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Changes in a New Zealand wetland bird community following creation of a predator-fenced sanctuary

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Abstract: There is limited information available on how New Zealand wetland bird communities respond to removal of mammalian predators, and reintroduction of locally extinct species. The forested Zealandia Te Māra a Tāne sanctuary in Wellington is surrounded by a mammal predator-exclusion fence, and contains two small lakes (2.7 and 1.1 ha). Counts of all visible wetland bird species were used to assess changes in the Zealandia wetland bird community over 28 years. This included a 3-year block of counts before the fence was built in 1999. Flocks of up to 143 southern black-backed gulls (karoro, *Larus dominicanus*) bathed on the larger lake before the catchment was opened to the public after 1999. Brown teal (pāteke, *Anas chlorotis*) and New Zealand scaup (pāpango, *Aythya novaeseelandiae*) both established resident breeding populations following releases of captive-reared birds between 2000 and 2003. Little shag (kawaupaka, *Microcarbo melanoleucos*), black shag (māpunga, *Phalacrocorax carbo*) and pied shag (kāruhiruhi, *P. varius*) all colonised naturally, and started breeding in 2003, 2008, and 2009 respectively. Paradise shelducks (pūtangitangi, *Tadorna variegata*) increased after the sanctuary was created, although numbers remained small (mean counts of *c.* 5 birds). Numbers of mallards (*Anas platyrhynchos*) were unaffected by creation of the sanctuary; however, there was an unexplained decline after 2016. Overall, the wetland bird community in Zealandia has become more diverse over time, and with a higher proportion of native and endemic species. However, we suggest that some of these changes (particularly the establishment of a large breeding colony of pied shags) might well have occurred even if the sanctuary had not been created.

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INTRODUCTION

Eradication and exclusion of introduced mammalian predators is a major focus of conservation management in New Zealand (Russell *et al*. 2015; Parliamentary Commissioner for the Environment 2017; Anonymous 2017). Mammalian predators have been eradicated from more than 70 New Zealand islands (Bellingham *et al*. 2010; Keitt *et al*. 2011), and by 2019 there were seven forested sanctuaries surrounded by predator-resistant fences (Burns *et al*. 2012; Innes *et al*. 2012, 2019; Butler *et*

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al. 2014). As a result of this conservation effort and associated monitoring, there is a growing body of information on how endemic forest birds and forest bird communities respond to mammalian predator suppression and eradication (Miskelly 2018; Fea *et al*. 2020). Several endemic forest birds that had disappeared from the mainland have successfully reestablished within fenced sanctuaries following translocations (Burns *et al.* 2012; Miskelly & Powlesland 2013; Smuts-Kennedy & Parker 2013; Butler *et al*. 2014; Azar & Bell 2016), and there is increasing evidence that 'deep endemic' species (i.e. those that are endemic at order, family, or genus level) benefit the most from predator suppression, and that they are able to out-compete 'shallow endemic' and non-endemic bird species provided that mammalian predators are absent or at low densities (Miskelly 2018; Binny *et al*. 2020; Fea *et al*. 2020). As a result, predator exclusion or suppression can create a trophic cascade, leading to forest bird communities with a greater abundance and diversity of deep endemic species, and lower abundance of species that have arrived in New Zealand more recently (Miskelly 2018; Binny *et al*. 2020; Fea *et al*. 2020; Miskelly *et al*. 2021).

