# *Waiau Toa/Clarence and Wakaputawatea/Acheron rivers tarapirohe/black-fronted tern monitoring project - 2023/24 operational report.*

# Waiau Toa/Clarence and Wakaputawatea/Acheron rivers tarapirohe/black-fronted tern monitoring project - 2023/24 operational report.

Baylee Connor-McClean, Deleece Augustyn, and Mats Olsthoorn.

Wildlife Management International Ltd
PO Box 607
Blenheim 7240
New Zealand
www.wmil.co.nz

**Document Quality Assurance:**

This report was prepared by Wildlife Management International Limited for the Department of Conservation in fulfilment of contract the Black-fronted tern outcome monitoring component (DOC-6301990).

**Citation:**
Connor-McClean, B.; Augustyn, D. & Olsthoorn, M. (2024) *Waiau Toa/Clarence and Wakaputawatea/Acheron rivers tarapirohe/black-fronted tern monitoring project - 2023/24 operational report*. Unpublished client report prepared for the Department of Conservation and Environment Canterbury by Wildlife Management International Ltd, Blenheim.

| | |
|---|---|
| **Authors:** | Baylee Connor-McClean, Ecologist |
| | Deleece Augustyn, Ecologist |
| | Mats Olsthoorn, Ecologist |
| **Reviewed by:** | Dan Burgin, Operations Manager |
| | Samantha Ray, Operations Manager |



**Version History:**

| Version | Authors | Date | Reason for edition |
|---|---|---|---|
| 1 | Baylee Connor-McClean, Deleece Augustyn, & Mats Olsthoorn | 20 April 2024 | First iteration. |
| 2 | | | Final accepted document. |

**Cover Image:**
"Curious observer": Adult tarapirohe/black-fronted tern *(Chlidonias albostriatus)* alert over the presence of field workers at the nesting site, December 2023. Credit: Josh Overend.

## Contents

## Executive Summary

This report provides a summary of results of the breeding outcomes from Wildlife Management International Limited's (WMIL) third monitoring season of the current five-year tarapirohe/black-fronted tern *(Chlidonias albostriatus)* (2021/22 - 2025/26) collaborative project with the Department of Conservation (DOC) and Environment Canterbury (ECan). Table 2 outlines the breeding outcomes of tarapirohe on the Waiau Toa/Clarence and the Wakaputawatea/Acheron rivers in northern Canterbury, New Zealand.

Active nests were first detected on the Waiau Toa between 17-25 October 2023, and between 25-10 November 2023 on the Wakaputawatea. Detection methods included both field and helicopter surveys (the latter being conducted on 1 November 2023). The monitoring area extended from Lake Tennyson to just downstream of the Wakaputawatea and Waiau Toa confluence, the end of the trap line, and from the Severn Shelter on the Wakaputawatea down to the Waiau Toa confluence.

The monitored area is divided into three zones; the treatment zone (a continuous stretch of river under predator control with chick shelters placed on all breeding colonies), enhanced island colonies (mechanically enhanced islands to enhance water flow around the island, increased island height, supress weeds, and has chick shelters deployed on all sites), and the non-treatment zone (no trapping, chick shelters, or enhancement works carried out).

Over the course of the 2023/24 tarapirohe breeding season, a total of 325 active nests, equivalent to 650 breeding pairs, were detected and monitored across 18 known colonies on the Waiau Toa and Wakaputawatea rivers. A total of 269 (82%) nests were recorded on the Waiau Toa, and 56 (18%) on the Wakaputawatea. A total of 322 (99%) nests had a known outcome and, of these, 151 nests hatched ≥ 1 egg (0.47 hatched per nest). Between 100 and 175 chicks fledged (0.31 and 0.54 fledglings per nest) from the 61 nests that fledged ≥ 1 chick (Table 2).

Nest failures primarily attributed to predation events, which occurred across both treatment (43.5% of predation events) and non-treatment zones (56.5% of predation events). Through the deployment of trail cameras at 109 (34%) nests, it was possible to determine that karoro/southern black back gull *(Larus dominicanus)* and tarapirohe were the predominate predators, although incidents involving ngeru/cats *(Felis catus)* and a single tori hura/ferret *(Mustela furo)* were also observed. A total of 56 (9.6%) of all eggs were documented as deserted. The cameras helped determine egg and chick outcomes and allowed for recording of tarapirohe breeding behaviours in the absence of human disturbance. However, there were a high number of nests that showed signs likely attributed to a predation event such as footprints, absent eggs, residual yolk within the nest, and other trademark signs, but these had to be listed as 'unknown predator' as predator species could not be confirmed. Furthermore, likely predation events could have also been missed by the trail camera (e.g., the camera didn't trigger, the target was just out of shot, or a malfunction), or due to the nest not being monitored by a trail camera. Of all 108 recorded predation events, 43% were unidentified (unknown predators with 19.4% (n= 21) of unknown predation events occurring in predator control treatment areas compared to 23.1% (n= 25) in non-treatment areas). No kāhu/Australasian swamp harrier (*Circus approximans*) predation events were recorded this season which could be related to camera coverage or other factors. Further banding and monitoring should continue to elucidate this potential predation pressure on tarapirohe nests.

Chick shelters were also deployed, to provide tarapirohe chicks refuge from the elements and aerial predators. Trail cameras were installed to assess chick shelter use by tarapirohe and other species. A total of 42 chick shelters were deployed across enhanced islands (36% n=15), natural islands (48% n=20), or mainland colonies (17% n=7) within predator control treatment zones (Appendix 6). Of the 42 shelters, 17 (40%) were assessed via the installed trail cameras to see if, and when, they were used by the chicks. Chicks were observed using the chick shelter at some point within the ~7-day window of chicks hatching and becoming mobile at 14 (82%) of the nests.

To increase understanding of the tarapirohe population trends, adults and chicks were banded opportunistically throughout the season. By the end of the season, 10 adults and 41 chicks were banded, taking the tally of tarapirohe banded over the past three years to 213 (61 adults and 152 chicks).

WMIL has the following key recommendations for future work:

**Tarapirohe/black-fronted tern monitoring**

- Monitoring of breeding colonies along the Waiau Toa and Wakaputawatea rivers continues on an annual basis.
- Chick shelters continue to be used.
- Chick shelter efficacy, research questions, methodology, and analysis criteria are expanded and clarified.
- The cause and effect of intraspecific predation is investigated further.

**Tarapirohe/black-fronted tern banding and resighting**

- Continue with, and increase, tarapirohe banding efforts, to better understand recruitment and population trends.

**Predator suppression/monitoring**

- Predator trapping along 26 km of the Waiau Toa and Wakaputawatea rivers continues.
- Facilitate more targeted trapping, for species such as cats, through nocturnal leg-hold trapping and shooting.
- Prioritisation for karoro control is undertaken through either alphachloralose use or targeted shooting.
- Kāhu banding and predation monitoring continues annually.
- Implement residual pest monitoring to complement existing pest control operations through trail camera surveys and/or installing permanent tracking tunnel lines.

**Advocacy**

- More advocacy signage is put into place, at key locations such as the Cobb Cottage campsite, to increase education and awareness, while encouraging visitors to report band sightings to WMIL, eBird, and/or DOC. This could be an opportunity for local iwi to participate and influence the interpretation design, ensuring te ao Māori inclusion.

**Island enhancements**

- Existing enhanced islands are maintained. Upper Swimming Hole and Cow Island are priority. Swimming Hole should be discounted, due to the silty base layer. Full details on maintenance required is outlined in Table 6.
- Weeds are cleared from the heavily vegetated islands. If using chemical methods, ensure dead vegetation is removed after spraying. It could be beneficial to leave native grasses to provide shade.
- Create more enhanced islands. Good candidates are Mike's Rock, Bush Gully, and Crossing Colony (Table 7).

# *Waiau Toa/Clarence and Wakaputawatea/Acheron rivers tarapirohe/black-fronted tern monitoring project - 2023/2024 operational report*

## 1. Introduction

Environment Canterbury (ECan) and Department of Conservation (DOC) have co-funded a five-year project aimed at monitoring and improving the breeding success of tarapirohe/black-fronted tern *(Chlidonias albostriatus)* on the Waiau Toa/Clarence and Wakaputawatea/Acheron rivers. This report produced by Wildlife Management International Ltd.(WMIL), provides a summary of the 2023/24 tarapirohe breeding season on the Waiau Toa and Wakaputawatea. The results of various habitat enhancement and predator control work carried out at treatment zone colonies over the past 12 months are reported on, together with tarapirohe breeding results from the 2023/24 breeding season. Recommendations for future tarapirohe conservation are also provided.

For ease of reading, repeated information from previous seasons' reports regarding introductions and methods have not been included. Please refer to the 2022/23 report (Connor-McClean et al. 2023) for these sections.

Te Reo names are used throughout the document for all bird species after the first use (e.g., tarapirohe/black-fronted tern) and common English names for all mammalian predator species after the first use (e.g., paihamu/common brushtail possum).

## 2. Methods

### 2.1 Enhanced Islands

The monitored area is divided into three zones; the treatment zone (a continuous stretch of river under predator control with chick shelters placed on all breeding colonies), enhanced island colonies (mechanically enhanced islands to enhance water flow around the island, increased island height, supress weeds, and has chick shelters deployed on all sites), and the non-treatment zone (no trapping, chick shelters, or enhancement works carried out).

Please refer to the previous report (Connor-McClean et al. 2023) for information regarding island enhancements. No island enhancements, except for weed spraying by DOC, were undertaken prior to the start of this season.

### 2.2 Kāhu/Australasian swamp harrier banding

Please refer to Ray & Burgin (2023) for details on kāhu/Australasian swamp harrier *(Circus approximans)* survey methods, banding, and monitoring.

### 2.3 Tarapirohe/black-fronted tern monitoring

Please refer to the 2022/23 report (Connor-McClean et al. 2023) for details on tarapirohe survey methods, monitoring, and chick shelter use. See Figure 1 for surveyed areas, and locations of tarapirohe colonies.

### 2.4 Predator control

During August 2023, OSPRI carried out an aerial sodium fluoroacetate (1080) operation targeting paihamu/common brushtail possum (*Trichosurus vulpecula*) within the Bush Gully Tarndale block

(**Error! Reference source not found.**). This was part of the ongoing 'TB-free' control program for p ossum, aiming to prevent the spread of bovine tuberculosis (OSPRI 2023). The operational area borders the true left section of the surveyed Waiau Toa area from Lake Tennyson down to the Wakaputawatea confluence, covering a large proportion of the trapping network, upstream of the confluence.

WMIL no longer holds the contract to trap predators along the rivers, but this is undertaken between August and January each year. Trapping results are available on Trap NZ under the *Upper Waiau Toa/Clarence Trapping Project*. WMIL did undertake a preliminary Molesworth pest abundance camera trap survey under a different contract, which involved trail camera monitoring review of predators between the predator control treatment types (e.g., 1080 and trapping). Further details can be found in Lamb & Augustyn (2023).

