

RAKAIA RIVER



Black-fronted tern monitoring 2021/2022

Rakaia River black-fronted tern monitoring 2021/2022

Elizabeth Bell and Finn McCool.

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

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Cover Image: Trail camera image of a pair of black-fronted terns (*Chlidonias albostratus*) on nest at the upper Rakaia River during 2021/2022 season [image taken 25 October 2021].

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EXECUTIVE SUMMARY

This report summarises the results of the 2021/2022 black-fronted tern monitoring project on the Rakaia River in Canterbury, New Zealand.

Wildlife Management International Ltd (WMIL) completed this work under contract from Boffa Miskell Ltd. The contract was only finalised on 29 September 2021, which gave very little lead-in time for the monitoring programme prior to the start of the black-fronted tern breeding season (October to January). Due to limited staffing capacity and restricted funding, only fortnightly monitoring checks were possible using one staff member. These proved to be insufficient to determine the key factors affecting black-fronted terns at the monitored colonies. WMIL increased the team size to two people after four weeks. It is recommended that any future monitoring occurs throughout the season with a two-person team based in the area to maintain more frequent (i.e., weekly) checks on the black-fronted tern colonies and nests.

Between 2017 and 2020, in conjunction with a predator control and large-scale weed control programme, black-fronted terns, wrybill and banded dotterel were monitored at three sites on the upper Rakaia River (Carson-Iles 2020).

These three historic colony sites were resurveyed to determine whether black-fronted terns were using these locations in the 2021/2022 breeding season. The three study colonies identified this year were very close to, or overlapped with, these historic colonies.

Peak river flows occurred frequently throughout the 2021/2022 black-fronted tern breeding season with at least ten above-average or significant flood events recorded during October, November, and December 2021. A number of nests were flooded during early peak river flow events in November, and all three study colonies were destroyed by the main extreme flood event in early December.

In total, 23 black-fronted tern nests were monitored, to assess nesting success across the three study colonies. All but one nest were followed by camera. In addition, one wrybill and one banded dotterel nest were also followed using cameras to determine whether predators were also targeting these species.

Disturbance by black-billed gulls and banded dotterels was recorded several times, particularly at Colony 2. Predation by southern black-backed gulls and black-billed gulls was recorded at Colonies 2 and 3.

Average nest hatching success (total number of nests that produced a chick(s)/total number of nests) was calculated to be 34% (range 0-50%), and average egg hatching success (total number of eggs that hatched/total number of eggs) was calculated to be 35% (range 0-36%) across the three study colonies. However, predation and flooding events meant no chicks fledged from any of the colonies (i.e., 0% breeding success).

Predator trapping using a combination of DOC series traps along the Rakaia River is being conducted by other agencies and the result of that work is not covered in this report.

It is recommended that the black-fronted tern monitoring work is continued under a more intensive regime with more frequent checks (i.e., weekly) of the colonies and nests using a two-person team. Also of value would be to increase the number of surveys across the wider area so as to follow colonies as they re-establish following disturbance, predation, and flooding. Rather than solely relying on land-based surveying, utilizing jet boat trips as a survey method would be valuable as this method can cover more critical ground more quickly than land-based surveys. Surveys from high points using drones to record aerial imagery also provided good coverage of the islands on the river to identify nesting colonies and this method should be continued.

Rakaia River black-fronted tern monitoring 2021/2022

1. INTRODUCTION

The black-fronted tern or tarapirohe (*Chlidonias albostratus*) is ranked as Nationally Endangered under the New Zealand Threat Classification System, with an estimated population of between 5,000 and 10,000 mature individuals and a predicted rate of decline of around 50% over the next three decades (Townsend et al. 2007, O'Donnell & Hoare 2011, Robertson et al. 2021).

This ongoing decline is the result of several interacting threats, including predation by introduced mammals (particularly cats *Felis catus*, ferrets *Mustela furo*, and hedgehogs *Erinaceus europaeus*) and avian species (particularly kahu/Australasian harrier *Circus approximans* and southern black-backed gull *Larus dominicanus*) and habitat loss as a consequence of the invasion of braided riverbeds by woody weeds (Balneaves & Hughey 1990, Keedwell & Sanders 2002; Keedwell et al. 2002, Sanders & Moloney 2002, Murphy et al. 2004, Keedwell 2005, O'Donnell et al. 2012, Steffens et al. 2012, Bell 2017).

The braided rivers of Canterbury are currently considered to be the global stronghold for black-fronted terns and are estimated to support around 60% of the breeding population of this species (O'Donnell & Hoare 2011). Several of these rivers, including the Rakaia, have recently been identified as Important Bird Areas by Forest & Bird/Birdlife International on the basis that they each support >1% of the global population of black-fronted terns (Forest & Bird 2016).