In contrast to forest bird communities, little is known about how New Zealand wetland bird communities respond to eradication of predatory mammals. There are few wetlands on islands that have been cleared of predators (exceptions include Kapiti Island and Tuhua/Mayor Island), and few wetlands within predator-fenced sanctuaries (exceptions include Rotokare in Taranaki and Zealandia Te Māra a Tāne in Wellington). While bird monitoring has been undertaken at some of these sites (e.g. Miskelly & Robertson 2002; Bell 2015; Miskelly 2018), information on changes in their wetland bird communities following predator eradications has not yet been published. The only study that we are aware of that investigated wetland bird responses to pest mammal exclusion using a fence was at Ruataniwha wetlands in inland Canterbury (Sanders *et al.* 2007). An electrified fence and low-intensity trapping were used to exclude feral cats (*Felis catus*) and ferrets (*Mustela furo*) from 39 ha of the wetland, although Norway rats (*Rattus norvegicus*) and mice (*Mus musculus*) remained abundant inside the fence (Sanders *et al.* 2007). Hatching success for banded dotterels (*Charadrius bicinctus*) was significantly higher inside the fence; however, fledgling success was significantly lower, and none of the other wetland bird species monitored showed a clear benefit from the fence (Sanders *et al.* 2007). Sanders *et al.* (2007) concluded that their results did not support ongoing use of the design of predator-fence installed at the site.

We report on changes in the wetland bird community at two small lakes in Zealandia Sanctuary, Wellington (Lynch 2019), following exclusion of predatory mammals and releases of two endemic duck species. Our analyses are based on a series of counts that were initiated before the sanctuary was created, and continued at intervals through to 2023.

METHODS

Study sites

Zealandia Te Māra a Tāne (Karori Sanctuary, 41°18′S, 174°44′E) is situated in a 3 km-long valley between the suburbs of Karori and Highbury in Wellington, New Zealand. The sanctuary is predominantly forested, apart from two small lakes (*c*. 150 and 170 m above sea level) that were created to provide water for Wellington city through construction of dams in 1876–78 (lower reservoir) and 1906–08 (upper reservoir) (Lynch 2019). Although decommissioned in the late 1990s, the lower reservoir (2.7 ha) remains at its designed water level. The upper reservoir was lowered to its current level in 1991 (Lynch 2019) and now covers only 1.1 ha.

The lower reservoir and surrounding slopes were enclosed by a 2-metre high fence to discourage human access while the lake was managed as a water storage reservoir. Access to the area around the lower reservoir remained restricted throughout the transition from water supply to predator-fenced sanctuary, whereas there were informal walking tracks around the upper reservoir before it was included within the fenced sanctuary now known as Zealandia Te Māra a Tāne. The sanctuary (225 ha, including both lakes) was enclosed by an 8.5 km-long predator-proof fence in 1999, and all introduced mammal species were eradicated the same year (Campbell-Hunt 2002; Lynch 2019). Mice (*Mus musculus*) reinvaded the sanctuary within a year, and have subsequently been controlled to low densities in the valley (Lynch 2019).

The lower reservoir was temporarily drained to about 6 m below its usual water level during March–May 2021, following which rotenone (a piscicide) was applied on 13 May, with the aim of eradicating introduced redfin perch (*Perca fluviatilis*) (Shanahan *et al*. 2022). The water level was fully restored by late June 2021 (Shanahan *et al*. 2022).

Access tracks run along the top of the two dams and the eastern sides of both lakes, providing view points for essentially all birds on the water surface and most birds roosting on the lake edges.

Study design, data collection and analysis

Direct counts of all wetland birds present on the two lakes were made from lakeside vantage points during quarterly bird counts undertaken by Ornithological Society of New Zealand (OSNZ) members during 1995–98 (before the fence was built

and pest mammals eradicated), 2002–05, and 2013–16. Changes in the forest bird community detected during counts from these three count blocks were summarised by Miskelly (2018). Ben Bell (BDB) began an ongoing series of walking transect counts that included the lakes, undertaken approximately every 3 weeks, from August 2011 (Bell 2015). These counts covered the entire 3 years of the 2013–16 OSNZ counts, and so we pooled data from both sets of counts. BDB's wetland bird data from the same four months (January, April, July, and October) between July 2020 and April 2023 were also included in the analyses, to provide a fourth 3-year block of quarterly counts (2020–23). Data on wetland bird populations were collected using the same methodology and vantage points throughout these 28 years.

