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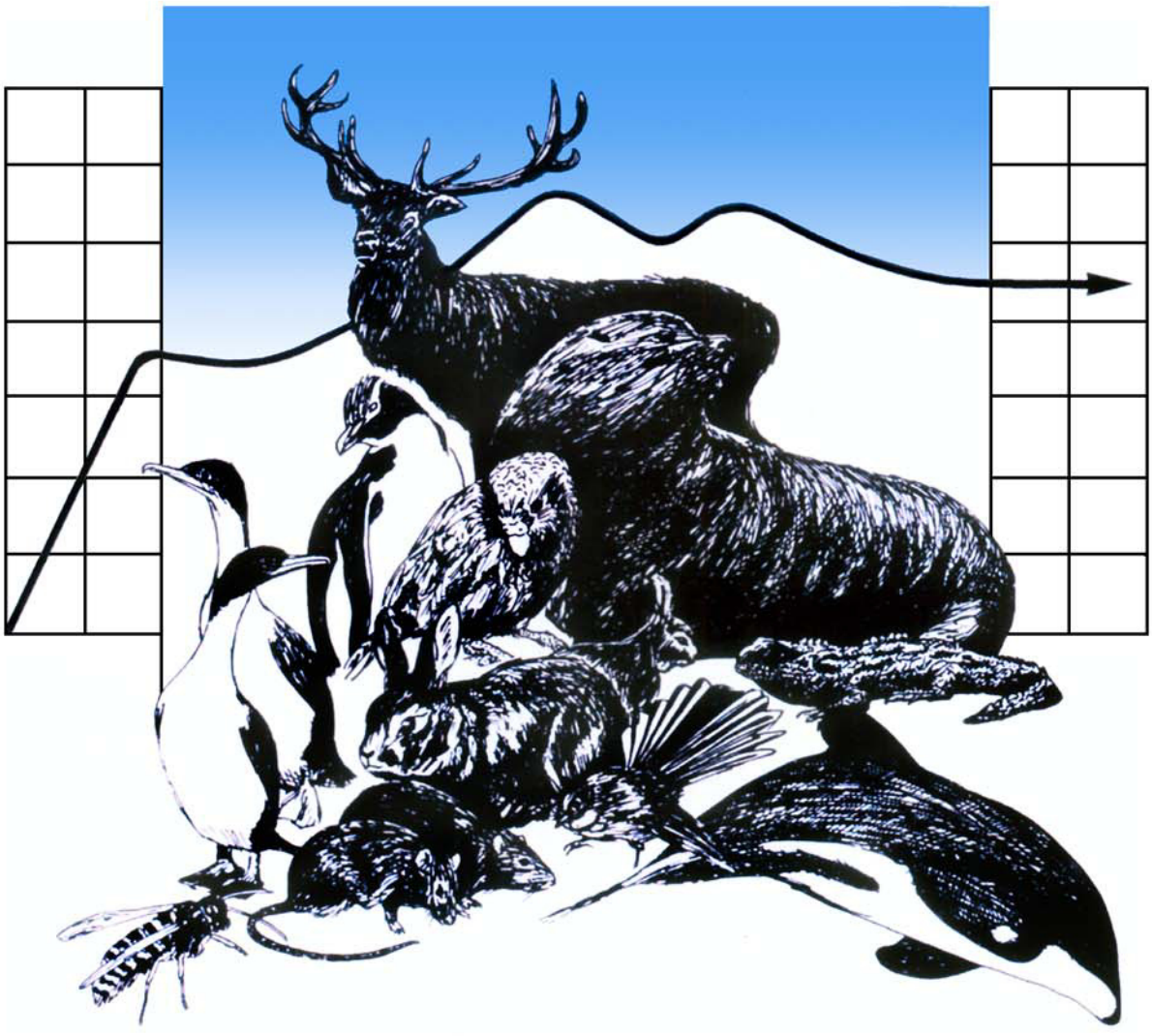

WILDLIFE MANAGEMENT

Identification of predators at black-fronted tern nests on the Wairau River using video footage and predator DNA: A follow up study

Aviva Stein

A report submitted in partial fulfilment of the
Post-graduate Diploma in Wildlife Management

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WLM Report Number: 234

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Executive Summary

The black fronted tern (*Sterna albostriata*) breeds exclusively on the braided riverbeds of the South Island of New Zealand, and is classified as nationally endangered. Predation is the primary cause of mortality and possibly the main cause of their decline. The nesting stage is a particularly vulnerable time, and effective methods of predator control are urgently needed. In 2008, a pilot study using video and DNA analysis was implemented by the Department of Conservation with the aim of identifying primary predators of black-fronted terns nesting on the Wairau River in the Marlborough region of the South Island. DNA analysis of tern nest contents was also carried out to determine whether such work, when compared with filmed predation events can be reliably used to identify predators. This study found Australasian harriers (*Circus approximans*) to be a main predator, and harrier trapping at colonies was subsequently instated. This present study repeats the video and DNA analysis, with the aim of increasing the sample size of nests monitored, and to observe if trapping harriers at breeding locations affected the predator profile. Results showed a number of species, including harriers, pied oystercatchers, black-backed gulls, stoats, rats and mice preying upon black-fronted tern eggs. It is possible that the removal of harriers only was a catalyst for this change in predator profile, but conclusions cannot be drawn due to the unbalanced nature of the study design and the lack of robust sample sizes. It is recommended that control operations for aerial predators including black-backed gulls be implemented, as well as a random block trapping regime established along the Wairau and more localised at black-fronted tern colonies. It is not recommended that DNA analysis be used as a means of potential predator identification in future studies of black-fronted terns, as this method can overlook many predators.