The Rakaia River is one of the largest braided rivers in New Zealand with a 203 m³s⁻¹ average flow. The catchment area is approximately 2900 km² extending to the northwest and north with the Matthias, Wilberforce, and Harper Rivers as main tributaries. The Rakaia River is glacially-fed from the Southern Alps and exposed to significant rainfall, and as such has peak (flood) flows throughout the black-fronted tern breeding season.

Black-fronted terns have been surveyed or intensively monitored on the Rakaia River using a range of techniques by a number of researchers since 1981 (for example see Hughey 1985, O'Donnell & Hoare 2011, Hamblin 2017, Carson-Iles 2020). Between 2017 and 2020, black-fronted tern hatching success ranged from 21 to 100%, but no chicks fledged due to flood events and predation (Carson-Iles 2020).

Predator trapping using a combination of DOC series traps, Steve Alan cat traps, and Timms traps is being completed by other agencies, community groups, and contractors along the upper Rakaia River, in conjunction with wide-scale weed control, and is not covered in this report (for details between 2012 and 2020 see Carson-Iles 2020).

Wildlife Management International Ltd (WMIL) was contracted by Boffa Miskell Ltd to complete outcome monitoring of black-fronted terns between October 2021 and January 2022 with the specific aim of identifying the reasons for nest failure of black-fronted terns on the upper Rakaia River.

This report provides a summary of the results following the monitoring of the black-fronted tern during the 2021/2022 season. Recommendations for focusing future conservation efforts to improve the breeding success of black-fronted terns on this section of the Rakaia River are also provided.

2. METHODS

The aim of the project was to undertake colony surveys at three study sites along the upper Rakaia River to assess black-fronted tern nesting success through the 2021/2022 breeding season. Once three

study colonies had been identified, up to 30 nests had to be selected across all three study colonies to be monitored. A trail camera was to be placed at each nest site with camera footage regularly recovered and reviewed until either the chicks had fledged, or the nest had failed. Fortnightly checks of the nests and colony sites were to be completed, dependent on weather and river flow. Table 1 outlines the date and purpose of each visit.

Table 1. Dates and purpose of each site visit during the black-fronted tern monitoring project on the upper Rakaia River, 2021/2022.

Site Visit	Dates	Purpose
1	21 to 26 October	Initial colony identification and nest camera placement
2	30 October to 3 November	Camera check, colony surveys and nest camera placement
3	15 to 19 November	Camera check, colony surveys and nest camera placement
4	29 November to 3 December	Camera check, colony surveys and nest camera placement
5	13 to 17 December	Colony surveys and black-fronted tern surveys
6	28 to 31 December	Colony surveys and black-fronted tern surveys
7	10 to 14 January	Black-fronted tern surveys

2.1 River and colony surveys

Surveys were carried out along the upper Rakaia River from late October until early December 2021 to locate black-fronted tern nesting colonies (Table 1). Observers identified colonies and areas of tern activity by scanning the river from high points using binoculars, telescopes, or (aerial footage obtained from) drones, and by walking sections of the river scanning un-vegetated gravel beaches and islands.

Each time a concentration of adult terns was found, where possible, the observer walked through the area that the terns were frequenting to assess whether the birds showed any defensive behaviours. If defensive behaviours were observed (e.g. dive-bombing, alarm-calling or general agitated behaviour) the observer then searched the general area for active nests or freshly-dug 'scrapes' (i.e., shallow bowl in the gravel/river stones/sand lined with few fine twigs or vegetation). Once nests or fresh scrapes were found, the location of the colony site was recorded using a Garmin™ GPSmap 64th handheld GPS unit so that the colony could be re-located easily during subsequent visits. A single nest, small group of nests, or large (loosely scattered) clusters of nests could all be defined as a black-fronted tern colony. Throughout the breeding season, the number of nests can increase and decrease at a monitored colony as nest fail or chicks fledge.

As the breeding season progressed, several short sections of riverbed were re-surveyed in response to colony failures, to check for new colonies formed by birds re-locating from failed colonies and attempting to re-nest. Black-fronted terns often re-nest within the same season at the same colony location or at a new location along the river if their nests fail early in the season.

Pack-rafts were used to access colonies on islands that were challenging to access on foot, particularly post flooding events.

2.2 Nest monitoring

Once a nesting colony had been located, it was then visited fortnightly until either all active nests had failed, or the last chick had fledged. During each check, an observer walked slowly through the colony, locating nests either by systematically scanning the ground or by observing terns returning to nests after being disturbed by the observer's presence. Once found, each nest was given a unique identification number, its location was recorded using a handheld GPS unit, and a small rock cairn was erected approximately one metre away in a downstream direction to assist with relocation during subsequent visits. Nest status and contents was recorded. Nests were re-checked until they either failed, or the chicks had fledged.

Nests were monitored using a trail camera in order to identify the causes of any failures, so as to quantify the relative impacts of various predators and other factors on black-fronted tern hatching success.