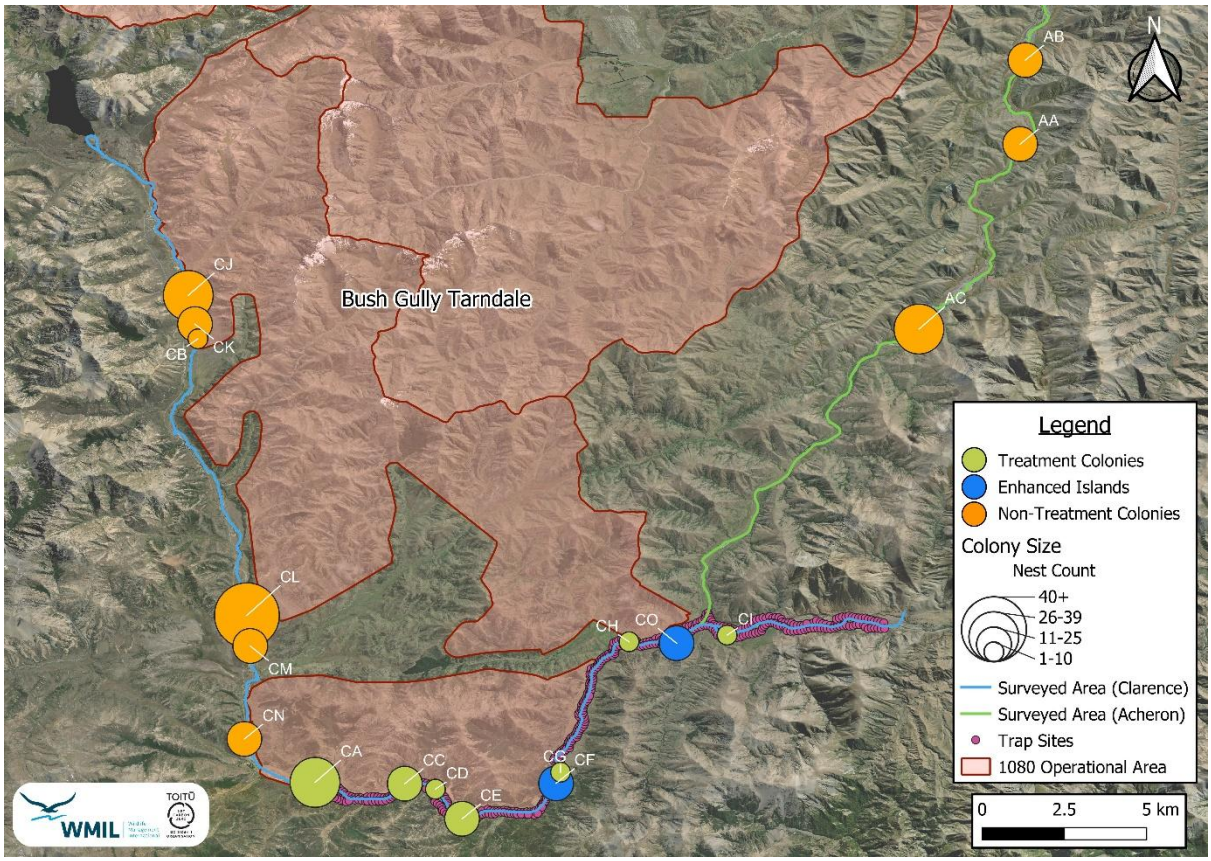



*Figure 1: Map of the Waiau Toa/Clarence and Wakaputawatea/Acheron rivers tarapirohe/black-fronted tern colonies and mammalian predator trapping network that overlapped with the August 2023 OSPRI 1080 operational area. Coloured circles outline the tarapirohe/black-fronted tern colony locations.*

# 3. Results

## 3.1 Enhanced islands

Only three of the seven original enhanced islands remained enhanced (Bridge Island, Upper Swimming Hole Island, and Mitchell's) as shown in Figure 2. Three of the remaining four islands (Cow Island, Upper Bush Gully, Eddy's Inlet (Figure 3) had all connected to the mainland with channels having dried up by the end of the season, and the final island (Swimming Hole) was too vegetated to be considered enhanced. Weeds, mainly common broom (*Cytisus scoparius*), rūpini/tree lupin (*Lupinus arboreus*) and skōti/gorse (*Ulex europaeus*), have become a problem on several islands (Table 6). Only two of the enhanced islands, Bridge Island and Mitchell's, were colonised by tarapirohe this season.

During winter 2023, river flow rates were relatively consistent, however, one major flooding event that occurred on 23 July 2023 caused river flow rates to spike at 143 $m^3/s$ (Figure 4). This flood would have put significant pressure on the braided river formation, causing islands to shift and channels to be altered including around enhanced islands. Despite the July 2023 flooding event altering some of the enhanced islands, new islands were created in the process and some previously existing islands became more favourable during the 2023/24 breeding season, such as Bush Gully (Figure 2 & Figure 5).

***Figure 2:*** *The remaining enhanced islands with comparison photos from October 2023 at 13$m^3/s$ (left) and January 2024 at 3$m^3/s$ (right) on the Waiau Toa/Clarence River. Top: Bridge Island; Middle: Upper Swimming hole; Bottom: Mitchell's.*

***Figure 3:*** *The state of some of the enhanced islands at the start of the 2023/24 tarapirohe/black-fronted tern breeding season on the Waiau Toa/Clarence River (October 2023). Top left: Upper Bush Gully; Top right: Swimming Hole; Bottom left and right: Cow Island (October).*

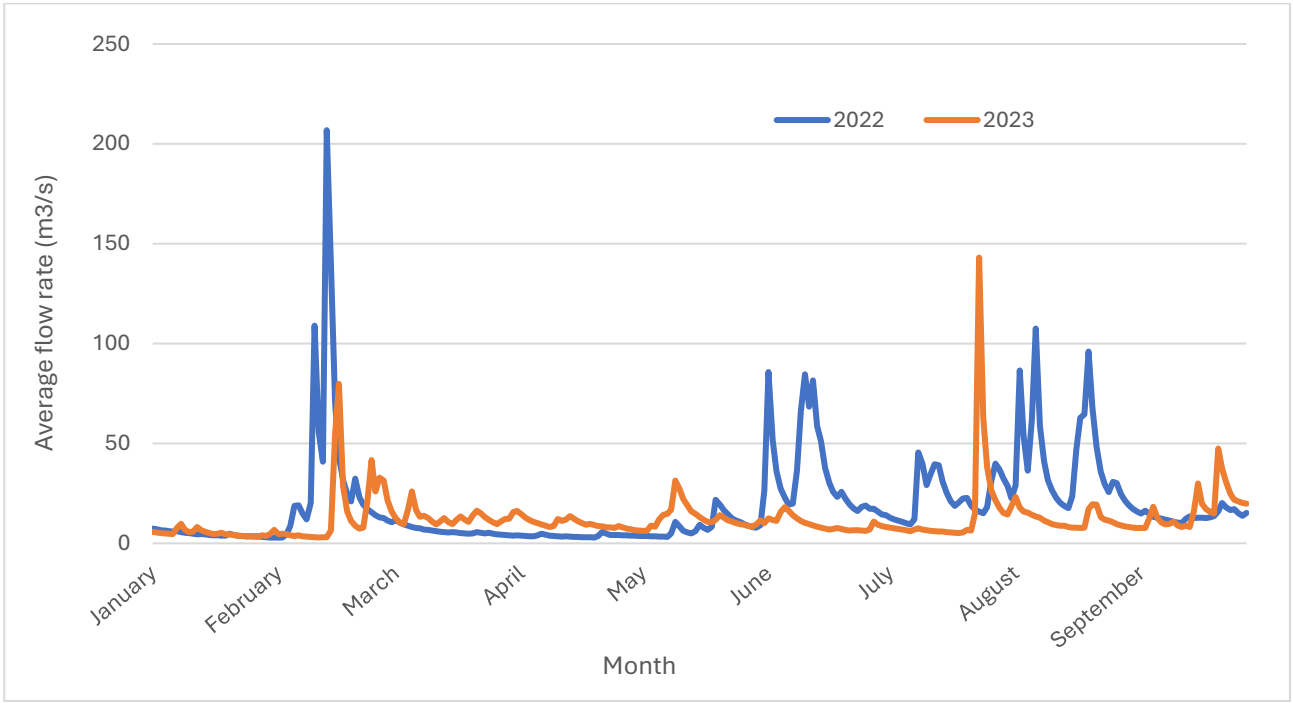



***Figure 4:*** *Comparison of average daily flow rates on the Waiau Toa/Clarence River during the months of January to October in 2022 and 2023.*

*Figure 5: A new natural island that emerged after bank stabilisation works redirected the river flow, and a significant flooding event in July 2023 at the Bush Gully site, Waiau Toa/Clarence River.*

## 3.2 Kāhu/Australasian swamp harrier banding

Nest predation by kāhu is known to have a significant impact on breeding tarapirohe (Bell & Harborne 2019). However, little is known on the population of kāhu around the Waiau Toa and the percentage of nests that are predated by different kāhu. To understand the extent of nest predation behaviour in the local kāhu population on tarapirohe nests, a capture and banding scheme was organised for the 2023/24 season (10-15 September 2023). A total of 103 kāhu have been captured and banded between 2021/22 and 2023/24. Further information can be found in Ray & Burgin (2023).

No kāhu predation events or band resights were noted this tarapirohe monitoring season.

## 3.3 Tarapirohe/black-fronted tern monitoring

### 3.3.1 Waiau Toa and Wakaputawatea river surveys

#### 3.3.1.1 Initial walk-through surveys

Initial walkthrough surveys were completed on 5 October 2023 on the Waiau Toa, and 13 October 2023 for the Wakaputawatea. Although no nests were found, there were several scrapes and the tarapirohe displayed agitated behaviour.

Eggs were first recorded on the Waiau Toa on 17 October 2023 at Lower Mitchell's and then on 25 October 2023 at Mike's Rock, Mitchell's, Bush Gully, and Confluence Colony. On Wakaputawatea, the first eggs were found at Acheron Island on 25 October 2023 and then at Paradise Island on 10 November 2023, after discovering the site by helicopter.

Subsequent surveys were conducted along the Waiau Toa throughout the breeding season where tarapirohe breeding behaviour was noted.

#### 3.3.1.2 Helicopter survey

A helicopter survey was conducted on 1 November 2023. The survey extended from Lake Tennyson to just downstream of the Wakaputawatea and Waiau Toa confluence, the edge of the treatment zone. The Wakaputawatea was surveyed from Severn Shelter to the Wakaputawatea and Waiau Toa confluence (Figure 6).

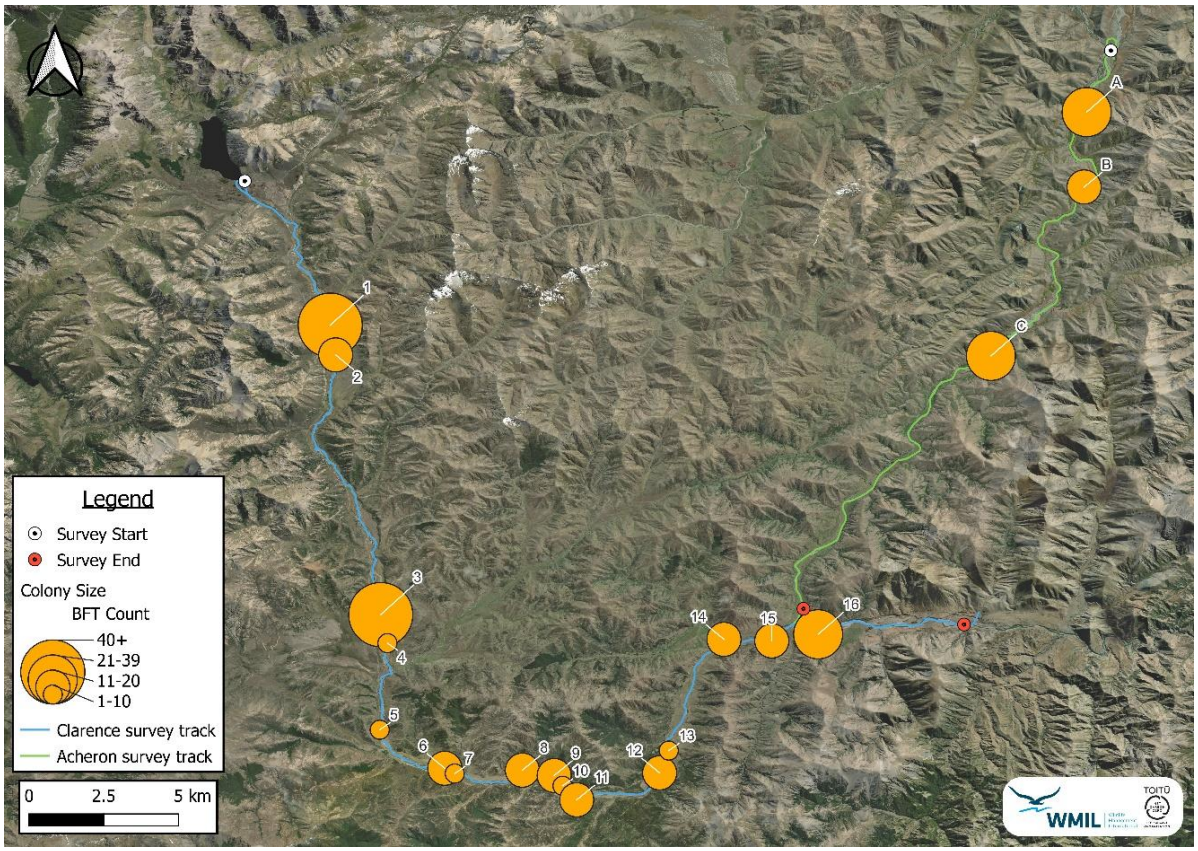



*Figure 6: Locations of tarapirohe/black-fronted tern potential colony sites and their population size during the 2023 helicopter survey along the Waiau Toa/Clarence and Wakaputawatea/Acheron rivers.*

A total of 452 tarapirohe were counted within 19 potential colony sites across both rivers. Seven of these sites were not previously found during the ground surveys. There were 16 (five new) sites on the Waiau Toa and 370 tarapirohe, 93 of which were seen between sites. On the Wakaputawatea, three (two new) sites were recorded, and 82 tarapirohe seen with 17 seen away from sites.