We collated counts for each month and year, and retained the maximum count for each species for each of the two lakes. Counts for each lake are discussed separately in the text accounts for some species, but were added together to provide whole-of-sanctuary population estimates for each species for the graphical and statistical summaries.

Means and standard errors for each species each month within each 3-year block are presented graphically for the nine most frequently recorded wetland bird species. The samples sizes (3 maximum counts per month per count block) were too small for statistical analyses for each month, and so we combined 3 years of consecutive quarterly counts to allow statistical comparisons for each species between the four count blocks.

Maximum counts for each species within each count block were compared using Kruskal-Wallis analysis of variance. Counts between blocks were considered to be significantly different if $P<0.05$.

RESULTS

Gulls

Apart from occasional records of red-billed gull (tarāpunga, *Chroicocephalus novaehollandiae scopulinus* – see Appendix 1), the only gull species recorded from Zealandia was southern black-backed gull (karoro, *Larus dominicanus*). Large flocks of karoro scavenged at the Southern Landfill rubbish dump, *c*. 3 km south of Zealandia, throughout the study. During 1995–1998, flocks of up to 143 karoro regularly flew in from the Southern Landfill and bathed in the lower reservoir (Fig. 1). The flocks ceased using the valley after mammals were eradicated and the lower valley was opened to human visitors, with the average number of karoro present dropping from 48.8 per count session in 1995–1998 to 2.0 for the remainder of the study period (Fig. 1).

A single pair of karoro nested beside the lower reservoir during 2021–22 and 2022–23, and fledged two chicks in 2022–23 (Chris Gee & Raewyn

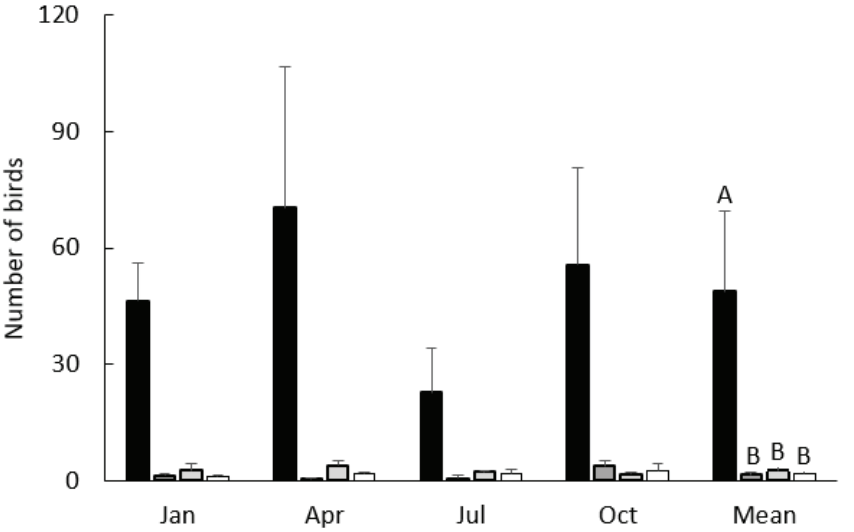

Figure 1. Southern black-backed gull / karoro counts in Zealandia sanctuary. Each bar represents the mean + standard error of the maximum count (lower + upper lake) for three consecutive years: 1995–98 (before the fence was built, black), 2002–05 (dark grey), 2013–16 (light grey), 2020–23 (white). Bars that share the same letter don't differ significantly (at $P = 0.05$).