At each nest, a Browning Dark Ops HD Pro X trail camera was mounted on a 0.4 metre tall wooden stand approximately 1 metre from the nest. Stands were anchored down with large river stones to prevent them from tipping over in the wind, during minor floods, or when knocked by livestock. Each camera was powered by six AA batteries and an external Browning solar panel charger and was equipped with a 64 GB SD memory card. Cameras were programmed to take three photos each time the motion sensors were activated in response to movement around the nest (see Appendix 8.1 for full camera setting details). Cameras were programmed to record both day and night, with a 30 second interval between consecutive activations. Cameras were checked at least once a fortnight and usually remained at the nest until it either failed or chicks had fledged. Cameras were temporarily removed from the site if large amounts of rain were predicted to prevent them from being washed away.

During each visit, records were kept of the numbers of fledglings seen at each colony, to provide a conservative estimate of the number of chicks that successfully fledged from each colony.

Egg Success (defined here as the proportion of eggs laid that hatched chicks) was calculated using apparent (observed) egg success. This was determined by calculating the proportion of nests monitored that successfully hatched one or more chicks. This measure of egg success has been used in other black-fronted tern monitoring sites at the Hurunui, Waiau and Waiau Toa/Clarence Rivers (see Connor-McClean et al. 2022, Miskimmin et al. 2022) and other shorebird studies (see Rebergen et al. 1998, Sanders & Moloney 2002) and follows DOC Protocols for best practice in monitoring braided river birds (Mischler & Maloney 2019). Nest Egg Success was defined as the proportion of nests that successfully hatched chicks and Fledgling (Breeding) success was defined as the proportion of nests that successfully fledged chicks.

2.3 River flow data

River flow on the Rakaia River (Fighting Hill NIWA station) was checked using the Environment Canterbury website (<https://www.ecan.govt.nz/data/riverflow/sitedetails/168526>) prior to every site visit to ensure access was possible to the study colonies.

River flow data for the Rakaia River for the entire study period was downloaded and used to create Figure 6.

The mean annual flow for the Rakaia River is $203 \text{ m}^3\text{s}^{-1}$ (see <https://braidedrivers.org/rivers/rakaia/>). For the purpose of this monitoring programme, peak flood events were classified as anything above $400 \text{ m}^3\text{s}^{-1}$ which allowed water to breach a number of islands within the braids of the study area. Extreme flood events were classified as anything above $1000 \text{ m}^3\text{s}^{-1}$.

3. RESULTS

3.1 Location and size of black-fronted tern colonies

A total of three study colonies were located within the survey area this season (Table 2, Figure 1).

Only one of the current study colonies overlapped with the known historic colony locations (Figure 1). The three colonies located this season were numbered Colony 1 (upper), Colony 2 (mid), and Colony 3 (lower) from north to south along the river.

Table 2. Summary of each site visit during the black-fronted tern monitoring project on the upper Rakaia River, 2021/2022.

Dates	Colony 1 (Upper)	Colony 2 (Mid)	Colony 3 (Lower)
21 to 26 October	<ul style="list-style-type: none"> Island inaccessible due to river flow. Drone used to identify nesting terns. 	<ul style="list-style-type: none"> Accessible by foot. 9 cameras placed out. Cameras placed at 1 wrybill and 1 banded dotterel nest. 	<ul style="list-style-type: none"> Inaccessible due to river flow. Binocular use identified nesting terns.
	<ul style="list-style-type: none"> Peak flood on 18 October. 		
30 October to 3 November	<ul style="list-style-type: none"> Still not accessible due to river flow. Binoculars and telescope used to identify nesting terns. 	<ul style="list-style-type: none"> Accessible by foot. Camera check (SD cards and batteries replaced as required) at ongoing nests. Cameras retrieved from failed nests. 3 cameras placed at new nests. 1 nest located on last day (no camera placed at nest). 	<ul style="list-style-type: none"> Accessible by pack raft. 4 cameras placed at nests.
15 to 20 November	<ul style="list-style-type: none"> Still inaccessible due to river flow. Abandoned. No nests visible. 3 black-fronted terns seen feeding. 	<ul style="list-style-type: none"> Accessible by foot. Cameras retrieved from failed nests. 3 cameras placed at nests. Black-billed gull colony (c. 1200 gulls) present adjacent to black-fronted tern colony. 	<ul style="list-style-type: none"> Accessible by pack raft. Cameras retrieved from failed nests. 4 cameras placed at nests.
	<ul style="list-style-type: none"> Peak flood 14 November and 16 November. 		
29 November to 3 December	<ul style="list-style-type: none"> Still inaccessible due to river flow. No breeding activity. 	<ul style="list-style-type: none"> Accessible by foot. Cameras retrieved from failed nests. 	<ul style="list-style-type: none"> Accessible by pack raft. Cameras retrieved from failed nests.
	<ul style="list-style-type: none"> Jet boat survey on 2 December (no new colonies located and very few black-fronted terns seen). Peak flood 28 November. 		
13 to 17 December	<ul style="list-style-type: none"> Destroyed by flooding. No breeding activity. 	<ul style="list-style-type: none"> Destroyed by flooding. No breeding activity. 	<ul style="list-style-type: none"> Destroyed by flooding. No breeding activity.
	<ul style="list-style-type: none"> Extreme flood 6 December and peak floods on 12 and 17 December. 		
28 to 31 December	<ul style="list-style-type: none"> No breeding activity. No black-fronted terns seen. 	<ul style="list-style-type: none"> No breeding activity. Very few black-fronted terns seen. 	<ul style="list-style-type: none"> No breeding activity. No black-fronted terns seen.
	<ul style="list-style-type: none"> Peak flood 21 and 28 December. 		
10 to 14 January	<ul style="list-style-type: none"> Survey not conducted as no remaining breeding activity. 		