Some of these sites never had nests detected, so were not counted as monitored colonies, and some new sites were discovered during ground surveys. The final number of monitored breeding colonies was 18 (see Section 3.3.2).

### 3.3.2 Local population size and distribution of monitored breeding colonies

A total of 18 tarapirohe nesting colonies were located on the upper Waiau Toa and Wakaputawatea rivers this season (Figure 7). Colony sizes ranged from 1- 45 breeding pairs, with an average size of 18 breeding pairs.

The maximum number of active nests counted throughout the 2023/24 season reached 325, equating to a maximum number of 650 breeding birds on the Waiau Toa and Wakaputawatea rivers (Table 1). Of this, more birds were recorded on the upper Waiau Toa (269 breeding pairs) than on the Wakaputawatea (56 breeding pairs).

This represents a 4.8% increase in recorded nests compared to 2022/23, where 310 nests were recorded (Table 2). See Appendix 1 for the maximum combined nest counts from 2012/13 to 2023/24 on both the Waiau Toa and Wakaputawatea rivers. Appendix 2 and Appendix 3 show maximum nest counts from 2012/13 to 2023/24 for the Waiau Toa and Wakaputawatea rivers respectively.

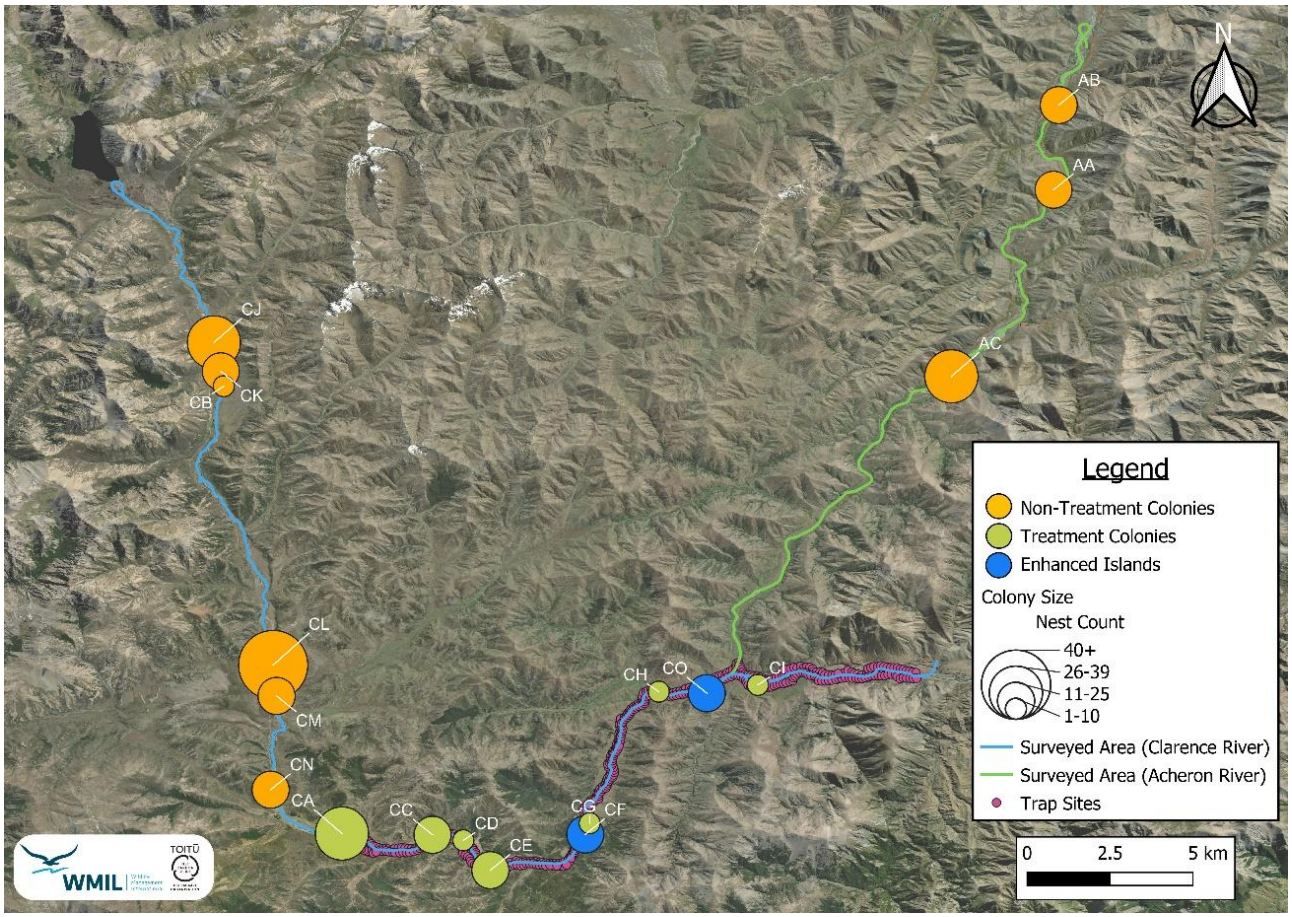



**Figure 7:** Tarapirohe/black-fronted tern colonies and population size along the Waiau Toa/Clarence and Wakaputawatea/Acheron rivers during the 2023/24 breeding season.

When viewing the maximum nest data separated by river, trends over time display a gradual increase in nesting pairs on the Waiau Toa (P= 0.119; correlation coefficient= 0.494) (see Appendix 2), whereas a steep decline in nesting pairs is visible on the Wakaputawatea (P < 0.05; correlation coefficient= -0.765) (see Appendix 3).

***Table 1:*** *Maximum number of nests and adult tarapirohe/black-fronted terns present on the Waiau Toa/Clarence and Wakaputawatea/Acheron rivers during each breeding season, 2012/13 to 2023/24.*

| Season | Active nests (Waiau Toa) | Active nests (Wakaputawatea) | Combined active nests | Number of breeding birds |
|---|---|---|---|---|
| 2012/13 | 177 | 202 | 379 | 758 |
| 2013/14 | 151 | 209 | 360 | 720 |
| 2014/15 | 154 | 149 | 303 | 606 |
| 2015/16 | 92 | 93 | 185 | 370 |
| 2016/17 | 275 | 118 | 393 | 786 |
| 2017/18 | 170 | 137 | 307 | 614 |
| 2018/19 | 211 | 52 | 263 | 526 |
| 2019/20 | 180 | 32 | 212 | 424 |
| 2021/22 | 185 | 56 | 241 | 482 |
| 2022/23 | 199 | 111 | 310 | 620 |
| 2023/24 | 269 | 56 | 325 | 650 |
| ***Footnote:*** *2020/21 has been excluded due to no monitoring being carried out that season. The darker shade of blue marks the beginning of the second 5-year study.* | | | | |

### 3.3.3 Use of enhanced islands

Tarapirohe attempted to nest on two of the remaining enhanced islands (Mitchell's and Bridge Island), but the Mitchell's colony was subjected to karoro/southern black back gull *(Larus dominicanus)* predation early in the breeding season. However, several re-nesting birds were successful in hatching and fledging chicks.

The late colony nesting on Bridge Island was subjected to predation by a ngeru/feral cat (*Felis catus*) when river levels dropped to 3 cumecs over the December – January period, leaving river channels on the true left very low. No chicks survived to fledge on this island.

### 3.3.4 Breeding Outcomes

Only 47% of tarapirohe nests hatched at least one egg, which is much lower than the 2022/23 season's hatching success of 61% (Table 2). Predation was the primary cause of known nest failures (33% of total nests, 10% higher than previous season), followed by desertion (17% of total nests) where 56 eggs (9.6%) were documented as deserted. Mainland colonies in the non-treatment block were heavily affected by predation, with 76% of nests being predated. In contrast, only 24% of nests on the mainland colonies in treatment areas failed due to predation.

There were 325 nests spread over 17 monitored colonies that successfully hatched 260 chicks (Table 2). Of these, 100 fledglings were confirmed. A further 75 chicks were estimated to have fledged as they were seen several days before they would have been old enough to fledge without events, such as flooding or predation, recorded to have impacted their success. Chicks were more likely to fledge in the treatment zone than the non-treatment zone (87% compared to 70% respectively).

However, establishing the fledging success of tarapirohe can be difficult as chicks often move out of the nest at a few days old. Once out of the immediate nesting area it is not possible to confirm which nest a chick is from unless they are banded. Furthermore, as chicks are highly camouflaged and will freeze when approached, they can be difficult to locate even with considerable search effort. Therefore, while a count of fledglings was undertaken during each monitoring visit, this count should be treated as the minimum number of successful fledglings. Appendix 4 provides a summary of breeding outcomes by location and treatment type, and Appendix 5 provides a summary of fledging success (eggs hatched vs. fledged) by treatment type.

