A review of the status and management of banded dotterels (*Charadrius bicinctus*) on Ōnoke Spit

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Cover Image: Adult male banded dotterel (*Charadrius bicinctus*) and flowering New Zealand daphne (*Pimelea* sp.).

Executive Summary

Ōnoke Spit in Palliser Bay is widely recognised for having high indigenous biodiversity values, supporting nationally and regionally significant populations of several Nationally Threatened plant and animal species.

Ōnoke Spit supports the largest population of banded dotterels breeding along the coastline of the Wellington region. The 25 breeding pairs that breed on the spit each year represent 14.4% of all banded dotterels breeding along the Wellington region coastline, and 6.7% of all banded dotterels breeding in the entire Wellington region.

The Department of Conservation and Friends of Ōnoke Spit have been carrying out mammalian predator and weed control, and managing off-road vehicle use on Ōnoke Spit since 2010. These management activities have succeeded in maintaining stable numbers of banded dotterels breeding on Ōnoke Spit, however the breeding success of these birds is unknown, and a local nesting colony of Caspian terns does not appear to have bred successfully since 2013.

Depredation of eggs and chicks by hedgehogs and cats continues to be the greatest threat to the productivity of banded dotterels on Ōnoke Spit, followed by off-road vehicle use. This report recommends that the efficacy of the existing mammalian predator control regime be reviewed, either by monitoring the fates of a sample of banded dotterel nests during the 2020-2021 breeding season, or by commissioning an independent audit of the existing predator control regime, including adopting elements of the proven predator management techniques that have driven a major recent increase in banded dotterel breeding success on the nearby Parangarahu Lakes foreshore. This report also recommends a series of measures aimed at minimising the negative impacts of off-road vehicle use on banded dotterel and Caspian tern productivity, and that further trail camera monitoring be carried out at the Ōnoke Spit Caspian tern nesting colony to determine whether predation by black-backed gulls is occurring.

The extent of sea level rise predicted to occur over the next 80 years has the potential to reduce the area of breeding habitat available to banded dotterels on Ōnoke Spit, and to greatly increase the risk of banded dotterel nests being lost to flooding. To mitigate this threat, this report recommends that an Ōnoke Spit sea level rise response plan be developed by 2030, to model the impact of predicted levels of sea level rise on the future size, location and morphology of Ōnoke Spit, and to evaluate options for ensuring that an equivalent area of coastal gravel beach habitat is maintained for banded dotterels and other threatened taxa along the future Palliser Bay coastline.

Keywords: banded dotterel, black-backed gull, Caspian tern, mammalian predators, Ōnoke Spit, Palliser Bay, sea level rise, Wairarapa Moana

1. Background

Ōnoke Spit is a 3.3 km long sand and gravel barrier beach situated in Palliser Bay that has formed as a result of marine sedimentation and tectonic uplift (Boffa Miskell, 2010). Ōnoke Spit formed approximately 3,000-4,000 years ago, extending across the mouth of a former coastal embayment and estuary to form Lake Ōnoke (Rhodes, 2012). Prior to the 1940s, periodic closing of Lake Ōnoke to the sea would result in major inundations of the lower Ruamāhanga Valley, a process known to local Māori as hinurangi. Since 1948 however, an artificial opening has been maintained at the eastern end of Ōnoke Spit to prevent these inundations and the associated flooding of farmland in the lower Ruamāhanga Valley (Silbery, 2012).

Ōnoke Spit is subject to harsh environmental conditions, including extreme temperatures, strong southerly salt-laden winds, and partial inundation during storm surges and king tides. As a result, the spit supports an ecosystem comprised of a relatively low diversity of highly specialised plant and animal species that are well-adapted to these harsh coastal conditions (Silbery, 2012). The spit is sparsely vegetated with drought- and salt-tolerant plant species including spinifex (*Spinifex sericeus*), pīngao (*Ficinia spiralis*) and a nationally significant population of sand tussock (*Poa billardierei*). Cushion plant herbfields are also present, comprised of *Raoulia australis* and New Zealand daphne, (*Pimelea* sp.) (Silbery, 2012; Todd et al, 2016; see cover image). Several rare or threatened invertebrates are present on the spit, including the katipō spider (*Latrodectus katipo*), and two moths: *Notoreas perornata* "Wairarapa/Wellington" and the endangered *Ericodesma aerodana* (Todd et al, 2016).

Ōnoke Spit also provides important breeding and roosting habitat for several threatened coastal bird species. The spit supports breeding populations of banded dotterels (*Charadrius bicinctus*) and variable oystercatchers (*Haematopus unicolor*), and the only breeding colony of Caspian terns (*Hydroprogne caspia*) to be found in the Wellington region (Challies & Scadden, 2010; Rebergen, 2012; McArthur et al, 2019a). Red-billed gulls (*Larus novaehollandiae*) and white-fronted terns (*Sterna striata*) also occasionally nest on the spit, although they do not appear to have done so since the early 2000s (Scadden, 2012). More recently, several pairs of royal spoonbills (*Platalea regia*) have recently begun nesting among a colony of black-backed gulls (*Larus dominicanus*) (McVeagh et al, 2019). During the non-breeding season, the spit provides roosting habitat for small numbers of both New Zealand and Arctic-breeding migrants, including black-fronted terns (*Chlidonias albostriatus*), wrybill (*Anarhynchus frontalis*) and turnstone (*Arenaria interpres*) (eBird, 2020).