Figure 1. Location of black-fronted tern colonies on the upper Rakaia River, 2021/2022. Red shaded areas = historic colony sites, and Green shaded areas = 2021/2022 study colony sites.

Black-fronted terns were also seen along other areas of the Rakaia River (Table 3, Figure 2), but no colonies were established at these sites. Terns were seen foraging on the river or adjacent farmland or transiting through these areas.

Table 3. Number and activity of adult black-fronted terns seen along the upper Rakaia River, 2021/2022 (see Figure 2 for location).

Location	Number of adult black-fronted terns	Activity
1	1	Foraging in river
2	3+	Foraging in river
3	10	Foraging on paddock adjacent to river
4	1	Transiting along river
5	2	Foraging in river
6	2	Foraging in river
7	2	Transiting along river
8	44	Foraging (in paddock with 50 banded dotterel, 12 black-billed gulls, 12 South Island pied oystercatcher and 2 wrybill)

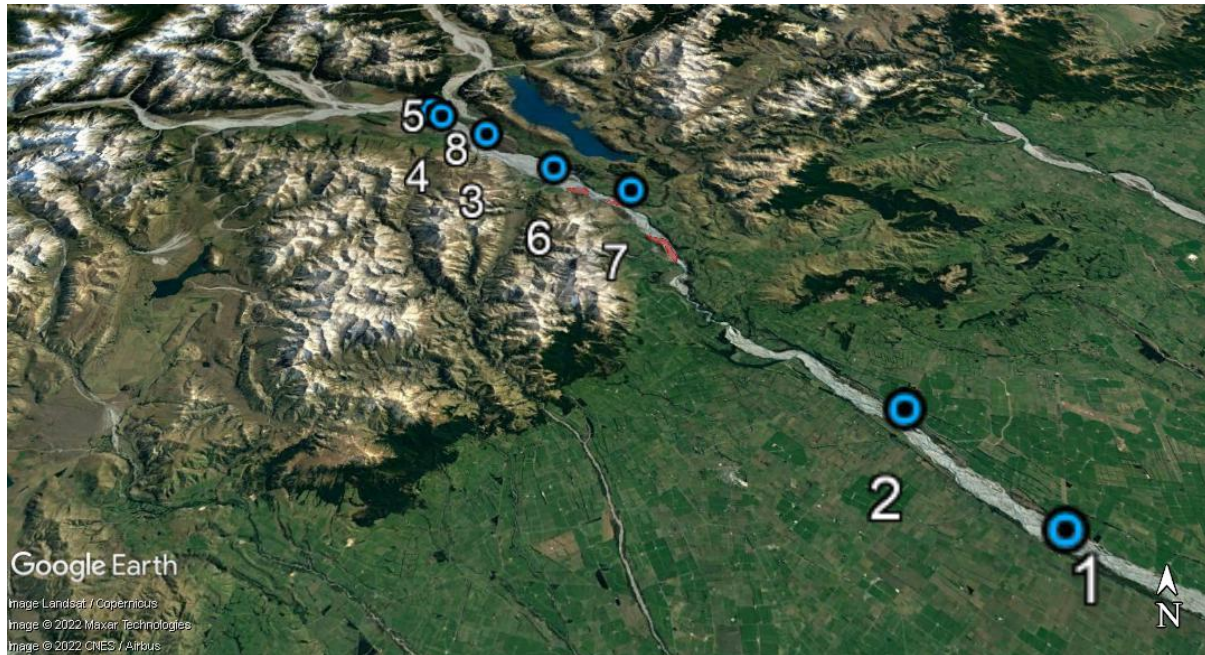


Figure 2. Location of sightings of black-fronted terns along the upper Rakaia River, 2021/2022 (blue circles, numbered 1-8). See Table 3 for numbers and activity at each location.

The total size of each black-fronted tern colony (number of breeding pairs) was determined by the highest count of active nests during any visit. However, due to flooding and predation events, Colony 1 was wiped out before access was possible to complete a ground-based nest count, so this nest count was obtained from the drone footage and using binoculars during the first two site visits only (prior to the colony being destroyed by flooding) (Tables 2 and 4). Access to Colonies 2 and 3 was also affected by flooding (Tables 2 and 4). For this reason, the total count of active nests at these study colonies may not be a true representation of the total number of breeding terns present. The highest count of black-fronted terns for each colony over the 2021/2022 season is shown in Table 4; these terns may not have been breeding, and only loosely associated with the colony.