Acknowledgements

First and foremost I would like to thank Kate Steffens for designing and implementing this project and for excellent company during fieldwork. Thanks to all the Department of Conservation staff who assisted in the field and/or with technical issues. This includes that Kakapo team for the loan of the digital video recorders; Dave Rees and Pete Gaze for field assistance and offering suggestions regarding avenues for this research; and Andy Hutcheon for providing valuable information on trapping methods. I would also like to thank Mike Bell from Wildlife Management International, as well as Ecogene and Landcare Research. Many thanks to Melanie Young and Kate Beer for reviewing drafts of this Manuscript. This study was made possible by funding from Wild South Vineyards and the Science Advisory Fund.

I. Table of Contents

1. Introduction

The black-fronted tern (*Sterna albostriata*) breeds exclusively on the braided rivers of the South Island, and is classified as nationally endangered (Miskelly et al. 2008, Heather & Robertson 1996). The braided river environment in which black-fronted terns breed is unique and under threat from removal of vital habitat components including gravel extraction, water abstraction, and through recreational use of riverbeds (Hallas 2003).

Little research has been attempted on the ecology of the black-fronted tern, however a study by Keedwell (2005) revealed that low breeding productivity and post-fledging survival caused by high levels of predation by introduced mammals was a primary cause of decline. Black-fronted terns nest in loose colonies on unvegetated or sparsely vegetated riverbeds, leaving them open to predation by a variety of predators (Heather & Robertson 1996; Keedwell 2002). The predators for nesting birds on braided rivers are traditionally recognised as hedgehogs (*Erinaceus erupaeus*), mice (*Mus musculus*), rats (*Rattus norvegicus, Rattus rattus*), cats (*Felis catus*) possums (*Trichosurus vulpecula*), and the mustelids: stoats (*Mustela erminea*), ferrets (*Mustela putorius*), and weasels (*Mustela nivalis*), and by native predators such as Australasian harriers (*Circus approximans*) and black-backed gulls (*Larus dominicanus*) (Keedwell 2002, Keedwell et al. 2002, Sanders & Maloney 2002). However, predator guilds and predation rates can vary significantly between years and sites and little is known about the relative importance of these predators for black-fronted terns. (Keedwell et al. 2002, Sanders & Maloney 2002). As well as predating on nests, predators are known to cause nest desertions when visiting tern colonies at night (Shealer & Kress 1991, Sanders & Maloney 2002).

The Wairau River of southern Marlborough is known to host a significant population of black-fronted terns (minimum of 12%) (Keedwell 2002). Intensive predator control operations were implemented at black-fronted tern colonies along the Wairau during the 2005-2008 breeding seasons. During the 2005 and 2006 breeding season, trapping of mustilids and cats began after the discovery of colonies. In 2007, trapping commenced ten weeks prior to colony establishment, and the use of decoy black-fronted terns to attract the birds to the potential nesting site was also trialed. The trapping operations consisted of a 10 km line along the Wairau River utilising 'Twizel' Groundset Conibear™ (Woodstream Corporation, Pennsylvania, USA) traps, DOC 200 (CMI Springs Ltd, Auckland New Zealand) traps and DOC 250 traps (CMI Springs, Ltd Auckland NZ) , as

well as night shooting of cats. Despite these efforts, there was no increase in hatching success when compared with untrapped colonies (DOC 2008). Other trapping operations along the Wairau include the Wairau TB survey, which targeted ferrets and had a high by-catch of feral cats (DOC 2008).

In 2008, remote video recorders were trialed with the aim of identifying prominent mammalian predators of the tern on the Wairau River, in order to refine trapping methods (DOC unpublished report 2009). This pilot study also attempted to determine whether DNA analysis of tern nest remains can be reliably used to identify primary predators at nest sites by corroborating video footage with DNA analysis of nest remains. The video footage identified several cases of harrier predation, and harrier trapping in close proximity to black-fronted tern colonies increased as a result of this pilot study. However, the sample size was too small for corroboration of DNA results and filmed nest predations.
The aims of the current study, as a follow up study to the previous one, were to:

(i) Continue to identify and measure the importance of major predators of black-fronted tern eggs using remote video recorders;

(ii) Compare DNA and video predation results to determine if DNA swabbing of eggs, adults and chicks killed by predation is an effective means of identifying the main predator at nest sites, and;

(iii) Based on the results of this study, suggest a trapping regime for the Wairau River valley in order to better protect black-fronted terns from predation during their breeding season.