***Table 2:*** *Tarapirohe/black-fronted tern breeding and fledging success during the 2023/24 season along the Waiau Toa/Clarence and Wakaputawatea/Acheron rivers separated by habitat and treatment type.*

| Tarapirhoe breeding outcomes 2023/24 | Overall | Treatment | | | Non-treatment | |
|---|---|---|---|---|---|---|
| | | Natural Island | Enhanced Island | Mainland | Natural Island | Mainland |
| Total no. of nests (A) | **325** | 47 | 40 | 17 | 188 | 33 |
| No. nests with known outcome (B) | **322** | 47 | 40 | 16 | 186 | 33 |
| No. nests in B that hatched ≥ 1 egg (C) | **151** | 13 | 19 | 4 | 111 | 4 |
| No. nests that failed | **174** | 34 | 21 | 13 | 77 | 29 |
| Total no. of eggs | **583** | 57 | 126 | 36 | 311 | 53 |
| *Of the nests in (B):* | | | | | | |
| No. eggs laid where fate known (D) | **579** | 56 | 126 | 36 | 311 | 50 |
| No. eggs where fate unknown | **4** | 1 | 0 | 0 | 0 | 3 |
| *Of the eggs in (D):* | | | | | | |
| Total number of eggs that hatched | **260** | 45 | 33 | 17 | 72 | 93 |
| Total number of eggs that died in incubation | **17** | 9 | 0 | 0 | 8 | 0 |
| Number of eggs that failed from other causes | **299** | 28 | 70 | 27 | 125 | 49 |
| **Hatching success (per nest) (E) = C/B** | **0.47** | 0.28 | 0.48 | 0.25 | 0.60 | 0.12 |
| *Nest Failure* | | | | | | |
| Total number of nests that failed | **174** | 34 | 21 | 13 | 77 | 29 |
| *Nest failure because of:* | | | | | | |
| Predation | **108** | 24 | 19 | 4 | 36 | 25 |
| Failed unknown/likely predation | **0** | 0 | 0 | 0 | 0 | 0 |
| Desertion (fertile eggs) | **56** | 7 | 2 | 8 | 35 | 4 |
| Abandoned and scavenged | **0** | 0 | 0 | 0 | 0 | 0 |
| Flooding | **0** | 0 | 0 | 0 | 0 | 0 |
| Died during incubation/ infertile | **7** | 3 | 0 | 0 | 4 | 0 |
| Damaged in nest | **0** | 0 | 0 | 0 | 0 | 0 |
| Heat stress | **1** | 0 | 0 | 0 | 1 | 0 |
| Failed, cause unknown | **3** | 0 | 0 | 1 | 2 | 0 |
| *Fledging Success* | | | | | | |
| Total no. females that attempted to breed | **325** | 47 | 40 | 17 | 188 | 33 |
| No. nests that hatched ≥ 1 egg | **151** | 24 | 19 | 6 | 100 | 2 |
| No. nests that fledged ≥1 chick (when/where possible) | **61** | 17 | 4 | 2 | 36 | 2 |
| No. nests that lost all chicks | **50** | 1 | 14 | 4 | 0 | 31 |
| No. nests with unknown fledgling outcome | **40** | - | - | - | - | - |
| No. chicks fledged as min/max **(F)** | **100/175** | 14/23 | 19/24 | 3/6 | 62/120 | 2/2 |
| **Fledging success (per nest, as min/max) (G) = F/A** | **0.31/0.54** | **0.30/0.49** | **0.48/0.60** | **0.18/0.35** | **0.33/0.64** | **0.06/0.06** |

### 3.3.5 Camera monitoring of nests

A total of 109 nests (34%) were monitored by trail cameras this season. Coverage varied between colonies depending on their location, accessibility, and discovery date (Table 3).

***Table 3.*** *Tarapirohe/black-fronted tern nest trail camera deployment coverage by colony on the Waiau Toa/Clarence and Wakaputawatea/Acheron rivers during the 2023/24 season.*

| River | Colony Location | Total Nests | Number of Cameras Deployed | Colony Coverage |
|---|---|---|---|---|
| Waiau Toa | CA | 34 | 15 | 44% |
| | CB | 7 | 3 | 43% |
| | CC | 14 | 5 | 36% |
| | CD | 1 | 0 | 0% |
| | CE | 19 | 9 | 47% |
| | CF | 15 | 6 | 40% |
| | CG | 2 | 2 | 100% |
| | CH | 6 | 2 | 33% |
| | CI | 7 | 2 | 29% |
| | CJ | 32 | 11 | 34% |
| | CK | 26 | 7 | 27% |
| | CL | 45 | 13 | 29% |
| | CM | 24 | 3 | 13% |
| | CN | 12 | 4 | 33% |
| | CO | 25 | 10 | 40% |
| | **Total** | **269** | **92** | **37%** |
| Wakaputawatea | AA | 15 | 4 | 27% |
| | AB | 14 | 4 | 29% |
| | AC | 27 | 9 | 33% |
| | **Total** | **56** | **17** | **30%** |
| **Combined Total** | | **325** | **109** | **34%*** |

*Footnote: *Average across all sites*

### 3.3.6 Predation events

Tori hura/ferret *(Mustela furo)* and karoro were the main known predators this season. Table 4 summarises all 2023/24 predation events on tarapirohe nests in relation to trapping regime and habitat type. Predator detections were primarily confirmed through direct observation from trail cameras. Where footage or evidence was inconclusive regarding which predator may be accountable, the predation outcome was recorded as "Unknown Predator". Figure 8 provides a series of examples of the trail camera footage collected over the survey period, including several instances of intraspecific predation by tarapirohe (Figure 8A).

***Table 4:*** *A summary of the 2023/24 tarapirohe/black-fronted tern nest predation events by predator species, habitat, and trapping treatment type. Note: no enhanced islands are within the non-treatment zone. SBBG = karoro/southern black-backed gull. BFT = tarapirohe/black-fronted tern.*

| Colony Location | | Predator Event Type | | | | | |
|---|---|---|---|---|---|---|---|
| | | Cat | Ferret | SBBG | BFT | Unknown | Total |
| Treatment (Trapping) | Natural | 0 | 0 | 1 | 9 | 14 | 24 |
| | Enhanced | 1 | 0 | 11 | 1 | 6 | 19 |
| | Mainland | 1 | 0 | 0 | 2 | 1 | 4 |
| | **Total** | **2 (1.9%)** | **0** | **12 (11.1%)** | **12 (11.1%)** | **21 (19.4%)** | **47 (43.5%)** |
| Non-Treatment (No-Trapping) | Natural | 6 | 0 | 12 | 1 | 17 | 36 |
| | Enhanced | 0 | 0 | 0 | 0 | 0 | 0 |
| | Mainland | 0 | 16 | 0 | 1 | 8 | 25 |
| | **Total** | **6 (5.6%)** | **16 (14.8%)** | **12 (11.1%)** | **2 (1.9%)** | **25 (23.1%)** | **61 (56.5%)** |
| **Combined Total** | | **8** | **16** | **24** | **14** | **46** | **108** |

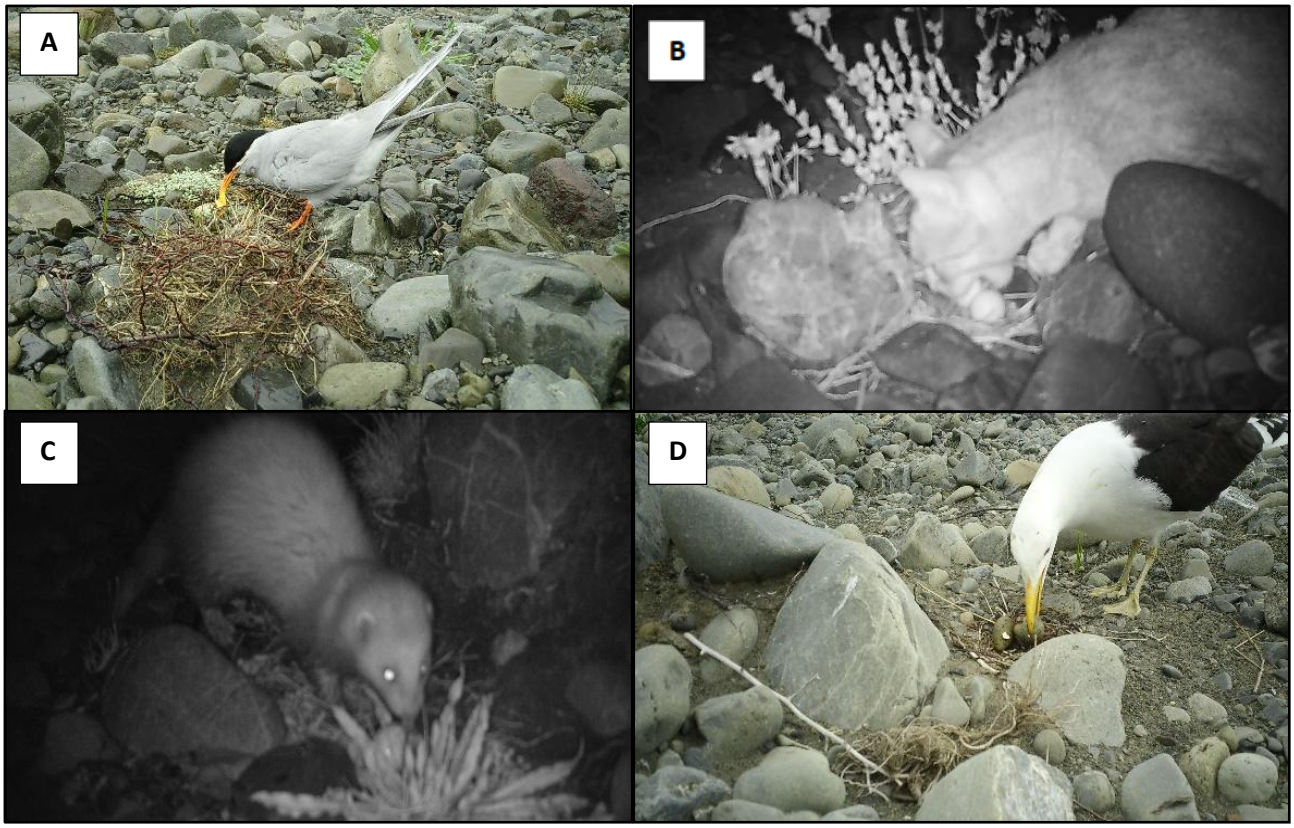



***Figure 8:*** *Predation events during the 2023/24 tarapirohe breeding season. A) Tarapirohe/black-fronted tern B) Ngeru/feral cat C) Tori hura/Ferret D) karoro/southern black-backed gull.*

### 3.3.7 Chick shelter use

Overall, a total of 42 shelters were deployed (see Appendix 6) across treatment colonies that were within the habitat modification zones (enhanced) (n=15, 36%), natural islands (n = 20, 48%), or mainland (n=7, 17%), and within predator control treatment zones (trapped). Of the 42 shelters, 17 (40%) were assessed via the installed trail cameras to see if, and when, they were used by the tarapirohe chicks. Chicks were observed using the chick shelter at some point within the ~7-day window of hatching and becoming mobile at 14 (82%) of the nests.

Several other behaviours were noted from the trail camera footage. The shelters were used by tarapirohe adults and chicks in a range of climatic conditions, from high temperatures to heavy downpours. During sunnier days, adults were also seen brooding and feeding chicks under the shelter (Figure 9C), suggesting the shelter does not alter normal chick-rearing behaviours. Chicks were seen using the shelters to escape from predators, including karoro.

On several accounts, field staff noted chicks running to shelters when approached by the field staff to carry out nest checks and camera servicing. Other species, including pohowera/banded dotterel *(Charadrius bicinctus)*, were also documented using the shelters (Figure 9D).