Colony sizes varied from 6 to 15 breeding pairs, with an average colony size of 10 breeding pairs (Table 4). A total of 29 nests were located simultaneously across all three colonies, but only 23 nests could be actively followed using cameras due to access. The minimum population size is thus determined to be 90 adult birds, of which 58 were breeding (Table 4).

Table 4. Number of nests, breeding pairs, and adult birds present at each monitored colony on the upper Rakaia River, 2021/2022.

Colony	1 (upper)	2 (mid)	3 (lower)	Total
Nests	6 ¹ (minimum)	15	8	29
Breeding pairs	6 ¹ (minimum)	15	8	29
Adults count ² (highest count)	18	45	27	90

1. This is a minimum nest count determined by drone footage and binoculars only. No ground survey could be conducted prior to Colony 1 being destroyed by a flood event. The colony may have been larger (i.e., more nests), as nests were difficult to determine from drone footage especially if the black-fronted terns had left the nest site.

2. This includes breeding adults associated with the nest (incubating and roosting near nest or feeding incubating adult) and other adults loitering or roosting at the site, but without nests.

3.2 Nest monitoring

A total of 23 nests containing 40 eggs were monitored across the three colonies (Table 5). Fourteen eggs hatched from 10 nests by 21 November (Table 5). Average nest hatching success was calculated

to be 34% (range 0-50%), average egg hatching success was calculated to be 35%), and fledgling success was nil across all monitored colonies (Table 5).

Overall, flooding and predation were the leading causes of nest failure; 35% of all monitored eggs or chicks were destroyed by flood events and 32.5% of all monitored eggs and chicks were predated (Table 6).

Table 5. Hatching, egg or chick success, and fledgling success of black-fronted terns on the upper Rakaia River, 2021/2022.

	Colony 1	Colony 2	Colony 3	Total
Total number of nests	6	15	8	29
Total number of eggs	Unknown	26	14	40
Total number of eggs failed: incubation	0	0	1	1
Total number of eggs failed: predation	0	3	1	4
Total number of eggs failed: flooding	6	9	4	13
Total number of eggs failed: unknown causes	0	5	3	8
Total number of eggs hatched	0	9	5	14
Total number of nests with hatched eggs	0	6	4	10
Nest hatching success (no. of known nests/no. of known nests that hatch one or more eggs)	0%	40%	50%	34.4%
Egg hatching success (Total no. of eggs that hatched/total no. of eggs laid where fate is known)	0%	34.6%	35.7%	35%
Total number of chicks hatched	0	9	5	14
Total number of chicks failed: at pipping	0	0	1	1
Total number of chicks failed: predation	0	8	1	9
Total number of chicks failed: flooded	0	1	0	1
Total number of chicks failed: unknown causes	0	0	3	3
Total number of chicks fledged	0	0	0	0
Fledging success (Total number of nests/no. of known nests that fledge chicks)	0%	0%	0%	0%

Table 6. Causes of egg and chick failure of black-fronted tern breeding attempts on the upper Rakaia River, 2021/2022.

Failure	Colony 1	Colony 2	Colony 3	Total
Egg failed: at incubation	0	0	7.1%	2.5%
Egg failed: predation	0	11.6%	7.1%	10.0%
Egg failed: flooding	100%	34.6%	28.6%	32.5%
Egg failed: unknown causes	0	19.2%	21.5%	20.0%
Chick failed: at pipping	0	0	7.1%	2.5%
Chick failed: predation	0	30.8%	7.1%	22.5%
Chick failed: flooded	0	3.8%	0	2.5%
Chick failed: unknown causes	0	0	21.5%	7.5%

Ground-based monitoring at Colony 1 was impossible throughout the season due to high river flow and flooding events. Six nests were identified using remote observation (telescopes, binoculars, and a drone) (Tables 2 and 5). Colony 1 was destroyed by flooding on 15 November and no eggs or chicks survived (Table 5).

Ground-based monitoring at Colony 2 was possible throughout the season and 15 nests were found (Tables 2 and 5, Figure 3). Fourteen nests were monitored by cameras. The final nest was found at the

end of the day (all cameras carried by the team had already been deployed and there was no time left in the day to return with one from the field base) with two eggs. It was found empty the following day, and was presumed to have been predated (Table 5). Nest hatching success was 40% and egg hatching success was 35%, but no chicks successfully fledged due to predation and the December 6 flood event.