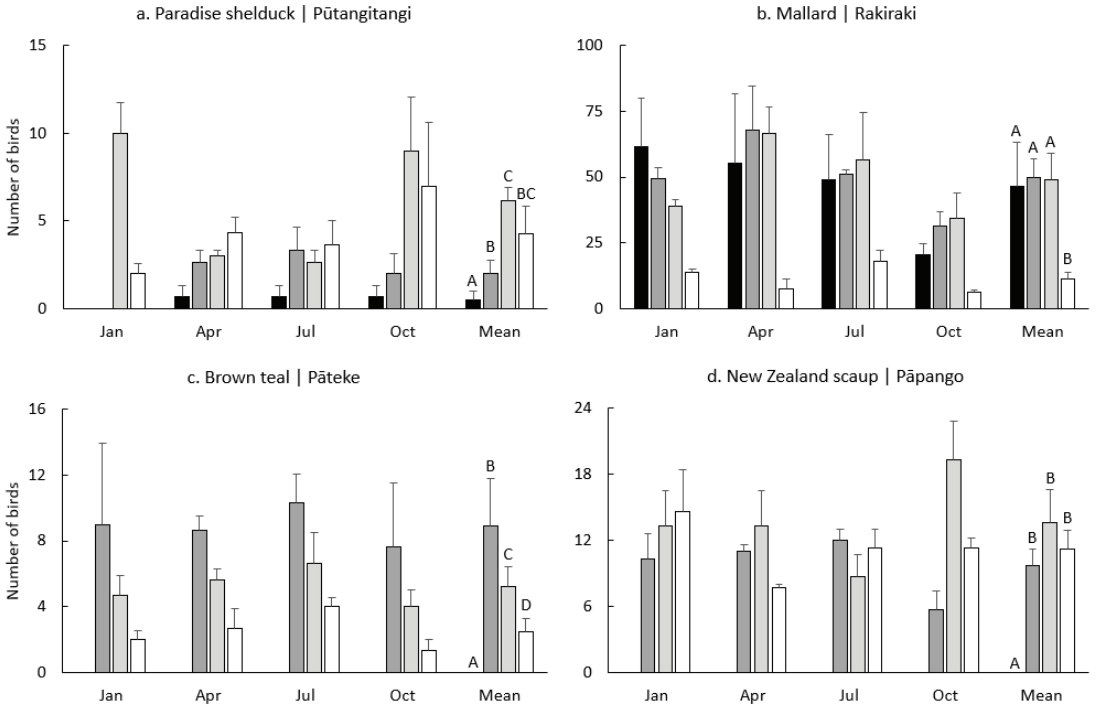

Figure 2. Duck (Anatidae) counts in Zealandia sanctuary. Each bar represents the mean + standard error of the maximum count (lower + upper lake) for three consecutive years: 1995–98 (before the fence was built, black), 2002–05 (dark grey), 2013–16 (light grey), 2020–23 (white). Note that brown teal and New Zealand scaup were not present in 1995–98. Bars that share the same letter don't differ significantly (at P = 0.05).

Empson, *pers. comms*). More than 100 "gulls and shags" gathered to feed on culled redfin perch in the lower reservoir in May 2021 (Shanahan *et al*. 2022), with 31 karoro recorded on 14 May (BDB, *pers. obs*.), the day after rotenone was applied (note that this temporary increase was not detected in the quarterly counts).

Ducks

The non-native mallard (rakiraki, *Anas platyrhynchos*) was the most abundant duck species in Zealandia throughout the 28-year study period (Fig. 2b). Their numbers remained unchanged (at an average count of 48.6 birds) after mammals were eradicated, but dropped significantly to a mean of 11.4 after 2016 (Fig. 2b). Mallard numbers were higher on the upper reservoir during 2020–23 (82% of the total, on average), and the large decline had already been detected in three of the quarterly counts before the lower reservoir was drained and rotenone applied there in May 2021 (BDB, *pers. obs*.).

Three endemic duck species were the only other Anatiformes that were frequently present in Zealandia (Fig. 2 and Appendix 1), with paradise shelduck (pūtangitangi, *Tadorna variegata*) present in low numbers when pest mammals were present (Fig. 2a). Shelduck counts increased significantly after mammals were eradicated, and continued to increase after 2005, after which they stabilised at a mean count of 5.2 birds per count session, with counts peaking when ducklings were present in spring and summer (Fig. 2a). Two or three pairs bred in the sanctuary each year (Chris Gee & Jo Ledington, *pers. comms*).