2. Methods

Monitoring and video recording of black-fronted tern nests commenced on 6 November 2009 and finished on the 20 December 2010 on the Wairau River bed, between St. Arnaud and Blenheim (Figure 1).

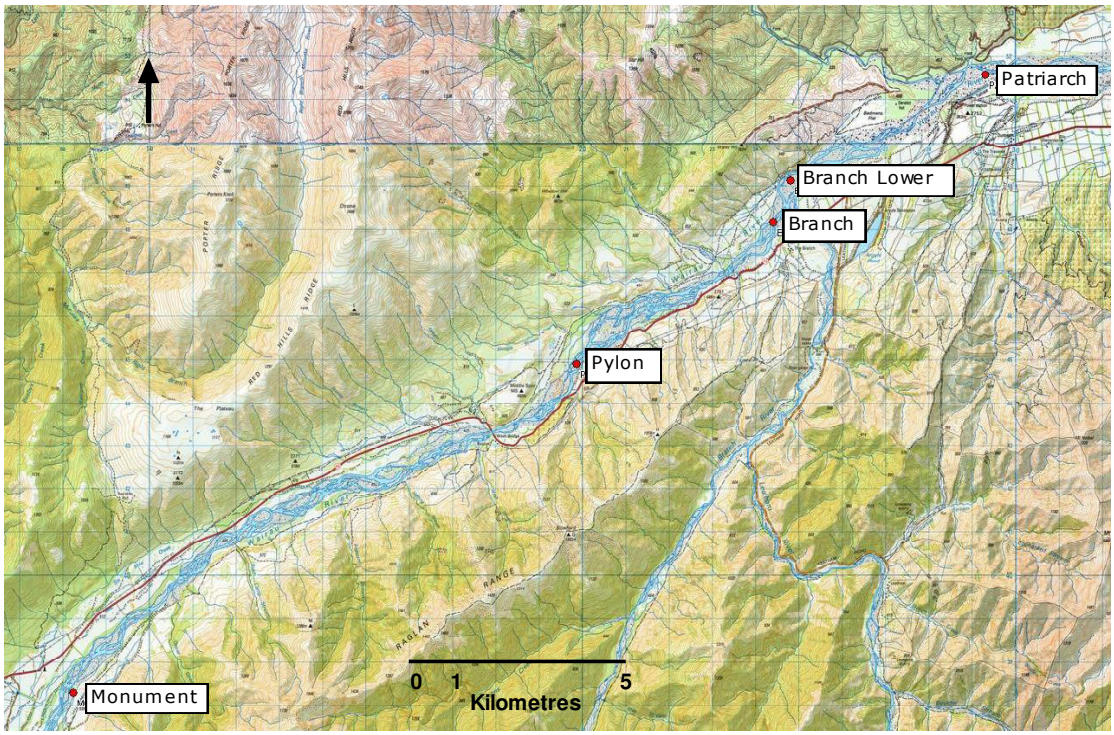

Figure 1. Location of black-fronted tern colonies where predation events were successfully filmed at a minimum of one nest.

2.1 Video study

Nests were filmed using black and white IR-sensitive cameras mounted on 0.3-0.5m high tripods, c.1.0-1.5m from the nest bowl. A 2.0m to5.0m cable ran from the camera to one 17.2Ah 12-V battery and a time-lapse digital 'security' video recorder (QV3094, Electus Distribution, Sydney Australia) following the methods employed in the previous study (DOC unpublished report 2009). Images were recorded on 2GB-4GB SD memory cards. Up to nine camera units were used at any one time.

Digital video recorders were operated on time-lapse mode, recording 2.0 frames per second, with a video size of 352x280 MP and the resulting footage was of medium quality. No audio recordings were made during the video filming. At these defined settings, approximately 5.5 days of data could be recorded using the memory cards. Batteries were changed every 48 hours, and SD memory cards changed every 4 days. Time spent by staff at each camera unit was kept to a maximum of 10 minutes to minimise disturbance to nesting birds.

When an event occurred at a filmed nest (predation, scavenging or desertion), the camera unit was relocated to a new nest. If the eggs at a nest hatched, the camera unit was moved to a new nest only after the chicks had left the immediate vicinity of the nest

bowl (usually one to two days). Camera units were also removed from the field before predicted flood events, and moved to new nests or new colonies after flood events.

The camera units were distributed around one to three tern colonies at any one time, and were relocated to areas with the lowest productivity and anticipated greatest observed predation rates, in order to increase the sample size of recorded predation events. Size of colonies was not a factor in site selection as these colonies can rapidly increase or decrease in bird numbers in a short period of time.

Each SD memory card was viewed using Windows Media Player (10, Microsoft Inc., Redmond Wa, USA) or Quicktime player (7, Apple Inc., Silicon Valley Ca, USA). Sections of the footage were sped up or skipped through until the predation event occurred and only then was all subsequent footage viewed thoroughly to identify the predator and any scavenging events. In general, the quality of footage was adequate during the day; however condensation on the lens often decreased the quality of the footage at night. See Appendix 1 for transcribed video footage.