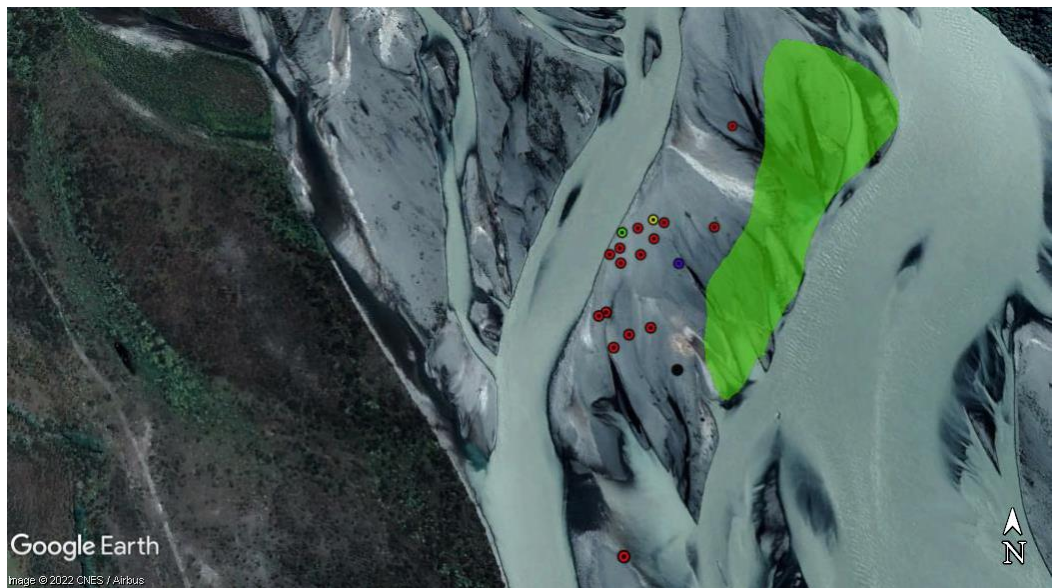


Figure 3. Location of black-fronted tern nests at Colony 2 on the upper Rakaia River, 2021/2022. Where red dot = black-fronted tern nests, yellow dot = banded dotterel nest, green dot/shading = black-billed gull nest/colony, blue dot = wrybill nest and black dot = South Island pied oystercatcher nest.

Monitoring at Colony 3 was typically possible by pack raft. Access was occasionally prevented due to river flow (Table 2). A total of 8 nests were found (Table 5, Figure 4). Three eggs from two nests disappeared without any images captured on the cameras, but predation is suspected to be the cause. Nest hatching success was 0.5 and egg hatching success was 0.36, but no chicks successfully fledged due to predation and the December 6 flood event.

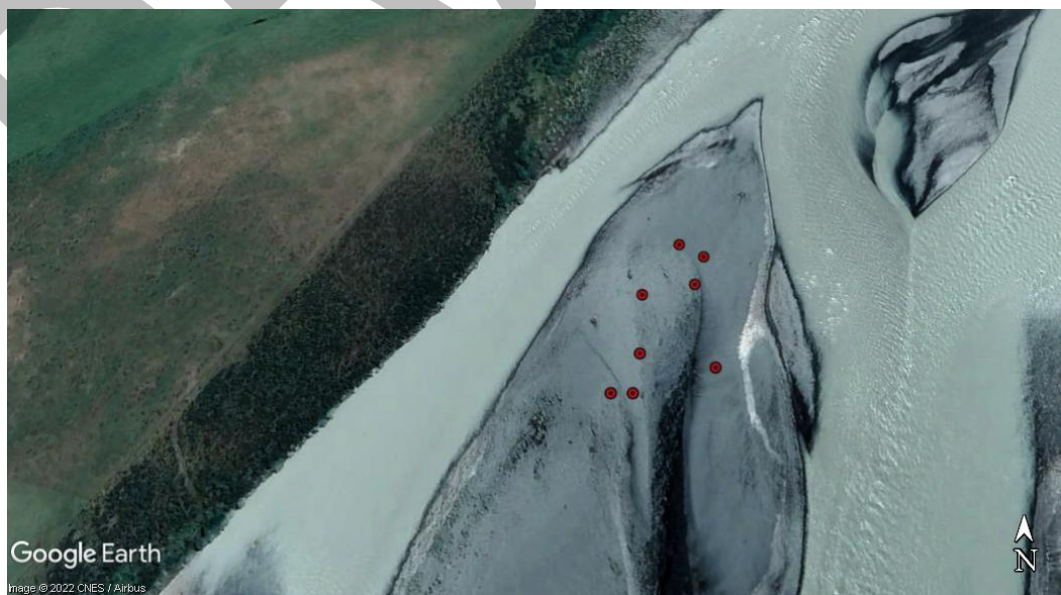


Figure 4. Location of black-fronted tern nests at Colony 3 on the upper Rakaia River, 2021/2022. Where red dots = black-fronted tern nests.



Figure 5. Observed predation or disturbance events recorded by camera at black-fronted tern nests along the upper Rakaia River, 2021/2022. A) Black-billed gull tossing black-fronted tern chick out of the nest. B) Black-billed gull eating black-fronted tern egg, C) Southern black-backed gull eating black-fronted tern chick, and D) Banded dotterel harassing black-fronted tern on its nest.