Due to these biodiversity values, Ōnoke Spit consistently ranks very highly during biodiversity prioritisation exercises. For example, Ōnoke Spit was assigned the highest possible score based on its flora and fauna community values and threatened species values, during a biodiversity prioritisation exercise carried out by Greater Wellington Regional Council. The aim of this work was to identify the best remaining examples of representative high biodiversity value sites in the Wellington region and to identify regional priorities for active management (Crisp et al, 2016). Ōnoke Spit is also scheduled as a "significant habitat for indigenous birds" in Wellington's proposed Natural Resources Plan, based on the presence of the region's only Caspian tern breeding colony, a relatively large breeding population of banded dotterels and the presence of a relatively large number of Nationally Threatened or At Risk bird species. (GWRC, 2015; McArthur et al, 2015). During a recent review of estuaries of the lower North Island, Todd et al, (2016) ranked Ōnoke Spit as part of the third most valuable

estuarine system in the lower North Island for its ecosystem and social values, and for the number of Nationally Threatened and At Risk species present. Ōnoke Spit also falls within the proposed Wairarapa Moana Ramsar Wetland (GWRC, 2013), and within the Wairarapa Moana Ruamāhanga Important Bird Area identified by Forest & Bird/Birdlife International (Forest & Bird, 2016).

Ōnoke Spit, along with the adjacent Kiriwai Lagoon and Lake Ōnoke, is managed as part of the Wairarapa Moana Wetland Project, a partnership between the Department of Conservation (DOC), Greater Wellington Regional Council (GWRC), South Wairarapa District Council and Ngāti Kahungunu ki Wairarapa and Rangitāne o Wairarapa (Todd et al, 2016). The Department of Conservation is taking a lead role in the management of the ecosystem and biodiversity values of the spit, with much of the day-to-day management work being carried out by a local community-led conservation group, the Friends of Ōnoke Spit (FOOS).

Ōnoke Spit has been identified as an Ecological Management Unit by the Department of Conservation, which has two Species Management Targets designated for this site, for the banded dotterel and *Notoreas perornata*. DOC currently has two management targets for banded dotterels, namely "threatened species under active management to improve understanding" and "threatened species under active management to ensure local security" (Anna Burrows, personal communication). To achieve this first banded dotterel management target, DOC has commissioned this report to summarise and review the existing knowledge of the Ōnoke Spit banded dotterel population, to review potential threats to the population and to prioritise management activities aimed at maintaining a healthy breeding population of banded dotterels at this site.

2. A review of the status of banded dotterels in New Zealand

The banded dotterel is a medium-sized dotterel that breeds only in New Zealand. Two subspecies are recognised, subspecies *bicinctus* breeds on the North, South and Chatham Islands and outlying islands, and subspecies *exilis* is confined to the Auckland Islands. The mainland subspecies breeds around the New Zealand coastline on both sandy and shingle beaches, and on braided riverbeds in Hawke's Bay, Manawatu and Wairarapa in the North Island, and Marlborough, Canterbury, Otago and Southland in the South Island (Heather & Robertson, 2015). Banded dotterels are a migratory species with a relatively complex regional pattern of migration. Coastal-breeding birds tend to be sedentary year-round, whereas inland-breeding birds in the North Island migrate to the nearby coast or lakes, or to estuaries in the Auckland region during the non-breeding season. In the South Island, birds breeding in the MacKenzie Basin and other high-altitude inland sites migrate across the Tasman Sea to the coastlines of Victoria and Tasmania during the non-breeding season, whereas birds breeding in Westland tend to migrate to Farewell Spit and birds breeding in coastal Canterbury and Marlborough migrate to estuaries in the Auckland region (Pierce, 1999).

The global population of banded dotterels is currently estimated to be around 19,000 birds (Hansen et al, 2016), and is believed to be declining at a rate of between 1.4 and 3.7 per annum (O'Donnell & Monks, in press). As a result, banded dotterels are currently ranked as Nationally Vulnerable under the New Zealand Threat Classification System (Robertson et al, 2017).

3. Population size, trends, and distribution of banded dotterels in the Wellington region

The population size and distribution of banded dotterels in the Wellington region is currently very well understood, as a result of a series of shorebird census surveys carried out by Greater Wellington Regional Council between 2017 and 2019. In January 2017, GWRC carried out shorebird surveys along 211 km of braided river habitats in the Wellington region (McArthur & Burgin, 2017), and between 2017 and 2018 surveyed shorebirds along the entire 450 km coastline of the Wellington region (McArthur et al, 2019a). In October 2019, GWRC also surveyed the distribution and abundance of shorebirds along a further 50 km of the Ōtaki, Waikanae and Hutt Rivers (GWRC, unpublished data).

From these surveys, we know that the greater Wellington region currently supports a breeding population of 741 banded dotterels, comprising 346 birds breeding along the coastline, a further 344 birds breeding on riverbeds in the Ruamāhanga and Opouawe River catchments, and an additional 51 birds breeding on the bed of the Ōtaki River (McArthur & Burgin, 2017; McArthur et al, 2019a; GWRC unpublished data; Figure 3.1). This regional breeding population represents 3.9% of the estimated global population of 19,000 banded dotterels (Hansen et al, 2016).

In contrast to the declining national population trend, the number of banded dotterels breeding in the Ruamāhanga and Ōtaki River catchments appears to have been relatively stable over the past decade (McArthur et al, 2019b; GWRC unpublished data). However, population trends among coastal-breeding banded dotterels in the Wellington region are not known. Based on this information, banded dotterels are currently ranked as Regionally Vulnerable in the greater Wellington region under the New Zealand Threat Classification System (GWRC/DOC unpublished data).