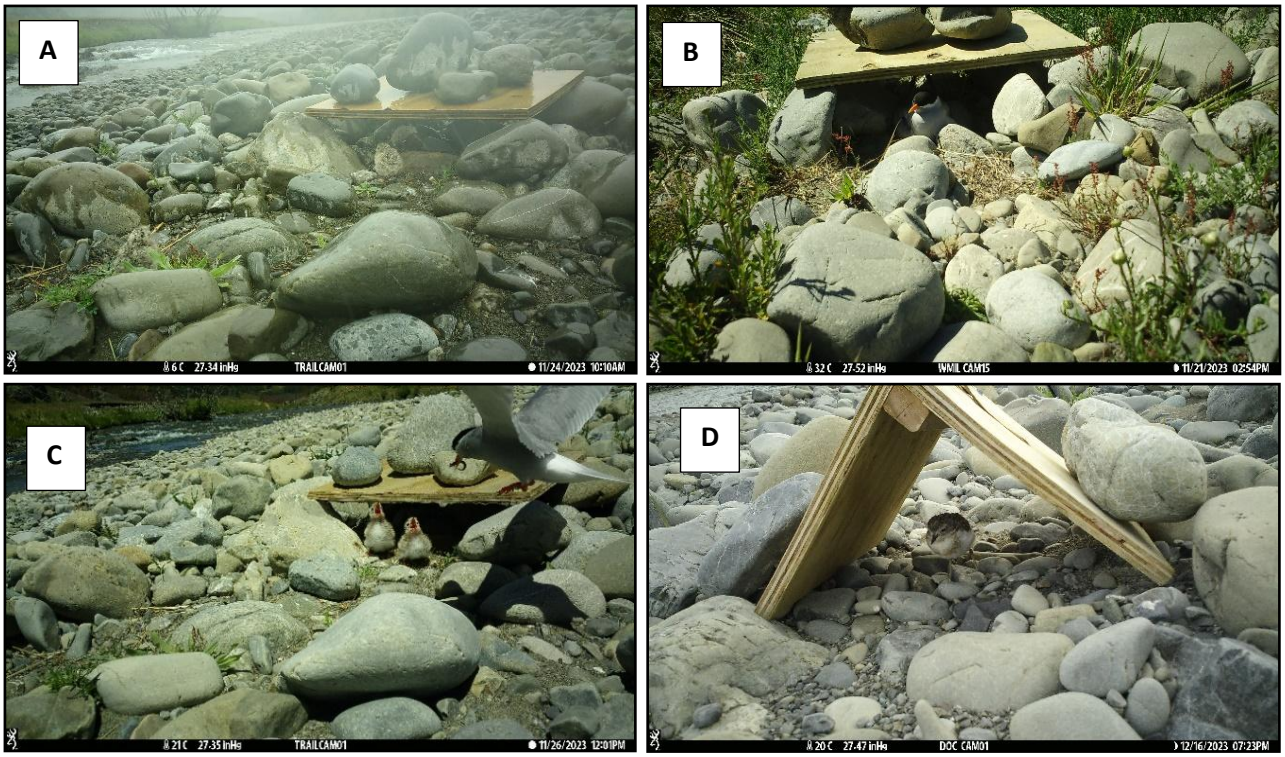



*Figure 9: Tarapirohe/black-fronted tern chick shelter use series A) tarapirohe/black-fronted tern chick sheltering from rain, B) tarapirohe/black-fronted tern adult brooding chicks, C) tarapirohe/black-fronted tern chicks being fed, D) Opportunistic pohowera/banded dotterel chick.*

# 4. Tarapirohe/black-fronted tern banding and resighting

## 4.1 Adult tarapirohe/black-fronted tern banding

Tarapirohe banding occurred over several days in November and December 2023. Ten adults were banded across five colonies; one on Wakaputawatea and four on Waiau Toa (Figure 10).

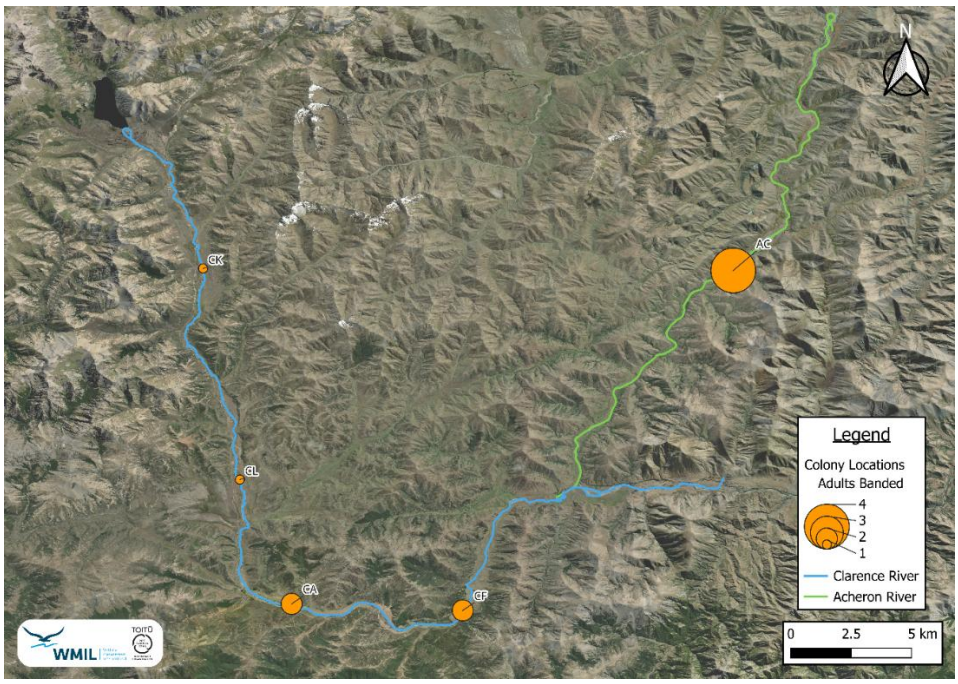



*Figure 10: Location and count of tarapirohe/black-fronted tern adults banded during the 2023/24 breeding season on the Waiau Toa/Clarence and Wakaputawatea/Acheron rivers.*

## 4.2 Tarapirohe/black-fronted tern chick banding

Tarapirohe chick banding was conducted throughout December 2023 and January 2024, with a concentrated effort between 14 and 19 December 2023. A total of 41 chicks were banded across 10 colony sites; one on Wakaputawatea and nine on Waiau Toa (Figure 11).

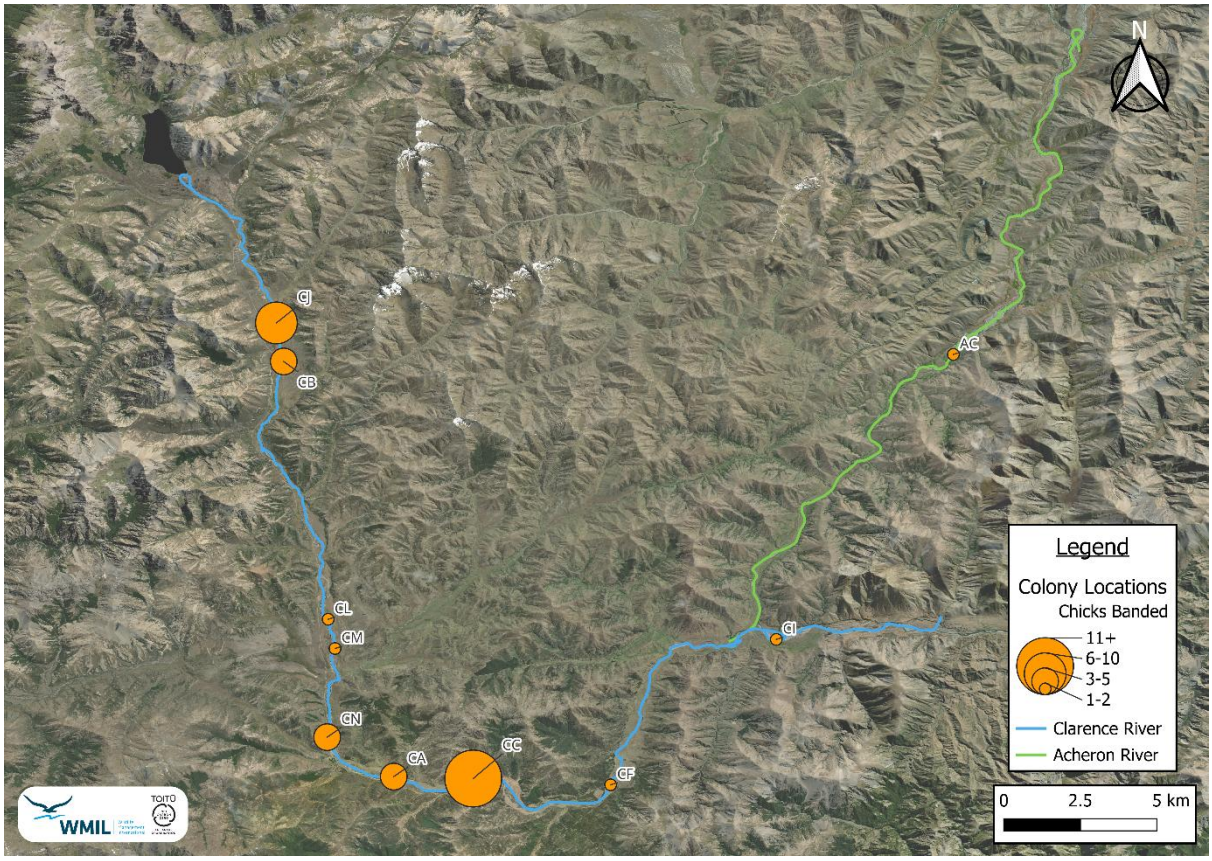



*Figure 11: Location and count of tarapirohe/black-fronted tern chicks banded during the 2023/24 breeding season on the Waiau Toa/Clarence and Wakaputawatea/Acheron rivers.*

## 4.3 Tarapirohe/black-fronted tern banding and re-sighting

The total number of tarapirohe banded this year was 51 (10 adults and 41 chicks). This is lower than last year but slightly higher than the 2021/22 breeding season. The total number of birds banded over the past three years is 213 (61 adults and 152 chicks). Table 5 summarises the past three years' worth of banding.

*Table 5: Tarapirohe/black-fronted tern banding totals for each season between 2021/22 to 2023/24 showing adult and chick tallies.*

| | 2021/22 | 2022/23 | 2023/24 |
|---|---|---|---|
| Adults | 31 | 20 | 10 |
| Chicks | 18 | 93 | 41 |
| **Total** | 49 | 113 | 51 |
| **Total banded over three years** | | | **213** |

There were 31 individual band and/or yellow flag resights made throughout the 2023/24 season. Most bands resighted were from trail cameras with 93% (n=29) captured via this method. The remaining 7% (n=2) of sightings were from recaptured birds. Nest cameras remain the best and least invasive way to resight bands (Figure 12). Of these resights, 77% (n=24) were tarapirohe banded during previous years: 2012 (n=1), 2013 (n=1), 2014 (n=1), 2016 (n=11), 2017 (n=2), 2018 (n=2), 2021 (n=4), 2022 (n=2), and 2023 (n=7).

All banding data can be retrieved from the DOC online FALCON banding database under the '*Black-fronted tern study'* project.

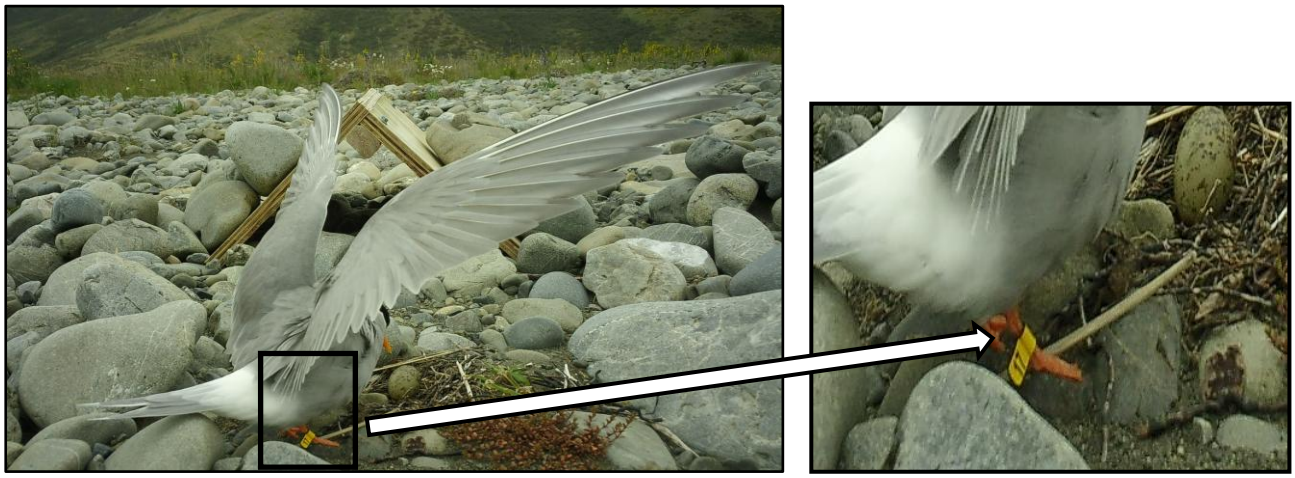


***Figure 12:*** *Returning tarapirohe/black-fronted tern adult with yellow flag (17) detected nesting at Crossing Colony, 4 January 2024.*

# 5. Discussion

## 5.1 Tarapirohe/black-fronted tern breeding outcomes

To minimise human disturbance and observe uninterrupted breeding behaviour and outcomes both active (in the field) and passive (trail camera) tarapirohe surveys were conducted. These monitoring methods enable the observer to surmise the breeding success by determining egg/chick outcomes, witness any predation events, and provide valuable insights into colony and individual behaviours.