Brown teal (pāteke, *Anas chlorotis*) were released in Zealandia in November 2000 and April 2001 (18 birds) and New Zealand scaup (pāpango, *Aythya novaeseelandiae*) in April 2001 and March 2003 (7 birds); all birds of both species were sourced from captive stock (Miskelly & Powlesland 2013; Lynch 2019; Sheridan & Waldman 2020). Both species were consistently recorded in our counts from 2002 (Fig. 2). Brown teal counts declined significantly between each count block from a mean of 8.9 in 2002–05 to 2.5 in 2020–23 (Fig. 2c), while New Zealand scaup were stable at an average of 11.6 birds between 2002 and 2023 (Fig. 2d).

All three endemic duck species were regularly observed on both reservoirs.

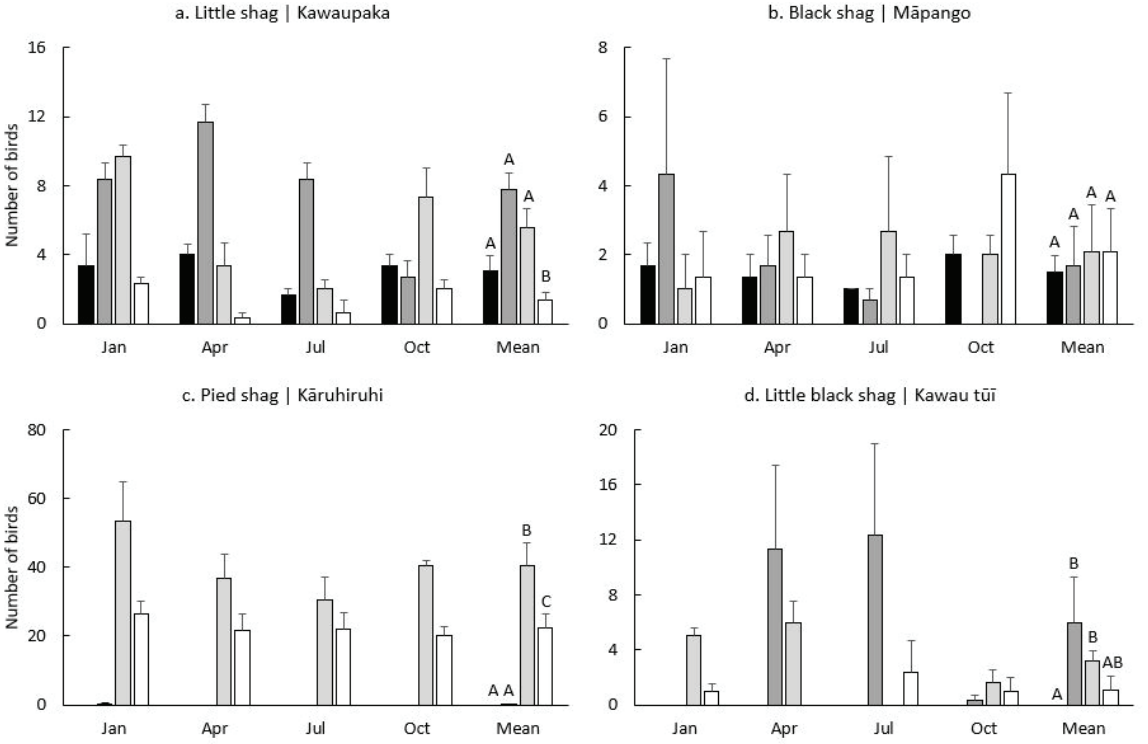

Figure 3. Shag (Phalacrocoracidae) counts in Zealandia sanctuary. Each bar represents the mean + standard error of the maximum count (lower + upper lake) for three consecutive years: 1995–98 (before the fence was built, black), 2002–05 (dark grey), 2013–16 (light grey), 2020–23 (white). Note that pied shag and little black shag were not present in 1995–98. Bars that share the same letter don't differ significantly (at P = 0.05).