Banded dotterels are sparsely distributed along the Wellington region's coastline and braided rivers, with the majority of birds found at a relatively small number of discrete sites. Banded dotterel numbers tend to be highest on relatively wide reaches of braided riverbeds that are comparatively free of woody weed cover, namely the beds of the Ōtaki, Waingawa, mid-Ruamāhanga and Opouawe Rivers. In contrast, they tend to be absent or relatively uncommon on narrower or highly channelised riverbeds, or those with significant woody weed infestations, including the beds of the Waikanae, Hutt, lower Ruamāhanga, Pahaoa and Awhea Rivers. Along the coastline, banded dotterels tend to be concentrated at river mouths, estuaries or headlands - all sections of coastline that have comparatively wide expanses of unvegetated sand or gravel. Key coastal breeding sites for banded dotterels in the Wellington region include the Waitohu Estuary, Oteranga Bay, the Parangarahu Lakes foreshore, Baring Head, Ōnoke Spit and Riversdale Beach. In contrast, banded dotterels are absent or rare along relatively narrow sand or shingle beaches, or along rocky shorelines (Figure 3.1).

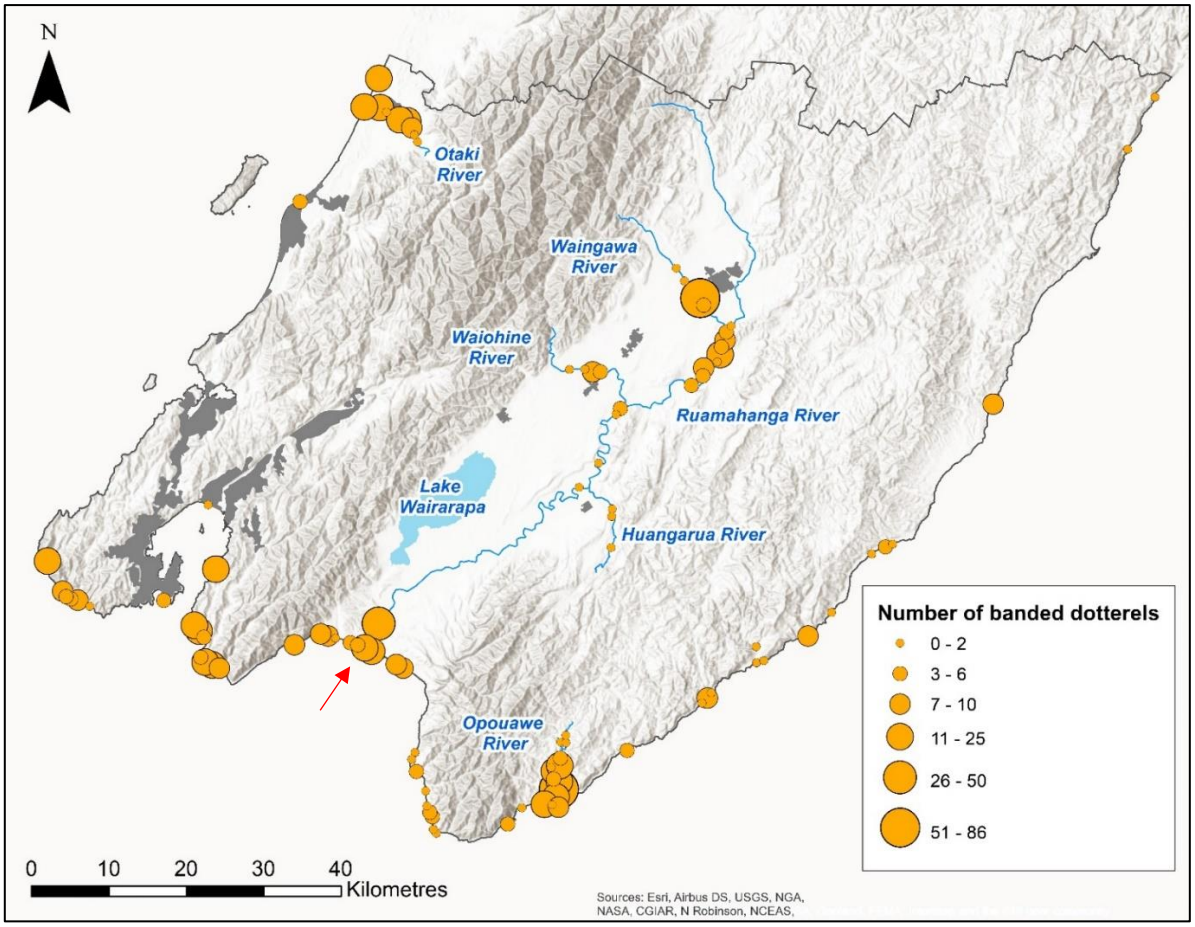

Figure 3.1: Spatial patterns in the abundance and distribution of adult banded dotterels in the Wellington region between October and January (red arrow indicates the location of Ōnoke Spit). This map has been produced using unpublished shorebird survey datasets held by GWRC, the results of which are summarised in McArthur & Burgin, 2017; McArthur et al, 2019a and McArthur et al, 2019b.

4. Population size, trends, and breeding success of banded dotterels on Ōnoke Spit

Ōnoke Spit currently supports a breeding population of between 15 and 25 pairs of banded dotterels, or 30 to 50 adult birds. This estimate is derived from four sources: two systematic surveys that have been carried out over the past ten years and two independent estimates supplied by Joanna McVeagh and Dougal MacKenzie.

On the 30th September 2012, Aalbert Rebergen carried out a systematic count of banded dotterels along Ōnoke Spit and counted a total of 42 adult birds (Rebergen, 2012). More recently, on the 4th December 2017, Samantha Ray and Patrick Crowe carried out a second systematic survey and counted a total of 50 adult banded dotterels on the spit (McArthur et al, 2019; GWRC, unpublished data). The results of these two surveys suggest that the maximum number of breeding pairs present on the spit in 2012 and 2017 were 21 and 25 breeding pairs, respectively.