Hatching success in both treatment and non-treatment areas was lower than the previous two seasons (61% in 2021/22, and 68% in 2022/23), but higher than the average of the previous seven seasons (47% in 2023/24, compared to 44% which is the average across the previous seven seasons. Many nests failed early in the season, causing a significant amount of re-nesting attempts. This may cause the breeding population to appear significantly larger than it is. Predators continue to be the main known cause for nest failures across seasons, particularly for mainland colonies outside of the treatment zone. One colony, "The Battler's," was heavily predated by a single ferret, destroying 16 nests.

Fledgling success was also lower this season at 0.31/0.54 fledglings per nest, compared to 0.46/0.68 in the 2022/23 season. This was largely due to a few colonies experiencing heavy predation and bringing the average fledgling success down. For example, none of the chicks that hatched on Bridge Island survived, with all 25 assumed predated by one cat. This is likely due to the river on the true left of the island being very low during the dry months and being ineffective as a predator barrier. Cats are also assumed to be responsible for the predation of chicks on Motu Island, another colony with poor fledgling success, after detecting a cat on nest cameras. Larger chicks may have fled to the river and got swept away as a behaviour to escape danger. Fledglings at other colonies were much more successful, with some fledging 100% of their chicks including, Upper Swimming Hole, Mike's Rock, Mitchell's, and St. James, all of which were surrounded by strong channels.

## 5.2 Nest predation

To date, trapping appears to have prevented ferret and toriura/stoat *(Mustela erminea)* predation within treatment areas. This suggests that these predators can be suppressed to levels which positively benefit tarapirohe. Cat predation, however, appears to be slightly higher than the past few seasons. Since the 2017/18 season, cats have only been recorded predating nests on mainland

colonies (Connor-McClean et al. 2023), yet this season they were recorded on islands, one of which was enhanced most likely due to narrow, low-flowing channels during months of drought. Cats have been identified as a problematic predator to trap (Connor-McClean et al. 2023); this season they were detected in both trapping and non-trapping zones eating eggs and tarapirohe chicks and are also thought to have caused several nest abandonments.

Evidence from this season indicates that tarapirohe in non-treatment (not trapped) zones experienced higher predation with 56.5% (n=61) of recorded predation events, in comparison to those in treatment (trapped) zones with 43.5% (n=47) of recorded predation events. Of the three enhanced islands, none were successful at protecting tarapirohe from predation. This is predominantly due to avian predators such as karoro having easily accessible access to these colonies throughout the season. Within the summer months, drought also caused channels around enhanced islands to dry out, revealing stepping stones and narrow sections of low-flowing water, allowing mammalian predators easier access to these sites. It is thought that a select number of individuals have learnt that tarapirohe nests provide an easy and abundant food source and return yearly. As karoro are unaffected by trapping or island enhancements (11.1%; n=12) predation in both treatment and non-treatment), a different approach is essential to mitigate their impacts on the tarapirohe colonies and should be prioritised in subsequent seasons.

No kāhu predation events were recorded this season which could be related to camera coverage or other factors. Further banding and monitoring should continue to elucidate this potential predation pressure on tarapirohe.

Tarapirohe individuals tend to settle near other conspecifics (Schlossberg & Ward 2004; Ward et al. 2011) and conspecific attraction has been reported to influence and play a role in colony size with synchronised breeding within a colony often attributed as a predator defence strategy (Reed & Dobson, 1993). Conspecific behavioural cues indicate habitat suitability (Ahlering & Faaborg, 2006), reducing time and energy output which could be beneficial with highly dynamic changes between breeding seasons (Ward et al. 2011). Hatching within a short space of time, creates a predation dilution effect and increases the chance of survival for some chicks.

However, as much as conspecific interactions may play a positive role in breeding success, there are also instances where intraspecific competition impacts on a colony's breeding outcomes.

### 5.2.1 Intraspecific predation

This season an increased number of intraspecific predation events were detected at tarapirohe colonies. This could be related to myriad factors.

Food availability may be a factor influencing this. As Connor-McClean et al. (2023) alluded to, amongst the surrounding exotic grassland there are also native tussock grasslands. The latter ecosystem provides habitat for many native invertebrates and lizards (Mark et al. 2013), which are an important food source to tarapirohe (O'Donnell & Hoare 2009). Introduced conifers, which are increasing within the Molesworth Recreation Reserve. This may be impacting invertebrate and lizard diversity (Dickie et al. 2011) by altering habitat availability. There is also potential for additional stressors on these food sources from the conifer aerial control treatments, which may also be negatively impacting non-target flora species close to the target species (conifers). This may negatively impact invertebrate habitats, thereby lowering tarapirohe prey availability. Similarly, 1080 has a high toxicity rate to invertebrates if enough is ingested (either directly or through secondary ingestion), which may also be detrimental to these food sources, however no evidence to suggest adverse effects on invertebrate populations at scale is available (OSPRI nd; Spurr 2012).

There is also speculation that the prolonged winter weather that carried into October may have caused tarapirohe to burn energy faster while regulating body temperature, requiring high density nutrients at an increased rate leading to the predation of eggs by other nesting birds close by. Most of the nest predations by tarapirohe occurred within the October months when a couple of snowstorms

developed during the incubation period (Figure 13). Through research on intraspecific predation in shorebird species, it is evident that this is not an uncommon occurrence. In Kubelka's 2020 review of inter and intraspecific predation within shorebird species, accounts of intraspecific predation were noted arising in populations of ruddy turnstones (*Arenaria interpres*) and snowy sheathbills (*Chionis albus*). Both populations were in harsh environmental conditions in the Arctic or Antarctic zones.


***Figure 13:*** *Tarapirohe/black-fronted tern incubating during snowstorm, 27 November 2023.*

More monitoring is needed to understand the intra-specific predation events documented at the beginning of the season. The hope is that with more banded individuals, there is a higher chance of confirming colony representation and determining which tarapirohe are exhibiting this behaviour. This represents another area of study notably exploring whether resources e.g., habitat type, prey abundance, or dietary intake, place any correlation to such events.

### 5.2.2 Unknown predator events

There were a high number of nests that showed signs of possible predation such as footprints, absent eggs, residual yolk within the nest, and other trademark signs, but these had to be listed as 'unknown predator'. Furthermore, possible predation events could also be missed by the trail camera (e.g., the camera didn't trigger, the target was just out of shot, or a malfunction), or due to the nest not being monitored by a trail camera. Of all 108 recorded predation events, 43% were unknown (with 19.4% (n= 21) of unknown predation events occurring in predator control treatment areas compared to 23.1% (n= 25) in non-treatment areas).

## 5.3 Chick shelters

This season chick shelters have proven to be an effective management tool for tarapirohe. Chick shelters were utilised by chicks for protection from the elements and occasionally predators with 82% (n=14) of the chick shelters being used within the first 7 days of hatching.

This is also the first season where evidence of adults using the chick shelters has been recorded. Main reasons for adult use of chick shelters were to brood their chicks in the shade, or to feed chicks.

Typically, to avoid predator detection tarapirohe chicks will rely on their camouflaged down to blend amongst the surrounding rocks. During the 2022/23 season, one chick was observed running and

hiding in the shelter during a karoro predation event (Connor-McClean et al. 2023). Additionally, three observations were made of chicks running to the safety of their nest and chick shelter upon approach by an observer. The chicks would freeze under the shelter until the observer left. This is the second season where chicks have been observed to use the chick shelters to escape predators. Due to most predation events occurring during the night, capturing the use of chick shelters to escape danger is difficult.

Additionally, species such as banded dotterel were also detected using them. WMIL has presented a broad overview of chick shelter use and further in-depth analysis could be undertaken outside of the original scope.

## 5.3 Island enhancement

Although island enhancement is a beneficial tool when used in conjunction with other management methods, they need consistent upkeep. The braided river system is highly mobile, with the cumulative impacts of climatic events (particularly in extreme scenarios) playing a major role in their formation and morphology. Without consistent maintenance enhanced islands could potentially lose important enhancement features.

While island enhancement works (channel clearing, vegetation clearance etc.) have been undertaken on Waiau Toa prior to the start of previous seasons, this season weed spraying was the only work undertaken. Consequently, only three enhanced islands (Upper Swimming Hole, Mitchell's, and Bridge Island) remained enhanced in the strictest sense (i.e. separated from the mainland, raised enough to avoid flooding, mostly cleared of ground vegetation, and with suitable nesting gravels present). Despite this, enhanced islands are still subject to much of the same pressures as other habitat types (i.e. mainland or naturally formed islands), such as nesting space availability and predators. This season, aerial predators (karoro) were a major cause of nesting failure on enhanced islands.

Tarapirohe site fidelity is quite low due to the highly dynamic braided river systems which create an ever-changing breeding habitat (O'Donell & Hoare 2011) and can negatively impact colony size and reproductive success (Steele 2009). The use of enhanced islands, which are relatively stable if routinely maintained each breeding season may enable a temporal review of site fidelity in the Waiau Toa and Wakaputawatea rivers. Increased banding of tarapirohe could help facilitate this analysis.

## 5.4 Anthropogenic Disturbance

The Molesworth Recreation Reserve is utilised extensively for recreation, which often leads to close encounters between humans and wildlife. This can be problematic for many of the ground-nesting braided river birds, such as tarapirohe. WMIL has seen members of the public investigating nest cameras and is concerned this could lead to nest abandonment or chicks fleeing into the river and washing away.

WMIL also observed stone bridges at "Bridge Colony" connecting the mainland to the enhanced island (Figure 14). These are assumed to be constructed by families around the Christmas and New Year holiday as a fun activity or to make small pools for kids to play in. This creates a bridge for predators to cross onto islands and needs to be prevented.

Improving awareness, through signage or advocacy programmes in core locations, would help minimise any potential effects.

***Figure 14:*** *A stone bridge constructed by members of the public which attaches the mainland to an enhanced island (Bridge Island) where tarapirohe/black-fronted terns were nesting on the Waiau Toa/Clarence River, January 2024.*

# 6. Recommendations

Based on the results over the last eight years monitoring tarapirohe along the Waiau Toa and Wakaputawatea, WMIL has the following recommendations for future monitoring work on this species:

## 6.1 Tarapirohe/black-fronted tern monitoring

- Helicopter surveys continue to be carried out during the peak of breeding season. The surveys provide a good initial tarapirohe population count and increases the likelihood that all colonies along the Waiau Toa and the Wakaputawatea are found.
- Dependent on funding, the scale of monitoring could be reviewed. Potentially reducing monitoring to six colonies covering all treatment types should provide enough data to determine factors that impact on tarapirohe breeding success and survival. These colonies could be determined following the helicopter survey.. This should be reviewed in line with comparability with earlier seasons.
- Chick shelters continue to be used.
- Chick shelter efficacy, research questions, methodology, and analysis criteria are clarified. For example, what percentage of chick shelters are used within the first 72 hours of hatching. This will better enable the data captured to be analysed against other variables and allow for more thorough statistical analysis to be undertaken.
- The cause and effect of intraspecific predation is investigated further.

- Research into tarapirohe dietary intake during the breeding season (e.g., egg-laying to chick rearing) is undertaken, which could link into intraspecific predation.