In conjunction with filming, nests were visually monitored every two to four days by DOC. This allowed for identification and collection of samples from predated nests for DNA analysis.

2.2 DNA study

DNA samples were collected and analysed in an attempt to identify predators of black-fronted tern eggs, chicks and adults. The black-fronted tern egg, chick and adult remains at each preyed on filmed nest and surrounds (<1.0 m) were collected and/or swabbed within 48 hours of the event for DNA analysis. Nest remains from nests that were not filmed were also collected. Eggshell fragments were collected using sterilised tweezers whilst wearing sterile surgical gloves that were wiped with alcohol in order to avoid contamination. The fragments were then placed in labeled zip lock bags. All samples were stored in a refrigerator upon return to base. Samples were later sent to Landcare Research for analysis.

2.3 Harrier trapping

Cage traps designed for harrier capture were placed at monitored tern colonies as soon as possible after discovery of the colony. Two live harrier cage traps and two DOC 250 traps were placed near the riverbank at each colony and monitored daily. Harriers caught

in the traps were dispatched immediately and taken back to base for analysis of stomach contents.

3. Results

3.1 Summary of colony productivity monitoring

Cameras were established at six black-fronted tern colonies along the Wairau River. These colonies varied in location, status, size and period of time that they were filmed (Table 1).

Between the sampling period of 9 November 2009 and 16 December 2009, 34 nests were filmed for a total of 175 days and 141 nights, however not all of this footage was usable due to software issues with the recorders.

Table 1: Basic description of black-fronted tern colonies where nests were recorded.

Colony	Status	GPS location	Period filmed	Total number of nests	Outcome of colony
Monument	Island	E1598244 N5375627	9/11/09 – 24/11/09	50	Very little egg predation. Majority of chicks gone 24/11. Suspect black-backed gulls.
Pylon	Island	E1619377 N5389899	10/11/09— 27/11/09	14	No chicks after 5/12. However chicks observed on unmonitored neighbouring Island.
Branch	Island	E1614411 N5386471	24/11/09— 17/12/09	33	All but one nest failed.
Branch Lower	Island	E1614812 B5387437	8/12/09— 17/12/09	10	All nests failed.
Patriarch C	Island	E1619311 N5390030	10/11/09— 25/11/09	18	Majority of chicks gone by 25/11. 5 Fledglings counted.
Patriarch D	Island	E1614812 N5389885	10/11/09— 25/11/09	70	Majority of chicks gone by 25/11.

3.2 Video study

The majority of the video recording occurred only in the upper Wairau, due to the employment of a contractor for the lower section.

In accordance with the 2008 study, only lethal predation of eggs was recorded; there was no predation of chicks or adult terns on the video footage.

Table 2. Nest outcomes at black-fronted tern colonies where predation events were successfully filmed at one or more nests.

Colony	**Nests predated (%)**	**Nests deserted (%)**	**Nests flooded (%)**	**Nests with unknown outcome (%)**
Monument	50	9 (18.8)	0 (0.0)	2 (4.0)
Branch	33	23 (71.9)	0 (0.0)	1 (3.0)
Branch Lower	10	8 (88.9)	1 (11.1)	1 (10.0)
Pylon	14	8 (57.1)	1 (7.2)	0 (0.0)
Patriarch C	18	8 (44.4)	0 (0.0)	0 (0.0)
Patriarch D	70	26 (37.7)	0 (0.0)	1 (1.0)
Total	**195**	**82 (42.1)**	**2 (1.0)**	**5 (2.6)**

3.3 Identified predators

During the two month sampling period, 12 events were recorded in which the predator was successfully identified out of 17 filmed predation events (Table 3). The footage from the other five predations could not be used due to difficulties with the software (Table 3).

The footage in which the predator was successfully identified included stoat predation (1), black-backed gulls (3), pied oystercatcher (*Haematopus longirostris*) (3), ship rats (2), and Australasian harrier (3). Scavenger events, excluding terns removing eggshell, included 3 incidents of mice (Table 3).

DNA analysis results were compared with predation footage, but only for nests with remains left from the observed predation event. This included two nests, in which both the video footage and the DNA corresponded (harrier, Table 3). Additionally, DNA corresponding with a filmed mouse scavenging event (BR33, table 3), and rabbit DNA was also identified (BR14, Table 3). Nest remains were not present at many of the nests due to the egg being consumed whole by predators such as black-backed gulls and pied oystercatchers.

Table 3. Summary of successfully recorded predation events (footage and DNA)

Nest no.	Date of event	Egg remains	Predator ID (footage)	Scavenging (footage)	DNA result
MM35	13/11/09	n	Stoat	n	-
BR03	27/11/09	n	Black-backed gull	n	-
BR04	07/12/09	n	Ship rat	Tern	-
BR08	07/12/09	n	Ship rat	Tern	-
BR25	07/12/09	y	Harrier	Tern	-
BR14	08/12/09	y	Harrier	Mouse	Harrier/ rabbit
BR33	08/12/09	y	Harrier	Mouse	Harrier/mouse
BL06	09/12/09	n	Black-backed gull	n	-
PY10	26/11/09	n	Black-backed gull	n	-
PC01	18/11/09	n	Pied oystercatcher	Tern, mouse	-
PC18	27/11/09	n	Pied oystercatcher	Tern, mouse	-

3.4 DNA results

DNA results collected from nest remains at filmed and un-filmed nests, as well as swabs collected from adult terns and chicks that had been preyed upon showed a variety of potential predators (Table 4.)