These two population estimates are fairly similar to two independent population estimates provided by Dougal MacKenzie and Joanna McVeagh, both members of the Wairarapa Region of Birds New Zealand and Friends of Ōnoke Spit. Both Dougal and Joanna have spent considerable amounts of time on Ōnoke Spit carrying out predator & weed control and monitoring the breeding success of Caspian terns, and have based their estimates on their anecdotal observations of the distribution and densities of banded dotterels they have encountered on the spit. Joanna estimates that the spit supports a population of around 15 banded dotterel breeding pairs, and Dougal estimates a breeding population of between 10 and 20 breeding pairs (Joanna McVeagh, personal communication, April 2020; Dougal MacKenzie, personal communication, April 2020).

Assuming a local breeding population of 50 adult birds as indicated by the most recent census survey, Ōnoke Spit currently supports 14.4% of the banded dotterels breeding along the Wellington region coastline, 6.7% of the banded dotterels breeding in the entire Wellington region, and 0.3% of the national population of 19,000 birds. Ōnoke Spit is also the fifth largest single-site breeding population of banded dotterels in the Wellington region, after the Opouawe, Ruamāhanga, Waingawa and Otaki Rivers, and is the largest single-site breeding population to be found along the 450 km coastline of the Wellington region (Table 4.1).

A total of sixty banded dotterel observations have been recorded in the New Zealand eBird database from Ōnoke Spit to date. The earliest observation on record was made on the 31st December 1922 by R.H.D. Stidolph, who noted that banded dotterels were “present” on the spit (Stidolph, 1922). The highest count of birds made during the breeding season was the 50 birds recorded by Samantha Ray and Patrick Crowe during their systematic survey of the spit in December 2017 (GWRC, unpublished data), and the largest number of birds counted during the non-breeding season was a flock of 72 birds counted by Joanna McVeagh on the 26th May, 2018 (McVeagh, 2018). Banded dotterels have been recorded on Ōnoke Spit during every month of the year, suggesting that the birds that breed on the spit are largely sedentary, or that breeding birds departing in late summer/autumn are replaced by non-breeders arriving from elsewhere. Two recent local re-sightings of marked birds do indicate that at least some movement of birds to and from Ōnoke Spit does occur throughout the year. On the 20th November 2013, a banded dotterel carrying a single metal band was photographed on the adjacent Whangaimoana Beach by Kevin Stevens, and subsequent investigations revealed that this

bird had been caught and banded as an adult on the shores of the Kaipara Harbour on the 4th March 2006 (Stevens, 2013). The timing of these two events suggests that this bird was breeding locally in Palliser Bay, and had migrated to the Kaipara Harbour for the non-breeding season, where it had been caught and banded. On the 19th April 2019 Joanna McVeagh spotted a banded dotterel on Ōnoke Spit that was carrying a white flag on its tibia. This bird had been caught on its nest on the Parangarahu Lakes foreshore the preceding season (MIRO, unpublished data), suggesting that this bird was spending at least some of its time at Ōnoke Spit during the non-breeding season.

Another pattern that emerges from the banded dotterel observations that have accumulated on the New Zealand eBird database for Ōnoke Spit and its environs is that flocks of up to 30 banded dotterels are also regularly counted on the mudflats of the Turanganui Delta, on the northern shore of Lake Ōnoke (e.g. McVeagh & Shore, 2014; McArthur, 2017; McVeagh et al, 2020). The birds observed at the delta are typically observed feeding on the mudflats that are exposed either at low tide, or when lake levels are low (Nikki McArthur, personal observation). An absence of a suitable high-tide roost nearby, and the similarity between the number of birds counted at the delta compared to the number estimated to be breeding on Ōnoke Spit suggests that the delta may provide valuable foraging habitat for banded dotterels that breed on Ōnoke Spit. This being the case, it may be important to manage habitat quality at both the Turanganui Delta and on Ōnoke Spit, in order to maintain the current breeding population on the spit.

Table 4.1: List of the ten largest populations of breeding banded dotterels in the Wellington region during 2017-2019. This table has been produced using unpublished shorebird survey datasets held by GWRC, the results of which are summarised in McArthur & Burgin, 2017; McArthur et al, 2019a and McArthur et al, 2019b.

Rank	Site Name	Habitat	Number of breeding adults
1	Opouawe River	Braided river	170
2	Ruamāhanga River	Braided river	67
3	Waingawa River	Braided river	61
4	Otaki River	Braided river	51
5	Ōnoke Spit	Shingle beach	50
6	Baring Head	Shingle beach	40
7	Parangarahu Lakes foreshore	Shingle beach	34
8	Wellington south coast	Shingle beach	24
9	Ocean Beach (western Palliser Bay)	Shingle beach	23
10	Oteranga Bay	Shingle beach	19
	Total		**539**

The breeding success of banded dotterels on Ōnoke Spit has never been systematically monitored, and there is currently some uncertainty over how productive this population is. Joanna McVeagh has not formed an impression of the proportion of nests that successfully hatch each year, but she believes that relatively few chicks that do hatch subsequently survive to fledging age. This impression is based on her observation that most of the chicks she has observed on the spit have been comparatively young (i.e. newly hatched), whereas she has only occasionally observed older chicks or fledglings. She has also noticed that many chicks that she has seen appear to be the only surviving member of their brood, indicating high rates of mortality during the first week following hatching (Joanna McVeagh, personal communication, April 2020). Dougal MacKenzie's impression is somewhat different, however. His impression is that nest survival and hatching success appears to be fairly good, with many nests that he has found remaining active for considerable lengths of time. He also typically observes broods of between one and two chicks and estimates that as many as 50% of these chicks may be surviving to fledging (Dougal MacKenzie, personal communication, April 2020).