## 6.2 Tarapirohe/black-fronted tern banding and resighting

- Continuing with and increasing tarapirohe banding efforts, to better understand recruitment, population trends, and site fidelity. This will require increasing resource capacity (namely staffing) to facilitate more adult and chick banding sessions during breeding season. Adult banding would primarily be undertaken during the colony checks at peak nesting and can prove difficult to undertake whilst also undertaking nest monitoring and colony surveys. Similarly, facilitating enough personnel to attend chick banding days to ensure the maximum number of chicks can be caught and banded in a safe manner is important. Ideally, 2 or 3 sessions over a 3–4-day interval, should be prioritised, allowing for chicks to be caught and banded at varying intervals before they fledge.
- Further investigate GPS tracking methods to determine tarapirohe post-breeding dispersal.

## 6.3 Predator suppression/monitoring

- Facilitate more targeted trapping, using methods such as spotlight shooting to target nocturnal species that may be trap shy, such as cats. This could be assisted through additional technology such as thermal imagery.
- Undertake nocturnal-only ten-day leg hold trapping periods to target cats during the season (October- January) where traps are opened in the evening and checked/closed in the morning each day.
- Karoro control is undertaken either using alphachloralose or shooting depending on colony location.
- Despite no kāhu predation events being recorded this season, further banding and monitoring should continue.
- Implement more residual pest monitoring which compliments existing pest control operations. This could include conducting pest trail camera surveys and/or installing permanent tracking tunnel lines.

## 6.4 Advocacy

- Increasing advocacy signage at key locations such as the Cobb Cottage campsite to increase awareness and encourage visitors to report band sightings to WMIL and/or DOC. This could be an opportunity for local iwi to participate and influence the interpretation design, ensuring te ao Māori inclusion.

## 6.5 Island enhancements

Table 6 and Table 7 outline the recommendations for island enhancements.

***Table 6:*** *Condition of enhanced islands on the Waiau Toa/Clarence River at the end of the 2023/24 season and maintenance required. Note, red= top priority, orange= mid-priority, yellow= low priority, green= no enhancement work required, grey= discontinued. All recommendations are correct time of writing, but subject to change depending on conditions.*

| River | Code | Site | Condition at end of 2023/24 season | Maintenance Required |
|---|---|---|---|---|
| Waiau Toa/Clarence River | C1 | Upper Swimming Hole | Channels still surrounding main section of island. Upper left side of island suspected to have flooded at the start of the season. Fairly low lying. | Build up height and strengthen island, especially the upper left edge of the island. Clear/widen true left channel of island from stepping-stone patches of gravel.<br>**Weed management |
| | C2 | Cow Island | True right channel fairly dried up creating easy access to the site. Surface of the island has good nesting gravels and limited spread of vegetation. | Diverting the main channel to flow down both sides of the island.<br>**Weed Management |
| | C3 | Eddy's Inlet | Connected to the mainland on true left side of island. Surface of the island contains good nesting gravels. Island height avoids flooding. | *Opening channel on true left side of island to divert river flow.<br>**Weed management |
| | C4 | Upper Bush Gully | Island heavily connected to the mainland on true right side. Island moderately vegetated. | *Opening and widening channel on true right side of island.<br>**Weed management |
| | C5 | Bridge Island | True left channel trickling making island easily accessible. Island covered in weeds and woody vegetation. Island height great to avoid flooding. | Divert flow to evenly flow down true left channel. Vegetation control to be carried out on surface of island.<br>**Weed management |
| | A | Swimming Hole | Island heavily vegetated with silty ground layer. Channels still surround island. | Due to silty base layer of island, sustained vegetation control may be difficult with nesting-gravels limited. Island no longer recommended for enhancement.<br>**Weed management |
| | B | Mitchell's | Island surrounded by wide, deep river channels. Island height optimal to avoid flooding. Vegetation restricted to the lower end of the island. | No enhancement works required.<br>**Weed management |

**Footnote**:
**Due to the natural flow of the river, creating a river channel on the mainland side of this island has been difficult to maintain. These works are recommended to only occur if there is time and funds to do so.*
***Weed management as required on enhanced islands.*

*Table 7. Condition of selected natural islands within the treatment zone on the Waiau Toa/Clarence River that are recommended for enhancement works. Note, red= top priority, orange= mid-priority.*

| River | Colony Code | Site | Condition at end of 2023/24 season | Maintenance Required |
|---|---|---|---|---|
| Waiau Toa/Clarence | CC | Mike's Rock | Wide channels surround island. Upstream end of island very low lying and susceptible to flooding. Vegetation in pockets along the edges. | Island height should be raised at the upstream end of island. |
| | CH | Bush Gully (Natural Island) | Natural island with wide, deep channels surrounding island. Island clear of vegetation. Slightly low lying and may be at risk to high flooding events. | Raise height of island. |
| | CA | Crossing Colony | Long island with wide river channels surrounding island. Elevated section of island heavily vegetated by weeds and woody vegetation. Lower lying areas containing suitable nesting gravels. | Remove vegetation on tops of island. Raise height of island where required. |

# 7. Acknowledgments

This is a collaborative project between the Department (DOC), Environment Canterbury (ECan) and Te Rūnanga o Kaikōura. Funding for the tarapirohe monitoring aspect was provided by DOC and ECan.

Special thanks go to:

- Ellery Mayence (DOC), Patrick Crowe (DOC), and Frances Schmechel (ECan) for their support.
- Te Rūnanga o Kaikōura, especially Clint McConchie for his assistance and support.
- Keara Nelson and Keegan Miskimmin (WMIL) for their assistance with fieldwork and other WMIL personnel for their assistance with reviewing trail camera footage and reviews of the reporting.
- All chick banding volunteers.
- Amuri Helicopters for their assistance with the river helicopter surveys.

The predator trapping aspect of this work along the Waiau Toa/Clarence River was completed by J & S Mears Contracting. This trapping aspect was funded by Land Information New Zealand (LINZ) and managed by Boffa Miskell (Pete Caldwell and Robin Pieper). WMIL thank these groups for their commitment and support for the tarapirohe work.

# 8. References

Ahlering, M.A. & Faaborg, J. (2006). Avian habitat management meets conspecific attraction: If you build it, will they come? *The Auk* 123: 301-312.

Bell, M. & Harborne, P. (2019). *Clarence River black-fronted tern restoration project – 2018/2019 operational report*. Unpublished client report prepared for the Department of Conservation by Wildlife Management International Ltd., Blenheim.

Connor-McClean, B.; Lamb, S. & Bell, E. (2023). *Waiau Toa/Clarence and Wakaputawatea/Acheron River black-fronted tern monitoring project- 2022/23 operational report*. Client report prepared for the Department of Conservation by Wildlife Management International Ltd, Blenheim.

Kubelka, V. (2020). Review of inter and intraspecific predation by shorebirds. *Ornis Fennica* 97(*4*): 177-185.

Lamb, S. & Augustyn, D. (2023). *Molesworth Pest Abundance Camera Trap Survey: A Preliminary Survey of Relative Pest Abundances in the Molesworth Recreation Reserve, Spring 2023*. Unpublished Wildlife Management International Technical Report to Boffa Miskell and the Department of Conservation.

Mark, A.; Barratt, B. & Weeks, E. (2013). *Ecosystem services in New Zealand's indigenous tussock grasslands: Conditions and trends*. Manaaki Whenua Press 1-33.

O'Donnell, C.F.J. & Hoare, J.M. (2011). Meta-analysis of status and trends in breeding populations of black-fronted terns (Chlidonias albostriatus) 1962–2008. *New Zealand Journal of Ecology* 35: 30-43.

OSPRI. (2020). *Bush Gully and Tarndale – Molesworth bovine TB control operation*. OSPRI. https://www.ospri.co.nz/assets/AerialOpsFactsheets/Bush-Gully-and-Tarndale-TBfree-Aerial-Factsheet.pdf

Ray, S. & Burgin, D. (2023). *Waiau Toa/Clarence River tarapirohe/black-fronted tern (Chlidonias albostriatus) Management 2023: Kāhu/Australasian harrier (Circus approximans) banding September 2023*. Unpublished Wildlife Management International Ltd. Technical Report to the Department of Conservation.

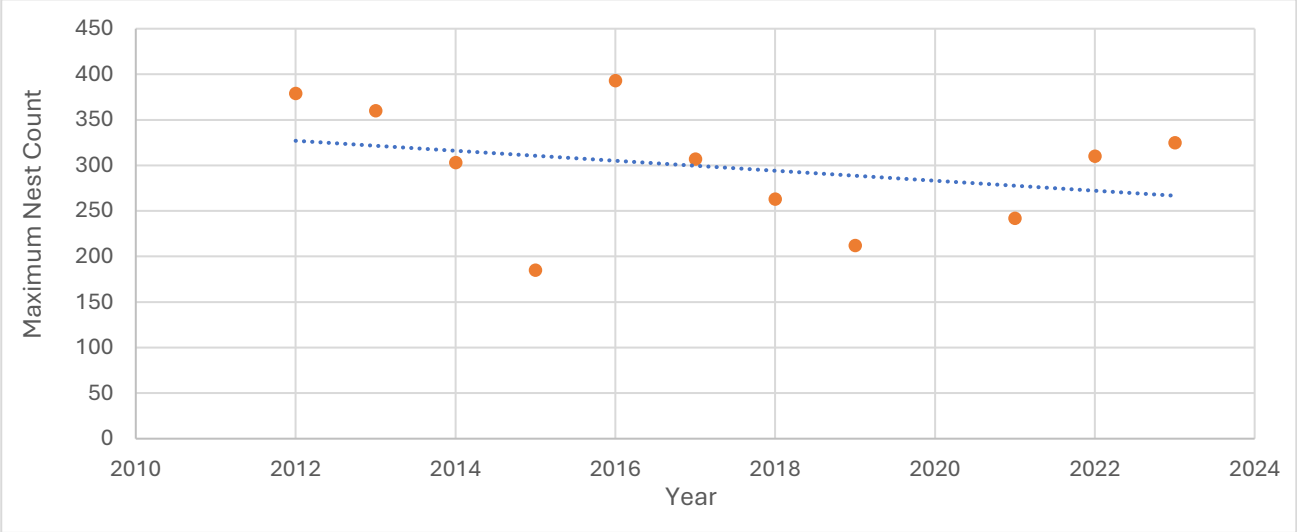
Reed, J.M. & Dobson, J. M. (1993). Behavioural constraints and conservation biology: conspecific attraction and recruitment. *Trends in Ecology & Evolution* 8: 253-256.

Spurr, E. (2012). 1080 impacts on invertebrate populations: A review and response to Benfield. *New Zealand Journal of Forestry* 56: 46–47.

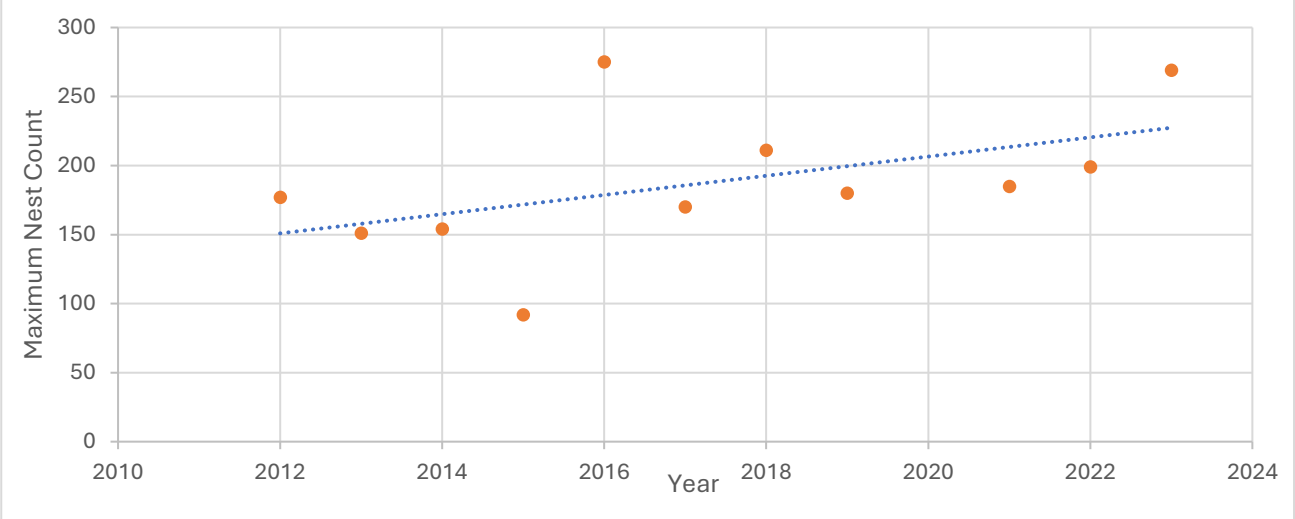
Steele, J.H.; Thorpe, J.M. & Turekian, K.K. (2009). *Elements of physical oceanography: a derivative of the encyclopaedia of ocean sciences*. Academic Press.