Shags

Four species of shag used Zealandia (Fig. 3), with three species nesting there. Little shag (kawaupaka, *Microcarbo melanoleucos*) and black shag (māpunga, *Phalacrocorax carbo*) were both present in low numbers before the predator-proof fence was built (Fig. 3a & b), and were first recorded breeding in December 2003 and December 2008 respectively (Raewyn Empson, *pers. comm*.). Daytime counts of little shags peaked around 2014, when 19 nests were recorded (Chris Gee, *pers. comm*.). However, larger numbers have used the valley as a night-time roost, peaking at *c*. 100 birds in 1996 (Raewyn Empson, *pers. comm*.). Little shags still breed in the sanctuary; however, counts declined significantly to a mean of 1.3 per count session in 2020–23 (Fig. 3a). Little shags occasionally nest on the east side of the lake, in tree canopies below the track, where they are difficult to view and count from the track. Black shag counts have remained stable at a mean of 1.8 birds per count session throughout the 28 years (Fig. 3b). The majority of sightings for both species were on the lower reservoir (little shag 87.1%, black shag 89.4%).

The first pied shag (kāruhiruhi, *Phalacrocorax varius*) was recorded in the sanctuary during a count in January 2005 (the only individual of this species recorded during the 2002–05 count block; Fig. 3c). Pied shags started roosting in the sanctuary regularly from mid-2008, with the first breeding reported a year later (Raewyn Empson, *pers. comm*.). They were a common breeding species during the 2013–16 count block (mean 38.5 birds per count session). Pied shag counts declined significantly to a mean of 22.6 in 2020–23 (Fig. 3c). All nesting and almost all sightings of pied shags were on the lower reservoir, with three single birds only (0.4%) reported on the upper reservoir. The number of pied shags roosting in the lower reservoir was unaffected by the lowering of the water level and eradication of redfin perch in 2021 (Chris Gee, *pers. comm*.).

Little black shags (kawau tūī, *Phalacrocorax sulcirostris*) are not known to breed in the Wellington region. They mainly use Zealandia as a night-time roost during winter (Raewyn Empson, *pers. comm*.). Our daytime counts peaked during 2002–05; the subsequent decline in counts of little black shags

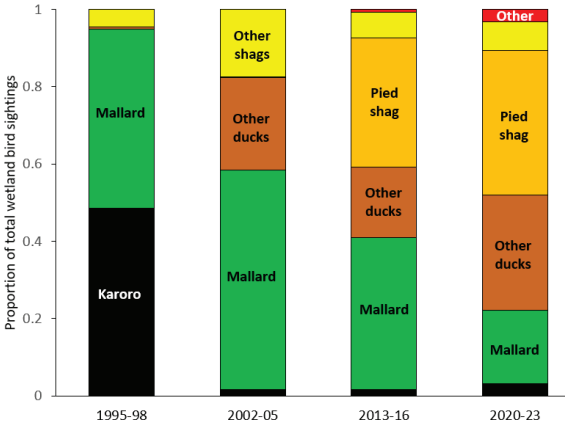

Figure 4. The composition of the Zealandia wetland bird community over 4 time periods, based on the proportional counts of each species or species group during counts undertaken in January, April, July, and October (counts averaged across seasons within each count block). The 1995–98 counts were undertaken before the predator-proof fence was built and the lower valley opened to the public. 'Other ducks' (across all four count blocks) included 55.0% New Zealand scaup / pāpango, 25.3% brown teal / pāteke, and 18.0% paradise shelduck / pūtangitangi, all of which are endemic, with brown teal and scaup released in the sanctuary. 'Other shags' were 51.5% little shag / kawaupaka, 26.7% little black shag / kawau tūī, 21.8% black shag / māpunga. 'Other' = other wetland bird species. Karoro = southern black-backed gull. Mallard / rakiraki was the only species among those graphed that was introduced to New Zealand.

through to 2020–23 was not statistically significant (Fig. 3d). Nearly all records were from the lower reservoir (98.1%).