Table 4. Potential predator DNA results from swabs of egg remains, adult terns and chicks from filmed and unfilmed nests.

	Harrier	Pied Oyster-catcher	Mouse	Wrybill	Cat	Stoat	Ship rat	Other	DNA unknown or not predator
No. of predations 2009 (%)	11 (21.6)	2 (3.9)	4 (7.8)	2 (3.9)	13 (25.5)	1 (2.0)	1 (2.0)	4 (7.8)	10 (19.9)
No. of predations 2008 (%)	27 (61.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.3)	0 (0.0)	14 (31.8)

The potential predator profile from DNA analysis is dissimilar to the results from 2008 (Table 4.) There are fewer cases of Australasian harrier predation, and an increase in predation from other potential predators including pied oystercatchers, wrybills (*Anarhynchus frontalis*), cats, and stoats. The wrybill is believed to be locally extinct on the Wairau, and this wrybill DNA is likely to be banded dotterel DNA (DOC unpublished report 2009).

3.5 Trapping

3.5.1 DOC 250s

Between 9 November 2009 and 15 December 2009, DOC 250 traps placed near the riverbank at colonies caught two hedgehogs, two Australian magpies (*Gymnorhina tibicen*) and two ship rats over three different colonies.

3.5.2 Harrier cage traps

Between 10 November 2009 and 10 December 2009, 16 Australasian harriers were captured over seven different colonies in live cage traps. Black-fronted tern remains were not present in the stomach contents of any dispatched Australasian harriers.

4. Discussion

4.1 Predator profile from video and DNA

- The potential predator DNA and predators filmed at nests differ from the results of the 2008 study (Tables 3 & 4) (DOC unpublished report 2009). It is possible that the targeted trapping of harriers at black-fronted tern colonies is responsible for this change in predator suite. However, the small sample size (due to costs associated with DNA analysis) and lack of scientific design for trapping harriers (ie. no control sites were established for comparison of hatching success), means that it is impossible to draw meaningful conclusions from these data. As it stands already, the relationship between predator and prey species, and the resulting impact on native species on braided rivers are not well understood (Norbury et al. 1998). This change in predator profile could be attributed to many other factors including but not limited to: weather; predator abundance; prey abundance; and location of colonies. Predator-prey cycles can also be largely driven by factors that are not well understood, such as the impact of abundance of the introduced European rabbit (*Orcytolagus cunniculus)* on adjacent predator abundance to braided river birds (Norbury

et al. 1998). Rabbits are a primary source of prey for many introduced mammalian predators (Keedwell & Brown, 2001). One aspect of this predator-prey relationship that has been studied and documented is that a decrease in rabbit abundance can lead to increased predation pressure on native river birds (Norbury et al. 1998; Rebergen et al., 1998). It is necessary to increase the understanding of these dynamics and their subsequent effects on black-fronted terns along the Wairau River.

4.2 DNA versus. Video

DNA analysis of egg remains, chicks and adult terns has the potential to be an effective means of predator identification, as the few samples that included both video identification and DNA analysis were corroborated and found to have the same result (Table 4.). However, a more robust sample size of videoed nest with egg remains is necessary to draw any meaningful conclusions. DNA analysis is expensive and, as shown in this study, has the possibility of overlooking many predators that would not otherwise be classed as a threat to the viability of balck-fronted terns. This includes oystercatchers and black-backed gulls, which were observed consuming eggs whole on the recorded footage, and leaving no remains for analysis.

4.3 Conclusions and recommendations

There is little knowledge and research regarding predators and predator control in relation to black-fronted terns in New Zealand. Limited resources and tight conservation budgets can lead to a concentration of resources on the most critically endangered species (Joseph et al. 2009). However, it is also important to focus on less-endangered species such as the black-fronted tern before numbers decline to the point where they become too difficult to study and successfully conserve. There is a chance decline can lead to reclassification and thus the possibility of increased allocation of funds and resources, however without monitoring this will not happen.

- The video study, direct observation and DNA results from the past two breeding seasons have highlighted the importance of aerial predators, especially black-backed gulls and Australasian harriers on tern eggs (Table 3 and 4). There were instances of tern colonies situated in close proximity to black-backed gull colonies, making them targets for frequent predation. In one instance, two black–backed gulls were observed taking three chicks within a 20 minute period (Steffens, pers. obs). It is recommended that control of black-backed gulls is implemented, in either the form of sensitively-targeted alphachloralose poisoning and/or egg pricking. Both these

methods are used to protect braided river birds in the Mackenzie Basin (Keedwell et al. 2002). A previous study on the effect of alphachloralose on black-fronted tern hatching success on black-fronted terns in the Mackenzie Basin failed to show positive results on hatching success (Lurling 2004). Despite this, the impact of black-backed gulls on black-fronted terns on the Wairau River cannot be ignored, and perhaps a study on the effect of poisoning of these colonies should be implemented.