Ward, M.P.; Semel, B.; Jablonski, C.; Deutsch, C.; Giammaria, V.; Miller, S.B. & McGuire, B.M. (2011). Consequences of using conspecific attraction in avian conservation: A case study of endangered colonial waterbirds. *Waterbirds* 34: 476-480.

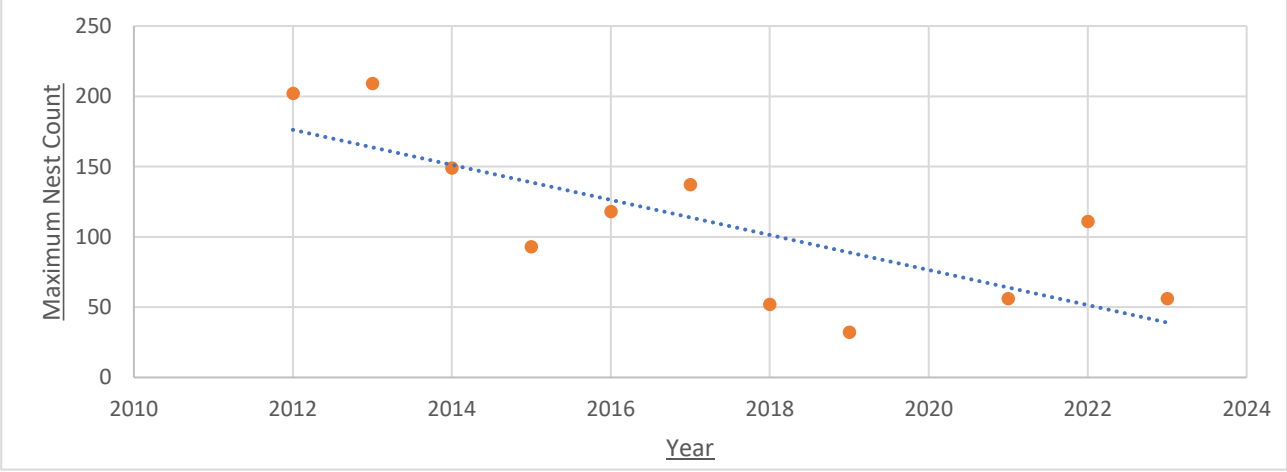
# 9. Appendices



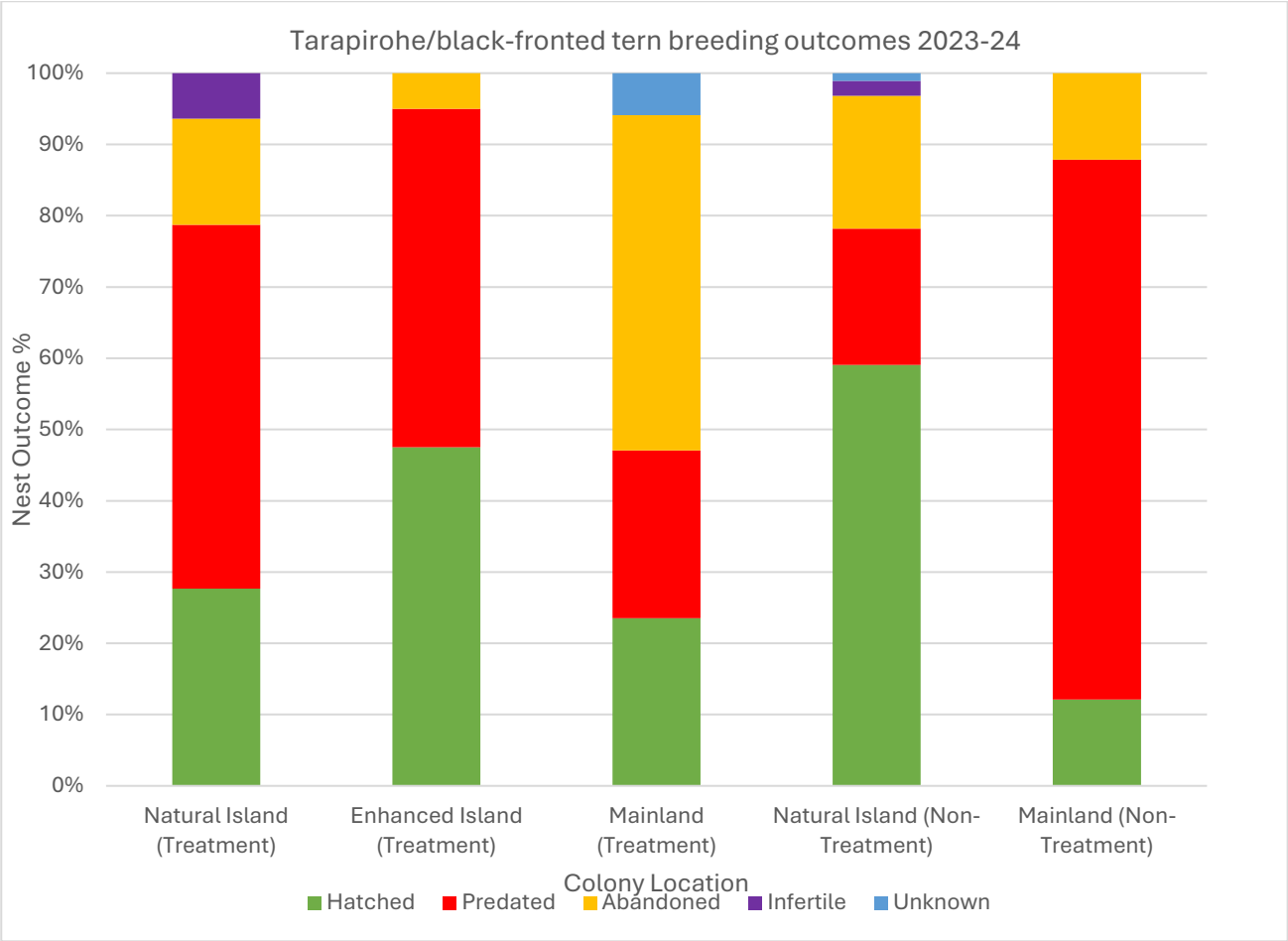

***Appendix 1:*** *Maximum combined tarapirohe/black-fronted tern nest counts from 2012/13 to 2023/24 on the Waiau Toa/Clarence and Wakaputawatea/Acheron rivers (Correlation= -0.30168).*



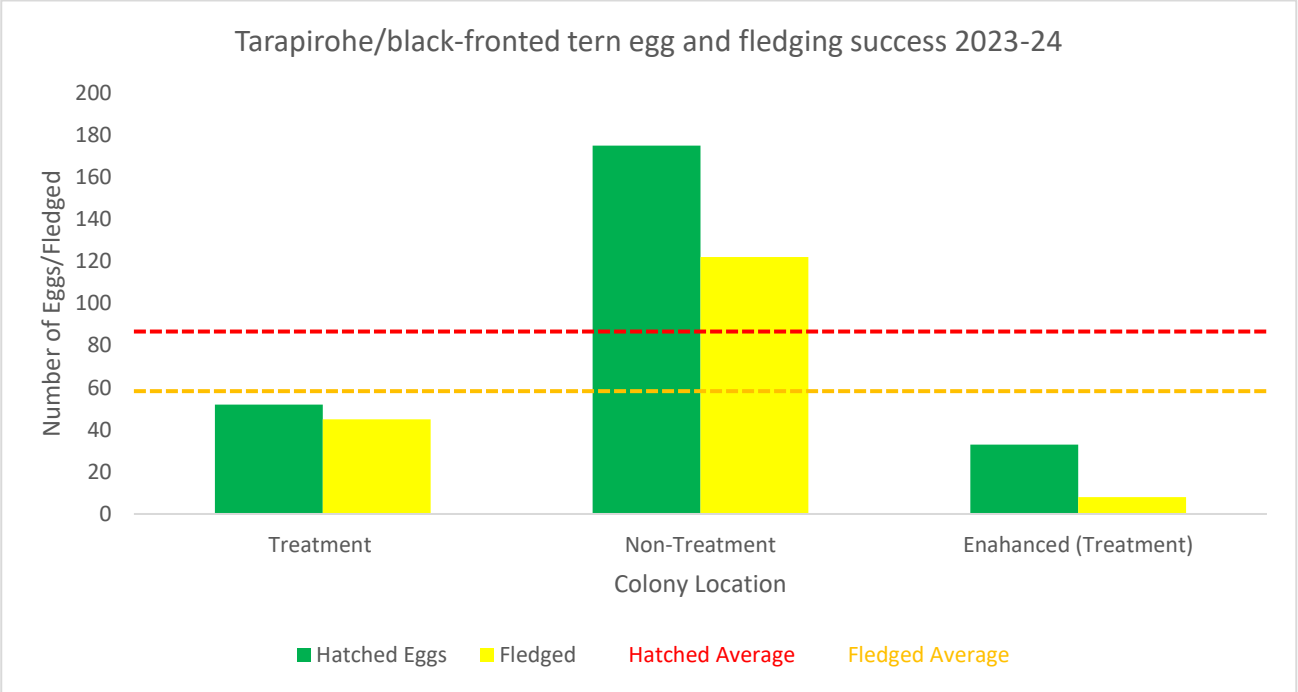

***Appendix 2:*** *Maximum tarapirohe/black-fronted tern nest counts from 2012/13 to 2023/24 on the Waiau Toa/Clarence river (Correlation= 0.493719).*




***Appendix 3:*** *Maximum tarapirohe/black-fronted tern nest counts from 2012/13 to 2023/24 on the Wakaputawatea/Acheron river (Correlation= -0.76503).*




***Appendix 4:*** *Overall tarapirohe/black-fronted tern breeding outcomes % by colony location and treatment types 2023-24 season. Natural Island (Treatment) n=47, Enhanced n=40, Mainland (Treatment) n=17, Natural Island (Non-treatment) n=188, and Mainland (Non-treatment) n=33.*




***Appendix 5:*** *Summary of tarapirohe/black-fronted tern egg/fledging success by treatment types 2023-24 season. Across all treatment (predator control vs non-predator control) totals are chicks hatched n=260 and chicks fledged n=175.*

| Colony Chick Shelter Deployment | | |
|---|---|---|
| Enhanced | Natural Island | Mainland |
| CF01 | CA02 | CA28 |
| CF02 | CA04 | CA29 |
| CF08 | CA11 | CA30 |
| CF14 | CA15 | CA30 |
| CF15 | CA21 | CD01 |
| CO03 | CA23 | CE05 |
| CO08 | CA16 | CE16 |
| CO09 | CA17 | |
| CO10 | CA27 | |
| CO11 | CA31 | |
| CO12 | CA33 | |
| CO14 | CC01 | |
| CO15 | CC03 | |
| CO16 | CC06 | |
| CO17 | CC07 | |
| | CC08 | |
| | CC09 | |
| | CC10 | |
| | CC12 | |
| | CI07 | |

***Appendix 6:*** *Tarapirohe/black-fronted tern chick shelter deployment by colony and treatment type.*