Changes in the Zealandia wetland bird community over time

The wetland bird community in Zealandia has changed dramatically since the sanctuary was created (Fig. 4). During the initial (1995–98) count block, the community was dominated by karoro and mallards, with a few little shags and black shags (Fig. 4). Karoro became a negligible component of the wetland bird community in all subsequent count blocks, and the newly-colonised pied shag was by far the most common shag species in the last two count blocks (Fig. 4). The actual and proportional decline in mallards (the only non-native wetland bird species present) over time meant that the indigenous component of the wetland bird community in Zealandia has increased from 53.6% before the sanctuary was created, to 81.1% in 2020–23. The proportion of endemic wetland bird species (all of which were ducks, including two translocated species) increased from 0.5% to 30.4% over the same time period (Fig. 4).

DISCUSSION

The wetland bird community in Zealandia changed substantially following creation of the sanctuary. Originally dominated by southern black-backed gulls / karoro and non-native mallards, both of these species have become much scarcer, and native pied shags and three endemic duck species are now the most conspicuous components of the wetland bird community. These changes are similar in direction to those reported for the forest bird community in the sanctuary (Miskelly 2018), and have contributed to the primary restoration objective of restoring indigenous character in the valley (Lynch 2000; Campbell-Hunt 2002).

The most dramatic change in the Zealandia wetland bird community over the 28 years was the disappearance of large flocks of karoro following pest mammal eradication and creation of the sanctuary. There is no evidence that this decline was associated with a change in gull or rubbish management at the nearby Southern Landfill, and karoro remain abundant there, often with more than 1,000 birds present (Biz Bell, *pers. comm.*). Human use of the lower valley changed from almost nil when it was a water catchment area with restricted access, to a continuous stream of sanctuary members and paying visitors moving along the Lake Road that overlooks the lower reservoir. We suspect that the regular presence of people near the lake discouraged karoro from settling and bathing. Karoro have become over-abundant near metropolitan centres, largely as a result of poor waste management by humans, and are frequently the focus of management actions to reduce their numbers or discourage them from congregating (Fordham 1967, 1968; Galbraith *et al.* 2015; Miskelly 2022). It is ironic that one of the earliest consequences of the Zealandia Sanctuary being created was a significant and permanent decline in the numbers of a native bird species that used the valley, even if it was a species that few people value (it is one of only two native New Zealand bird species that currently has no legal protection; Miskelly 2014).

Unlike the gulls, mallard numbers appeared unaffected by creation of the sanctuary, and their numbers remained stable for at least 21 years. The marked decline in mallard numbers after 2016 did not appear to be directly linked to any management actions within the sanctuary, nor did it reflect any change within the Wellington region (including Horowhenua and Wairarapa), where mallard numbers were stable or increasing over the same period (Kavermann 2022). The decline occurred before redfin perch eradication was attempted in the

lower reservoir, and there was no contemporaneous increase in the two endemic duck species that had been released between 2000 and 2003 (Fig. 2), and so the decline in mallards was unlikely to have been due to competition. It is possible that mallards were affected by trophic changes following the eradication of brown trout (*Salmo trutta*) from the upper reservoir in 2015 (Lynch 2019), although no link has been proposed or investigated.