In addition to these observations, there are two further sources of uncertainty regarding the productivity of the Ōnoke Spit banded dotterel population. Firstly, observed levels of hatching success almost always tend to be higher than 'true' levels of hatching success, because those nests that are found and monitored by an observer tend to be those that are inherently more likely to hatch in the first place, whereas nests that are at greater risk of failure due to being situated in areas that are more prone to flooding, disturbance or predation are more likely to fail before they're found by an observer (Mayfield, 1961; 1975). Secondly, banded dotterel chicks are highly precocial, well-camouflaged and very mobile prior to fledging, all factors which make it extremely challenging to quantify how many chicks hatch and subsequently fledge from active nests, particularly when both the chicks and their parents are unmarked (Keedwell, 2001). The answer to both problems is to systematically monitor the survival of known nests and individually-marked chicks, and to model the daily survival rates of nests and chicks to estimate the likely proportions of each that survive to hatching and fledging respectively (Keedwell, 2001; Dinsmore, 2002).

5. An evaluation of threats to the Ōnoke Spit banded dotterel population

Causes of banded dotterel nest failure and chick mortality on Ōnoke Spit have not been quantified in any systematic way. However, a prioritised list of threats likely to be having a negative impact on banded dotterel survival and productivity can be compiled using three sources of information, namely: 1) drawing upon the observations of Dougal MacKenzie and Joanna McVeagh; 2) inferring predator impacts from Ōnoke Spit trap-catch data; and 3) extrapolating from banded dotterel monitoring data collected elsewhere, particularly from the Parangarahu Lakes foreshore and Baring Head. The following sections list each of the likely threats to the banded dotterels on Ōnoke Spit in descending order of priority or seriousness of impact, together with any evidence that each threat is having an impact on the productivity or survival of banded dotterels on the spit.

5.1 Mammalian predators

Based on these three sources of information, it is likely that the most important factor limiting the productivity and survival of banded dotterels on Ōnoke Spit is depredation by European hedgehogs (*Erinaceus europaeus*) and feral cats (*Felis catus*). Both Dougal MacKenzie and Joanna McVeagh share the view that hedgehogs are likely to be the most important predator of banded dotterels on Ōnoke Spit, and this is supported by the large number of hedgehogs (121) that have been trapped on the spit since 2010, and the fact that hedgehogs are being trapped along the entire length of the spit (Joanna McVeagh, personal communication, April 2020; Dougal MacKenzie, personal communication, April 2020; Trap.NZ unpublished data, https://www.trap.nz/, accessed 01/05/2020).

This impression is also consistent with banded dotterel nest monitoring results from the Parangarahu Lakes foreshore and from Baring Head, two nearby coastal sites with similar shingle beach habitats to Ōnoke Spit. Between 2011 and 2013, 10 out of 15 banded dotterel nests (67%) filmed at these two sites were preyed upon by mammalian predators, with nine of these nests (90%) being preyed upon by hedgehogs and one nest (10%) being preyed upon by a cat (GWRC, unpublished data). Trail camera footage filmed at these nests strongly indicated that hedgehogs were highly effective at locating banded dotterel nests, whereas cats would more typically be attracted to nest sites once the eggs had been broken open by a hedgehog. This in turn suggested that cats were more often acting as scavengers rather than predators of banded dotterel eggs, but that cats may have been more of a threat to hatching eggs and to newly hatched chicks, due to being more readily attracted to nest sites once the eggshell had been breached (GWRC, unpublished data; Nikki McArthur, personal observation).

Although hedgehogs appear to be the most abundant predator on the spit, there is strong circumstantial evidence that feral cats are preying on shorebird nests, chicks, and adult birds on the spit. Cats have recently been filmed visiting the Ōnoke spit Caspian tern colony at night (Figure 5.1.1) and have also been associated with a mass mortality event of 20-30 white-fronted terns on the spit (Figure 5.1.2). Dougal MacKenzie has noted that the impacts of cats may spike whenever the outlet to Lake Ōnoke becomes blocked by gravel build-up at the eastern end of the spit, creating a land bridge between the settlement of Lake Ferry and eastern tip of Ōnoke Spit. Dougal is concerned that both domestic and feral cats cross this land bridge when it forms, and then can potentially become trapped on the spit once the lake outlet is artificially re-opened (Dougal MacKenzie, personal communication, April 2020).

In addition to hedgehogs and cats, a total of 24 mustelids (*Mustela* spp.) and 67 rats (*Rattus* spp.) have also been trapped on Ōnoke Spit since 2010, indicating that both mustelids and rats may also be potentially preying on shorebird populations on the spit (Trap.NZ unpublished data, https://www.trap.nz/, accessed 01/05/2020).

Figure 5.1.1: Trail camera images from the Ōnoke Spit Caspian tern colony. The top image shows several adult terns sitting on their nests during the daytime, whereas the bottom image shows a cat walking through the same field of view at night. No eggs or chicks appear to have been preyed upon during this encounter, however the adult birds have clearly been flushed from their nests by the cat in the lower image (Images courtesy of Dougal and Denise MacKenzie/Stuff https://www.stuff.co.nz/environment/88190920/feral-cats-ravage-vulnerable-caspian-tern-breeding-colony-in-wairarapa; accessed 01/05/2020).

Figure 5.1.2: Some of the remains of up to 20-30 white-fronted terns found near the eastern end of Ōnoke Spit. Cat tracks were observed in the sand and gravel surrounding these remains and a feral cat was observed hiding beneath driftwood nearby, with another cache of bird remains. (Image courtesy of Dougal and Denise MacKenzie/Te Rakau Birding https://www.terakaubirding.co.nz/; accessed 01/05/2020).

