap, which was significantly higher than in 2024 (0.7 kōura per trap), but not significantly different from 2023 (1.0 kōura per trap). Catch rates remain more consistent here than at Hinemoa's Point, likely due to the spring-fed nature of the Utuhina Stream and its relatively stable water levels and temperatures, which rarely exceed 18°C. The lowest catches generally occurred in winter, while the highest catch rates were typically recorded in spring.

Kākahi densities increased slightly in 2025, with a mean of 2.8 kākahi per m² compared with 2.1 kākahi per m² in 2024 and 2.7 kākahi per m² in 2022/23. As in previous years, kākahi continue to be significantly more abundant at the Whittaker Road site than at St Faith's and Hinemoa's Point, indicating consistent spatial patterns in population distribution. Kākahi densities varied little among seasons but were generally highest in spring and winter and lowest in autumn and summer.

Given the consistently low kōura numbers recorded during winter surveys at Hinemoa's Point and the Utuhina Stream, it is recommended that winter monitoring at these sites be discontinued in 2026. In addition, kākahi monitoring could be reduced to a single annual survey, undertaken in either spring or winter.

[8]Hammond, K., Hollows, J.W., Townsend, C.R., and Lokman, P.M. 2006. Effects of temperature and water calcium concentration on growth, survival and moulting of freshwater crayfish, *Paranephrops.* Aquaculture, 251: 271–279.