- The harrier trapping may or may not have influenced the variety of predators observed to be involved with black-fronted tern nest predation this season. As demonstrated in many predator control operations, in the absence of the option of complete eradication, removing one predator guild will just make way for another. Past efforts of targeted predator control on the Wairau River did not indicate that predator control increased hatching success of black-fronted terns (DOC unpublished report 2008). However there is evidence that predator control increases survival in other braided river bird species in New Zealand, thus contributing to the overall recovery of braided river environments (Keedwell et al. 2002). As little is understood concerning the dynamics of predation on a braided river, trapping regimes need to be based on systematic studies concerning efficacy, such as trap characteristics and placement within the landscape (Cameron et al. 2005). Therefore, it is recommended that trapping be carried out in random block designs using a variety of traps and bait types for potential predators along the Wairau River, concentrated around the tern colonies. Using a random design can be used to estimate probabilities of captures in order to determine the most effective variable surrounding trapping (Andy Hutcheon, pers. comm.).

- When designing wildlife studies, it is important to begin with a consideration of the basic design principles (Joseph et al. 2008), especially with regard to the replication of study sites in which comparisons can be made. If fledging success is greater in one of the sites, then there is a higher chance of measuring the effectiveness of a trapping regime, or identification of a specific predator guild. Since the Wairau River does not branch into the neighbouring Rotoiti lakes area, then the river could be divided and a control site designated based on the home rages of targeted predators. If this study was based on a balanced design implementing a control site, then harrier trapping may have been measured against hatching success.

- Residual predator/pest monitoring should be taking place along the Wairau River. Monitoring of residual predator and pest numbers during and after a control operation not only provides insight into the effectiveness of the control regime, but also helps to determine the predator densities that can be tolerated within the site (Maloney et al. 2005). Residual monitoring in the form of tracking tunnels and spotlight rabbit counts along the Wairau River and at tern colonies could be used to account for predator-prey cycles.

This study has shown that DNA analysis is clearly not the optimal means of potential predator identification for black-fronted terns, as some predators do not leave remains for analysis. However, this study has gained insight on predators of terns on the Wairau River that would have otherwise been overlooked. Although sample sizes from this study, as well as those from DOC (unpublished report 2009) are too small to draw conclusions from, it is not recommended that this study be repeated in the immediate future, or in its current form. This is due to the difficulty in collecting a robust sample size, software issues, time constraints, the number of cameras in operation and effort required to operate equipment. Identification of predators using video technology and DNA will most likely evolve and become cheaper and easier to operate in the future, and has the potential to be an important tool for wildlife management conservation.

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Appendix: Filmed events at black-fronted tern nests, 2009

The following descriptions are of filmed predation, desertion, scavenging and chick hatching events at black-fronted tern nests on the Wairau, 2009.
1. **Patriarch Colony**

(ii) Nest: PC18
Event: Predation
Nest Remains: No
Scavenging event: No
Date of event: 27/11/09
Footage: Tern leaves nest at 09:42hrs, returns 09:45hrs for 30 seconds leaves again, and returns 09:49hrs. Pied oystercatcher enters the background (possibly 10m from nestbowl) at 09:55hrs leaves frame at 10:01hrs. Tern becomes agitated at 10:14hrs, leaves nest at 10:19hrs for 1 minute, lands again and acts agitated until 10:22hrs when it flies away. Pied Oystercatcher enters at 10:23:56, breaks one egg open, and leaves after being harassed by terns at 10:24:13, but returns and picks up shell fragment seconds later. Oystercatcher returns at 10:25:00hrs and pecks at second egg, then picks up shell fragment from the first egg, pecks at the second egg and then leaves at 10:25:54hrs. Oystercatcher then runs around behind the nest being harassed by terns. Returns to nest and continues pecking at egg for a few seconds, then leaves. Tern removes eggshell remains at 10:28:32 and does not return to nest. Oystercatcher returns at 10:59:24 and leaves at 10:59:43 after looking at the empty nest bowl.

(ii) Nest: PC15
Event: Predation
Nest remains: Yes
Scavenging event: Unknown
Date of Event: 27/11/09
Footage: None

(iii) Nest: PC14
Event: Predation
Nest Remains:
Scavenging event: Unknown
Date of Event: Unknown
Footage: None/ Codec error