5.2 Off-road vehicle use and associated human activity

Both Dougal MacKenzie and Joanna McVeagh agree that off-road vehicle use on the spit poses the next most serious threat to banded dotterels, though both have pointed out that given that banded dotterel nests are very sparsely distributed along the length of the spit, they're at much lower risk of being disturbed or destroyed by vehicles than colony-nesting birds such as Caspian terns.

This view is supported by the observation that vehicle use, vandalism and other human-related disturbance events have been a leading cause of breeding failure at the Ōnoke Spit Caspian tern colony for many years (Challies & Scadden, 2010). This situation has been worsening over time as vehicle use on the spit continues to increase (Elsworth, 2004; Dougal MacKenzie, personal observation), and has led to near-zero reproductive success at the colony since 2013 (Dougal MacKenzie, personal communication, April 2020). A key observation made by Challies & Scadden (2010) is that more Caspian tern chicks tend to be reared during a breeding season when early-season nests are successful, with subsequent nesting attempts generally being less successful. This being the case, vehicle disturbance causing the loss or abandonment of early-season nests can have a disproportionately large impact on Caspian tern breeding success on Ōnoke Spit, because in addition to the loss of early season nests, later season re-nesting attempts caused by the loss of early season nests are also inherently less successful. In addition to the serious, ongoing impacts of off-road vehicle use on the Ōnoke Spit Caspian tern colony, this activity also poses a serious threat to the fragile *Raoulia/Pimelea* herbfields on the spit, and therefore to the quantity and quality of habitat available to the *Notoreas perornata* moth.

It should be noted however, that evidence from elsewhere suggests that off-road vehicles pose a much lower risk to banded dotterel nesting success than may be expected given the extent of traffic or vehicle tracking at a site. For example, between 2011 and 2015, none of the 104 banded dotterel nests monitored at the nearby Parangarahu Lakes foreshore and Baring Head sites failed as a result of being disturbed or destroyed by off-road vehicle use, despite the presence of vehicles and heavy vehicle tracking apparent at these sites (GWRC, unpublished data). Similarly, less than 1% of the over 500 shorebird nests monitored by Manaaki Whenua Landcare Research contractors on braided rivers in the MacKenzie Basin between 2016 and 2017 failed due to off-road vehicle use, despite regular recreational vehicle use at these sites (Nikki McArthur, personal observation; Manaaki Whenua Landcare Research, unpublished data).

5.3 Black-backed gulls

Both Dougal MacKenzie and Joanna McVeagh have identified depredation by black-backed gulls (*Larus dominicanus*) to be a potential threat to banded dotterel productivity on Ōnoke Spit, but both acknowledge that there is no local evidence of this, and that black-backed gull impacts are likely to be relatively insignificant in comparison to those of mammalian predators.

These impressions are supported by the banded dotterel nest success monitoring carried out at the Parangarahu Lakes foreshore and at Baring Head between 2011 and 2015. No incidents of black-backed gull predation were recorded at either of these sites, whereas at least two-thirds of the 104 nests that were monitored failed due to being preyed upon by hedgehogs and cats. During this study, banded dotterels were observed to exhibit defensive behaviours at the nest whenever black-backed gulls passed overhead however, with the incubating bird typically crouching low over the nest to simultaneously conceal it's bright white chest and bands, and to present the sandy brown plumage of the back and the head to the sky, while peering upwards to track the movements of the gull (Nikki McArthur and Annette Harvey, personal observation). This provides some evidence to suggest that banded dotterels do recognise black-backed gulls as a threat.

Black-backed gulls are known to be significant predators of the eggs and chicks of black-billed gulls (*Larus bulleri*), white-fronted terns and black-fronted terns whenever these species are nesting in proximity to each other (e.g. Stead, 1932; Schlesselmann et al, 2018). Direct predation by black-backed gulls on banded dotterel eggs or chicks has only rarely been recorded however (e.g. Moon, 1992), and there appear to be no records of black-backed gulls preying upon Caspian tern eggs or chicks. Dougal MacKenzie has observed that the Ōnoke Spit Caspian terns do not appear to be particularly concerned about black-backed gulls and has never observed black-backed gulls venturing into the colony. However, FOOS have captured trail camera footage of black-backed gulls visiting the Ōnoke Spit Caspian tern colony at night (Joanna McVeagh & Nikki McArthur, personal observation) and Stidolph (1937) has also observed Caspian terns at Ōnoke Spit aggressively driving black-backed gulls away from their nesting colony. These latter observations provide some circumstantial evidence that black-backed gulls may be preying upon Caspian tern eggs or chicks on Ōnoke Spit, however the possibility also exists that Caspian terns benefit from nesting in proximity to black-backed gulls, via the shared defence of nesting colonies from other predators such as cats.

5.4 Weeds

Encroachment by both herbaceous and woody weeds into open gravel habitats on Ōnoke spit has likely led to a reduction in the total area of nesting habitat available to banded dotterels on the spit (Buckley, 2016). Furthermore, dense stands of woody weeds may be having an indirect impact on banded dotterel productivity by providing shelter and cover for mammalian predators such as cats and mustelids, and their primary prey, rabbits and hares (O'Donnell & Moore, 1983; O'Donnell et al, 2016). Marram (*Ammophila arenaria*), gorse (*Ulex europaeus*) and pink ragwort (*Senecio glastifolius*) are currently being controlled on Ōnoke Spit by both DOC and FOOS (Buckley, 2016; Dougal MacKenzie, personal communication, April 2020; Anna Burrows, personal communication, May 2020).