Southern-blackbacked gulls and black-billed gulls were both recorded on camera predating chicks or eggs (Figure 6, Table 7). Southern black-backed gulls were responsible for at least 25% of all predation events and black-billed gulls for at least 29% (Table 7). Banded dotterels and black-billed gulls were also recorded disturbing nesting black-fronted terns (Figure 6). This caused the terns to abandon their nests for short times, which allowed gulls to predate nests.

Table 7. Species recorded on camera predating black-fronted tern eggs or chicks on the upper Rakaia River, 2021/2022.

Predator	Number of eggs and chicks combined			
	Colony 1	Colony 2	Colony 3	Total
Southern black-backed gull	0	4 (25%)	2 (25%)	6 (25%)
Black-billed gull	0	7 (43.75%)	0	7 (29.2%)
Unknown	0	5 (31.25%)	6 (75%)	11 (45.8%)
Total predation events	0	16	8	24

Flooding was the most significant cause of nest failure, accounting for 35% of nest failures (Table 5). High rainfall resulted in higher-than average river flow rates (Figure 4). Most tern nesting attempts began around the middle of October 2021. Due to high rainfall, peak flows (i.e., flood events) were recorded on 18 October, 14, 16, and 28 November, and 6, 12, 21 and 28 December. The extreme flood event on 6 December (peaking at over $1100 \text{ m}^3\text{s}^{-1}$) wiped out all remaining nesting attempts at all colonies (Tables 2 and 5, Figure 4). The terns did not re-nest following this flood event.

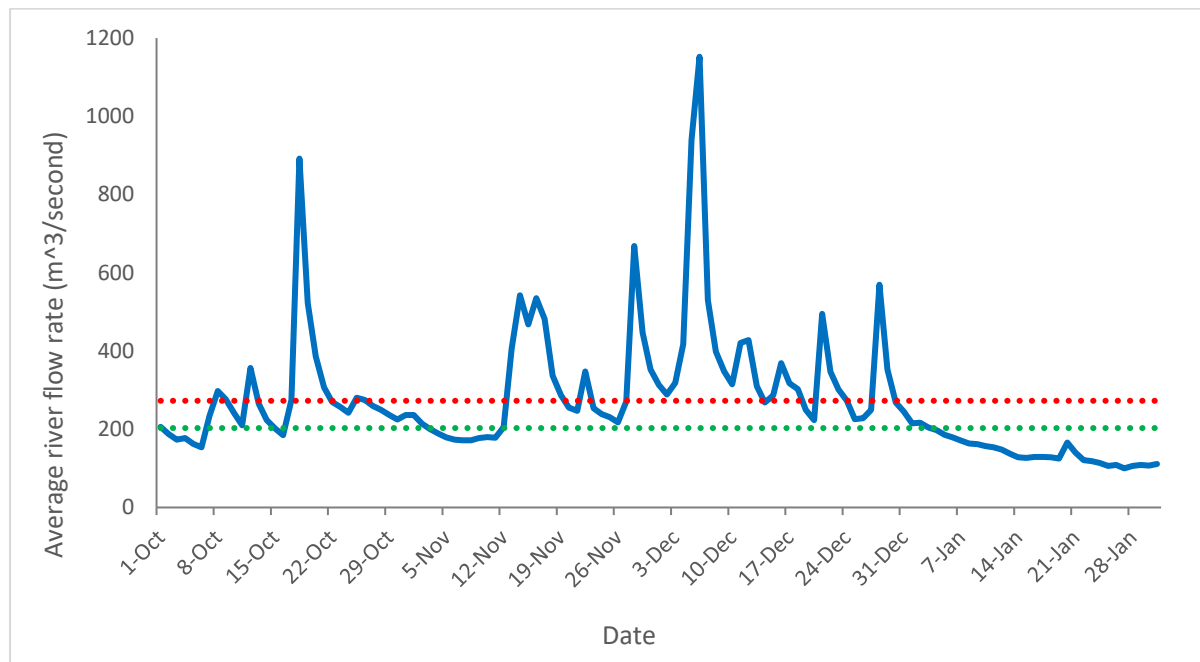


Figure 17. Rakaia River flow rates as recorded at Fighting Hill between 1 October 2021 and 31 January 2022. The red dotted line is the average flow between 1 October 2021 and 31 January 2022 ($273 \text{ m}^3\text{s}^{-1}$) and the green dotted line is the annual average flow ($203 \text{ m}^3\text{s}^{-1}$).

Because of the flood events and predation, fledgling success per nest across all three colonies was zero (Table 5).