(iv) Nest: PC01
Event: Predation
Nest Remains:
Scavenging event: Rat
Date of event: 18/11/2009
Footage: at 20:07:59hrs the tern leaves the nest. Pied oystercatcher approaches nest at 20:08:19hrs while clearly being mobbed by terns, there are terns circling in the background as well. Oystercatcher breaks one egg open and proceeds to eat it while being mobbed by terns until 20:09:13hrs, when it approaches the nest bow l and rolls the second egg out and pecks at it OC stands around nest getting dive bombed until 20:10:07hrs when it finally walks out of the frame. Adult terns are still seen circling. Pied oystercatcher is seen in the background, possibly visiting another nest, then approaches the first nest again, looks around, and leaves. Terns seen circling and dive-bombing in

the background, chasing the pied oystercatcher, which returns to the first nest at 20:13:37, pecks at the ground, and then leaves. Adults return to the nest at 20:15:44 and carries off first shell fragment and returns again at 20:17:07 for another. Tern returns at 20"25:38, observes nest and leaves again at 20:26:0hrs, and again 20:29:59. Again it sits briefly on the empty nest bowl until 20:32:36 when it flies away gain. At 22:51:45 a rat visits the nest. It searches the nest appears to stop and eat something, then leaves at 22:52:12hrs. At 23:49:48hrs the rat returns, stays at the nest foraging until 23:50:50, then returns again at 23:59:47, stays in the nest bowl until 00:01:35. Can see blurry movements around nest, possible terns flying around. Rat returns again and 00:34:03, and leave at 00:34:29. Returns again at 2:27:13, appears to forage some more, then leaves at 02:27:51, appears again at 3:29:00hrs, eats something in the nest bowl, and finally leaves at 3:33:00hrs.

(v) Nest: PC01
Event: Predation
Nest Remains: no
Scavenging event: Rat
Date of event: 18/11/2009
Footage: at 20:07:59hrs the tern leaves the nest. Pied Oystercatcher approaches nest at 20:08:19hrs while clearly being mobbed by terns, there are terns circling in the background as well. Oystercatcher breaks one egg open and proceeds to eat it while being mobbed by terns until 20:09:13hrs. Then it approaches the nest bowl and rolls the second egg out and pecks at it OC stands around nest getting dive bombed until 20:10:07hrs when it finally walks out of the frame. Adult terns are still seen circling. Pied oystercatcher is seen in the background, possibly visiting another nest, then approaches the first nest again, looks around, and leaves. Terns seen circling and dive-bombing in the background, chasing the pied oystercatcher, which returns to the first nest at 20:13:37hrs, pecks at the ground, and then leaves. Adults return to the nest at 20:15:44hrs and carries off first shell fragment and returns again at 20:17:07 for another. Tern returns at 20:25:38hrs observes nest and leaves again at 20:26:0hrs, and again 20:29:59hrs. Again it sits briefly on the empty nest bowl until 20:32:36hrs when it flies away again. At 22:51:45hrs a rat visits the nest. It searches the nest appears to stop and eat something, then leaves at 22:52:12hrs. At 23:49:48hrs the rat returns, stays at the nest foraging until 23:50:50hrs, then returns again at 23:59:47hrs, stays in the nest bowl until 00:01:35hrs. Can see blurry movements around nest, possible terns flying around. Rat returns again and 00:34:03hrs, and leaves at 00:34:29. Returns again at 2:27:13, appears to forage some more, then leaves at 02:27:51, appears again at 3:29:00hrs, eats something in the nest bowl and finally leaves at 3:33:00hrs.

Bigger picture: Large colony suddenly hit by many predation events, all but 3 nests abandoned and predated on between 21/11/09 and 27/11/09.

2. Branch Colony

(i) Nest: BR03
Event: Predation
Nest Remains: No
Scavenging event: No
Date of event: 26/11/2009
Footage: Tern leaves nest at 06:20:22hrs. Black-backed gull enters at 06:22:25hrs and swallows both eggs. Leaves nest at 06:22:39hrs. Tern returns at 06:34:05hrs and

incubates empty nest bowl until 06:40:19hrs. Then it stands next to the nest bowl until 06:43:05hrs then sits back down again, flying away at 06:43:46hrs. Tern proceeds to sit down near the nest until 07:08:50 when it finally flies away. Tern returns at 7:24:34hrs, incubates empty nest bowl until 7:24:05hrs then flies away.

(ii) Nest: BR04
Event: Predation
Nest Remains: No
Scavenging event: No
Date of event: 5/12/09
Footage: Tern leaves the nest at 01:28:10hrs. Rat appears at nest at 01:28:50hrs. It takes one of the eggs away from the nest bowl at 01:30:01. Rat returns at 01:42:40hrs and takes the second egg away from the nest bowl. Rat returns at 01:49:30hrs, inspects the camera, then appears to eat one of the eggs on the corner of the nest bowl then comes and goes until 01:54 hrs. Tern returns to nest at 05:29:09 and removes a shell fragment, and returns to incubate the empty nest at 05:53:25hrs, coming and going one more time, then finally leaving an hour later. The rat can be seen in the background at 18:31:11hrs.

(iii) Nest: BR08
Event: Predation
Nest Remains: Yes
Scavenging event:
Date of event: 6/12/2009
Footage: Tern leaves nest at 3:32:42hrs. Rat appears at nest at 3:33:13hrs, and eats the first egg at 3:38:38hrs and moves onto the second egg 6:12 3:44:05hrs, leaving at 3:51:51hs. Rat returns at 04:26:50 and leaves after a minute. Tern returns at 05:27:34hrs and removes eggshell fragments.