5.5 Hares and rabbits

Both hares and rabbits are present on Ōnoke Spit and cause significant browsing damage to the *Raoulia/Pimelea* herbfield vegetation (Todd et al, 2016). This impact is likely to have a negative effect on the *Notoreas perornata* moth, which is the subject to DOC's other Species Management Target for Ōnoke Spit, due to reductions in the number, size and health of their *Pimelea* host plants. However, there is also some evidence from South Island braided rivers that sudden decreases in the abundance of hares and rabbits can lead to increases in nest predation rates for ground-nesting shorebirds (Norbury & Heyward, 2008).

5.6 Australian magpies

Dougal MacKenzie has noticed a gradual increase in the abundance of Australian magpies on Ōnoke Spit over the past few years, but is unsure whether they're likely to be having any impact on the banded dotterels breeding on the spit (Dougal MacKenzie, personal communication, April 2020). Magpies have been recorded preying upon banded dotterel chicks elsewhere however (Keedwell & Sanders, 1999), and Joanna McVeagh has recorded an instance of a group of magpies preying upon a New Zealand dotterel nest at Riversdale Beach (McVeagh, 2016). This indicates that there is some potential for magpies to prey upon banded dotterel nests and chicks on Ōnoke Spit.

5.6 Sea level rise

The Intergovernmental Panel on Climate Change Fifth Assessment Report estimates that global mean sea levels will rise by up to 0.98 m above current levels by the year 2100, assuming unmitigated growth in carbon emissions over that time (Church et al, 2013). However, a more recent survey of climate scientists has estimated that global mean sea-levels could rise by up to 1.32 m over the same period (Horton et al, 2020). Under this scenario, Ōnoke Spit is predicted to migrate slowly inland while maintaining its current form, although it is likely that it will become more prone to flooding as a result of a substantial and rapid increase in the frequency of extreme storm-tide and skew-surge events around the New Zealand coastline (Iain Dawe, personal communication; Stephens et al, 2020). These changes will potentially lead to changes in the area of nesting habitat for banded dotterels on Ōnoke

Spit and will substantially increase the risk of nest failure due to flooding in the coming decades, and these impacts will occur irrespective of actions taken in the meantime to mitigate threats posed by mammalian predators and off-road vehicle use.

6. Conservation management priorities for the Ōnoke Spit banded dotterel population

6.1 Mammalian predator control

The results of this review indicate that the control of mammalian predators, particularly hedgehogs and cats, remains the highest priority management action required to maintain a healthy, productive breeding population of banded dotterels on Ōnoke Spit. Although the existing predator control regime that has been in place since 2010 has succeeded in removing over two hundred mammalian predators from Ōnoke Spit to date, it is not clear whether this has resulted in local improvements in banded dotterel breeding success. The total number of banded dotterels breeding on Ōnoke Spit doesn't appear to have increased between 2012 and 2017 for instance, and there is some anecdotal evidence that fledging rates may be low (Rebergen, 2012; McArthur et al, 2019; Joanna McVeagh, personal communication, April 2020).

Given this, there are two options available for optimising the mammalian predator control on Ōnoke Spit, to improve outcomes for breeding banded dotterels. The first option is to closely monitor the outcomes of a sample of banded dotterel nests on Ōnoke Spit during the 2020/2021 breeding season, to monitor nest success rates and causes of nest failure. The results of this monitoring can then be used to check whether the existing predator control regime is adequately targeting the predator species that are accounting for the largest proportion(s) of nest losses. This approach has been successfully used at both the Parangarahu Lakes foreshore and at Baring Head to optimise conservation management actions targeted at increasing the breeding success of banded dotterels. 104 nests were monitored at both sites between 2011-2015, and these monitoring results were used to develop and test a mammalian predator control regime that has increased the hatching success of banded dotterel nests at the Parangarahu Lakes foreshore from a low of 3% between 2011 and 2013, to a high of 57% between 2017 and 2019 (McArthur & Jones, 2019).

The second option is to simply apply the mammalian predator control regime currently in use at the Parangarahu Lakes foreshore to Ōnoke Spit, on the assumption that given the close similarities in habitat, pest mammal abundance and indigenous biodiversity values between these two sites, similar improvements to banded dotterel breeding success are likely to occur. To achieve this, it is recommended that DOC and FOOS engages Darren Lees (Biosecurity Officer at Greater Wellington Regional Council) to undertake a review of the existing Ōnoke Spit mammalian predator control regime, and to suggest changes and improvements. Darren has been instrumental in developing and implementing the mammalian predator control regime now in place at the Parangarahu Lakes foreshore, and that has resulted in substantial improvements to banded dotterel nesting success at this site. It is recommended that Darren's review includes, but not be limited, to the following:

- A review of the number, layout and type of traps being used on Ōnoke Spit.

- A review of the trap baiting and maintenance regime.

- An investigation of whether additional control measures, such as night shooting using thermal scopes, are required to adequately control local populations of hedgehogs and cats.

- An assessment of whether local populations of rabbits and hares should also be controlled to reduce primary prey abundance for cats and mustelids, and to reduce browsing pressure on the *Raoulia/Pimelea* herbfield vegetation on the spit.

- The development of an additional "rapid response" component to the mammalian predator control regime (e.g. the deployment of live-capture traps), designed to intercept cats, hedgehogs and mustelids that gain access to the eastern end of the spit whenever Lake Ōnoke becomes completely blocked.

It is recommended that DOC and FOOS consult with each other to jointly decide which of these two options to action. Once a choice has been made, it is recommended that the cost of implementing the preferred option be estimated, and that DOC provides FOOS with technical assistance to apply for a grant to meet the costs of implementing this preferred option.

Dougal MacKenzie and Joanna McVeagh have both mentioned the considerable travel expenses involved with undertaking trapping and monitoring work on Ōnoke Spit and have also acknowledged the financial support provided by DOC in the form of petrol vouchers to offset these travel expenses. It is recommended that DOC continues to provide this financial support, either through the direct provision of funds or by providing FOOS with assistance in applying for grants, in exchange for the volunteer labour being provided by FOOS when carrying out conservation management activities on the spit.