4. DISCUSSION

The black-fronted terns on the upper Rakaia River had an extremely poor nesting season in 2021/2022. There was no evidence that any chicks fledged successfully. Repeated and high flood events occurred in the river in October, November, and December, preventing or reducing any re-nesting of the black-fronted terns. Predation by southern black-backed gulls and black-billed gulls was recorded. Nest abandonment was also observed and was related to disturbance by gulls and banded dotterels. With the exception of a house mouse, no mammalian predators were recorded at any of the colony sites. No nest failures could be attributed to mammalian predators. However, as monitoring was frequently disrupted by flooding and access issues, mammalian predation cannot be disregarded. Additional monitoring is required to gather sufficient data to determine whether the predator trapping regime on the adjacent mainland provides enough protection for black-fronted terns to breed successfully.

Three black-fronted tern colonies were identified early in the season (mid-October), but within two weeks one had been destroyed by flooding. Only one colony was within the boundaries of historic 2017-2020 black-fronted tern colony locations. The other two colonies monitored this season were very close to these historic locations. The location of black-fronted tern colonies is known to move both within a breeding season as well as from year to year, particularly following major failure events. As such, it will be important to survey the entire area (from the Rakaia Gorge to the Mathias/Rakaia Confluence) again each year to identify colony locations for that season as well as focusing within the range of the predator control areas adjacent to the historic 2017-2020 colony sites.

Nest monitoring checks occurred fortnightly by one person. This frequency of visitation was insufficient for collecting detailed nest outcome data. A number of nests were predated between monitoring checks. Flood events wiped out one entire colony before observers could access the colony to establish cameras. It was also apparent within the first month that one person could not complete this work even with the fortnightly schedule, and as such the team was increased to two persons for the remainder of the project.

Monitoring work was frequently delayed due to the logistical constraints and adverse weather. Colony 1 could not be accessed due to peak river flow prior to the colony being destroyed by flooding. Colony 2 was easily accessible by foot early in the season, but then had to be accessed by pack raft as river flow increased and changed the river channel depth and width. This colony was highly disturbed by a black-billed gull colony which established on the edge of the tern colony. Footage was obtained of terns constantly leaving their eggs due to black-billed gulls flying overhead or hassling the terns for nesting material. A number of nests were abandoned by the terns, and black-billed gulls were recorded throwing chicks out of the nest or smashing and eating eggs. A banded dotterel was also observed harassing a nesting tern. Access to Colony 3 was by pack raft only as the channel was too deep to wade across and river flow was consistently too swift. Colony 3 was also highly disturbed by southern black-backed gulls, and footage of predation of eggs and chicks was recorded.

Peak flood events caused significant access issues to the colonies. Often the cameras could not be checked or even put into position prior to nests failing. Alternative access options (such as jet boats) need to be built into the project to allow more reliable ways to access colony sites regularly.

5. RECOMMENDATIONS

It is recommended that:

- In addition to the mainland surveys along the river on foot and using vehicles, a river survey using a jet boat is undertaken on the upper Rakaia River in early October to determine black-fronted tern activity and colony locations. A drone should also be used to help confirm colony locations from the mainland.

- Monitoring occurs from 1 October to 31 January (or when black-fronted terns depart from the area).
- Monitoring is intensive, i.e. five days a week for the entire breeding season, by a two-person field team (rather than fortnightly checks at colonies as per this season which resulted in reduced accuracy regarding causes of failures and complications due to flooding events and access to colonies).
- A minimum of three colonies are intensively monitored, and observations of black-fronted terns across the upper Rakaia River are also undertaken to determine whether other areas are being used by breeding terns.
- Cameras are to be placed at a minimum of 30 nests sites across three intensively monitored colonies.
- Alternative access options (such as jet boat) are investigated and built into the project budget to allow monitoring to continue without significant impact on data collection during periods of peak river flow.
- Landowners continue to be informed of the work, methods, and outcomes. Access to these colonies requires permission to travel through private land and it is vital that good relationships with the landowners are maintained.
- If monitoring of black-fronted terns is to continue at this site next season, the project requirements are clarified and agreed upon as soon as possible, and suitable contractors are advised early to provide quotes for the work. The contract for this work should be signed well in advance of the breeding season to allow the successful contractor sufficient time for preparation.

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The efficiency and effectiveness of monitoring activities conducted as part of this project is also largely reliant on being given permission to access the riverbed across private property. We are extremely grateful to all the landowners that have granted permission to access the river across their land. Their enthusiasm for this project is also very encouraging.

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8. APPENDICES

8.1 Appendix 1: Browning (Dark Ops HD Pro X) camera settings used for black-fronted tern nest monitoring, 2021/2022.

Table 8. Browning (Dark Ops HD Pro X) camera settings used for black-fronted tern nest monitoring 2021/2022.

Camera Settings	
Date	Month, Day, Year
Clock	Set to correct time (am/pm)
Mode	Trail
Capture Delay	1 second
Image size	Medium (8 Megapixels)
Multi-shot	RPF-4 shot
Cap start	12:00 AM
Cap End	12:00 AM
SmartIR	Off
NightExp	PwrSave
Temp Unit	C
Info strip	On
SD management	Off
Motion Detect	Normal
Motion Test	On
Language	English
Name	TRAILCAM (number engraved on camera)