(iv) Nest: BR25
Nest Remains: No
Date of Event: 6/12/2009
Scavenging event:
Footage: Tern leaves nest at 19:45:42hrs and does not return until 5:41:18hrs. Tern comes and goes from then nest until 12:00:48hrs. Harrier arrives at 12:10:58hrs, eats both eggs at the nest bowl, and leaves at 12:13:53hrs. Tern returns to nest at 12:25:19hrs and 12:26:10hrs to remove nest fragments. Tern returns at 12:26:41hrs, but leaves a few seconds later.

(v) Nest: BR14
Nest Remains: No
Date of Event: 7/12/2009
Scavenging event: Rat
Footage: Tern leaves nest at 15:15:34hrs. Harrier arrives at nest at 15:29:40hrs and eats both eggs until 15:35:03hrs when it flies away leaving behind very small visible shell fragments. At 22:20:04hrs a rat appears at the nest, picks up a shell fragment and leaves at 22:20:29hrs. The rat returns at 00:47:49hrs, appears to forage at the nest bowl on a fragment, then leaves at 00:48:54hrs, leaving with a shell fragment. Tern does not return to the nest.

(vi) Nest: BR33
Date of Event: 7/12/2009
Scavenging event: Rat
Nest remains: yes
Footage: Tern leaves nest at 15:09:09hrs. Harrier approaches nest at 15:10:08, takes one egg but then leaves the frame until 15:16:02 and break the egg and eats it in the nest bowl, finally leaving at 15:17:40. Rat arrives at nest at 01:22:46hrs. Rat forages on egg fragments until 01:29:28hrs. Rat returns at 03:50:00 and continues to forage in the nest bowl until 3:53:20. The rat returns again at 04:32:40hrs and stays at the nest bowl until 04:33:48hrs. It returns again at 05:08:50 leaving again at 05:12:20hrs.

(vii) Nest: BR27
Date of Event: Unknown
Event: Abandon

Bigger picture: New colony discovered on 25/11/09 with 28 nests found before the 27/11/09. Black-backed gulls seen foraging in the area. Almost completely wiped up by 8/12/10 by predation events.

3. Branch Lower
(i) Nest: BL06
Date of Event: 08/12/2009
Scavenging Event: No
Nest Remains: No
Footage: Tern leaves nest at 15:52:10hrs. Black-backed gull arrives at nest at 15:57:17 and swallows the only egg in the nest leaving at 15:47:52hrs. Tern returns to the nest at 16:00:00hrs and comes and goes until 17:07:51hrs, never actually landing.

Bigger picture: All nests failed by 17/12 (except one still going on 17/12 but footage showed the tern leaving this nest overnight . Eggs probably dead). One fledgling was observed on this island on the 17th, with a large group of adults.

4. Monument Colony

Nest: MM35
Event: Predation
Nest Remains: No
Scavenging event: No
Date of Event: 12/11/2009
Footage: At 10:39:32hrs the tern leaves the nest. At 10:45:44hrs a stoat approaches the nest and takes one of the two eggs and carries it away. Tern returns to the nest at 10:51:10hrs and proceeds to incubate the second egg, coming and going for the next few hours. Terns can be seen mobbing in the background for about ten minutes at 11:07:31hrs. Stoat can be seen a few metres from the empty nest at 14:09:35, however it does not approach the nest bowl. Tern returns at 14:10hrs, but comes and goes while colony mobs until 14:39:33hrs when the stoat returns, runs through the nest bowl past the remaining egg again. Tern returns at 14:41:35 and leaves the nest at 18:43:27hrs. Stoat returns at 18:44:13 hours, and removes the second egg from nest. Birds are seen mobbing in the background for the next few minutes. At 19:40:50hrs there is mobbing in the background. Tern does not return to the nest.

Bigger Picture: Terns nesting at upper end of an island. Black-backed gulls nesting at lower end of the same island (with one gull nesting amongst the terns). Very little egg predation , however majority of chicks vanished overnight at/around 24/11. Suspect black-backed gulls taking chicks (2 chicks with peck holes in head). It is possible that last few chicks survived to fledging.

5. Pylon Colony

(i) Nest: PY10
Event: Predation
Nest Remains: No
Scavenging event: No
Date of Event: 25/11/09
Footage: At 06:59:51hrs tern leaves the nest, can see terns dive-bombing and mobbing in the background. At 07:08:15hrs Black backed gull approaches, and takes both eggs whole, then flies away at 07:09:14hrs. Tern returns to the nest at 07:11:17hrs, and agitatedly incubates the empty nest bowl until 07:15:38hrs when it flies away for a few minutes, returning at 07:17:43hrs. It flies away again almost immediately, returning again at 07:22:48hrs, when it stands near the nest bowl for a few minutes, then flies away. It returns again at 08:03:22hrs and stands a few metres from the nest, and then its mate arrives at 08:03:57 and incubates the empty nest bowl until 08:05:48 when it finally flies away.

Bigger picture: Although no chicks were observed on the monitored island after 5 Dec, chicks were observed on a neighbouring island (not monitored) and it is possible that these chicks fledged.