Dougal MacKenzie has also pointed out however, that this financial support does not currently cover vehicle maintenance costs associated with operating vehicles in the harsh, highly abrasive, and salt-laden environment of Ōnoke Spit. These costs run to many hundreds of dollars per year per vehicle and are currently being met by four key members of FOOS, namely Dougal and Denise MacKenzie, and Joanna McVeagh and Colin Shore. Dougal has identified these costs as a constraint to the amount of time he can invest in conservation management activities on the spit, and has suggested that if DOC can meet these costs in future, for example by providing a de-commissioned fleet vehicle for use by FOOS members on Ōnoke Spit, then this will increase the group's capacity to undertake future work on the spit (Dougal MacKenzie, personal communication, April 2020).

6.2 Off-road vehicle use

It is recommended that current efforts to manage off-road vehicle use on Ōnoke Spit be continued, to minimise the risks that this activity poses to nesting banded dotterels and Caspian terns. A ban of vehicles on Ōnoke Spit is not recommended, due to the lack of evidence that this activity is having a negative impact on banded dotterel breeding success, as well as the likely resistance that the local community will have to such a measure being enforced.

Instead, it is recommended that the following measures be taken:

- Maintain the existing permanent signage at Ōnoke Spit, informing recreational users of the biodiversity values of the spit and recommending that vehicles always remain on the formed access track or below the high tide line on the spit.

- Erect temporary signage on the 1st September each year at all access points, and near the Caspian tern colony, drawing attention to the presence of nesting birds and reiterating the message for vehicles to remain on the formed track and below the high tide line at all times. Remove this signage on the 28th February each year.

- Install wooden vehicle track markers along the entire length of the central vehicle track, so that it is clearly delimited to recreational vehicle users. Ideally these wooden markers need to strike a balance between being relatively conspicuous to track users, while also blending into the natural character of the Ōnoke Spit landscape.

- Install temporary fencing to create a physical barrier between the central vehicle track and the Caspian tern colony once it forms each year, along with accompanying temporary signage, to encourage vehicle users to remain on the vehicle track when in the vicinity of the colony. Such a fence may either completely enclose the area used by nesting Caspian terns, or run either side of the vehicle track for 50-100 m adjacent to the Caspian tern colony.

- In September each year, deliver leaflets to Lake ferry and local rural properties and publish articles in community newsletters or local newspapers, drawing attention to the fact that shorebirds will be nesting on the spit, and to the vehicle access restrictions that are in place to protect nesting shorebirds, and encouraging local residents to report any conspicuous or damaging infringements of these rules to DOC.

- Provide the local community with an annual update on the performance of the local Caspian tern colony, at the end of each breeding season.

6.3 Black-backed gulls

Despite the presence of a large black-backed gull breeding colony on Ōnoke Spit, there is little evidence that black-backed gulls are having an impact on the breeding success of the banded dotterels or Caspian terns on Ōnoke Spit. The incidence of black-backed gull predation on banded dotterel eggs and chicks appears to be low nationwide, in comparison to losses caused by mammalian predators. Furthermore, there is only weak circumstantial evidence that black-backed gulls may be preying upon Caspian tern eggs or chicks on the spit, and this possible negative impact needs to be balanced against the potential positive impacts of black-backed gulls nesting in proximity to the Caspian terns, through the mutual defence of eggs and chicks from other predators such as cats.

This being the case, there appears to be little justification for controlling the numbers of black-backed gulls breeding on Ōnoke Spit at the present time. That said, it is recommended that further trail

camera monitoring be carried out at the Ōnoke Spit Caspian tern colony, to confirm whether or not the black-backed gulls that have been observed visiting the colony are preying on eggs or chicks.

6.4 Weeds

It is recommended that DOC and FOOS continue to control existing weed infestations on Ōnoke Spit, and to undertake regular surveillance monitoring to detect new weed incursions as they occur. We recommend that weed control and surveillance efforts tasks be scheduled between January and August each year wherever possible, to avoid any potential adverse impacts on nesting shorebirds. Where this is not possible, we recommend that any weed control or surveillance carried out between September and December inclusive be preceded by a survey for active shorebird nests or young chicks, and an exclusion zone of 50m radius be maintained around any nests or chicks during subsequent weed control or surveillance activities. We recommend that these pre-works surveys be carried out by an ornithologist with a minimum of 160 hours' shorebird monitoring experience, to maximise the likelihood that all nests or chicks within each operational area are identified.

6.5 Sea level rise

The predicted rise in sea level over the coming decades has the potential to severely impact the size and productivity of the local breeding population of banded dotterels on the spit, and this in turn may negate any efforts that have been made in the meantime to reduce the negative impacts of mammalian predators and off-road vehicle use.

The measures required to avoid or minimise the predicted extent of future sea level rise and its impact on the Ōnoke Spit banded dotterels fall well outside the scope of this report. However, it is recommended that DOC works with FOOS and other Wairarapa Moana Wetland Project partners to develop a plan to mitigate the impact of future sea level rise on the biodiversity values of Ōnoke Spit. Such a plan would need to include detailed modelling of the impact of predicted levels of sea level rise on the future size, location and morphology of Ōnoke Spit, and an evaluation of options for ensuring that an equivalent area of coastal gravel beach habitat is created or maintained at a suitable location on the post-sea level rise coastline of Palliser Bay. It is recommended that an Ōnoke Spit sea level rise response plan be developed by 2030, and that this plan be reviewed every five years, to accommodate ongoing improvements to climate, sea level and coastline models, and their resulting predictions.

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