While New Zealand scaup have had a stable population in Zealandia from soon after their release, counts of brown teal declined following a peak in 2002–05. A study undertaken in the sanctuary during 2013–14 estimated that there were 40–50 brown teal in the sanctuary, with most of the birds living along forested streams away from the lakes (Sheridan & Waldman 2020). During the same period, we recorded mean counts of only 5.3 brown teal on the lakes, which suggests that diurnal lake counts detect less than 13% of the brown teal present in the sanctuary, and may not have been a reliable index of the status of the species. It is unknown whether the ratio of lake-dwelling to forest-dwelling brown teal has changed over time; however, we suggest two factors that may have resulted in brown teal becoming more secretive in Zealandia over time. The first is the deaths of the founding birds, which were all captive-reared and so may have been more confiding than wild-reared birds. The second was the colonisation of the sanctuary by New Zealand falcons (kārearea, *Falco novaeseelandiae*) from 2009 (Miskelly 2018). A falcon attacking brown teal ducklings was reported to BDB on 25 June 2023. The presence of falcons may have led to brown teal roosting among vegetation, where they would not be visible from the public tracks used for the wetland bird surveys. We are therefore uncertain whether the declining counts of brown teal after 2005 are due to a population decline or a change in the birds' behaviour, or a combination of the two.

Pied shags were not known to breed in the Wellington region before 1996, when a colony was discovered at Makara Beach (Powlesland *et al*. 2008). They started breeding at Zealandia in 2009 (reported here) and on Mana Island in 2010 (Miskelly 2023). By 2023 there were at least seven colonies between the Pencarrow coast (east of Wellington Harbour entrance) and Kapiti coast (data from eBird, viewed 7 August 2023). This rapid colonisation and population expansion within the Wellington region, and the fact that five colonies have established at sites where mammalian predators are present, suggests that pied shags would likely have colonised Zealandia regardless of the predator management regime there. Unlike pied shags, both little shags and black shags were recorded using the two lakes during the 1995–98 counts, before the predator-proof fence was built. The fact that both species began breeding 4–9 years after fence construction suggests that this was a response to predator exclusion; however, we note that both species breed at numerous mainland sites in the absence of predator control. While all three shag species likely benefited from the absence of predatory mammals at their nest sites, this may not have been a necessary condition for them to establish breeding colonies in the sanctuary.

The eradication and subsequent exclusion of mammalian predators from Zealandia was a necessary requirement before brown teal were released there, as they are highly vulnerable to introduced predators (Parrish & Williams 2001; Williams 2001; O'Donnell *et al*. 2015). The absence of mammalian predators may also have allowed New Zealand scaup to establish and maintain a small, stable population in the valley. However, we suggest that the other changes in the wetland bird community reported here (the decline in gulls, and the large increase in shags) were driven by factors other than the absence of introduced mammals in the sanctuary.

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APPENDIX 1. Wetland bird species recorded from Zealandia Te Māra a Tāne between 1995 and 2023. BDB, CMM, and DMB are the authors' initials. OSNZ = Ornithological Society of New Zealand quarterly bird surveys as described in Methods. 'Zealandia' records are from records maintained by the Zealandia conservation team (Jo Ledington, *pers. comm*.). Many additional records and species from eBird were disregarded, as some visitors to Zealandia apparently used the site as a 'catch-all' location for additional species they recorded in the Wellington region, including at coastal sites.

Black swan (kakīānu, *Cygnus atratus*) – 1 from 13 February to 15 March 2016 (eBird), 1 from 8 February to 21 May 2017 (DMB, CMM, eBird) with 2 on 23 March and 26 May 2017 (eBird), 1 on 3 July 2020 (BDB).

Paradise shelduck (pūtangitangi, *Tadorna variegata*) – resident, breeding (see main section).

Grey teal (tētē-moroiti, *Anas gracilis*) – 2 on 26 June 2016 (eBird), 2 on 14 & 25 June 2017 (eBird), 3 on 12 October 2017 (BDB), 2 on 27 February 2022 (eBird), 2 on 6 June 2023 (eBird).

Brown teal (pāteke, *A. chlorotis*) – resident, breeding (see main section).

Mallard (rakiraki, *A. platyrhynchos*) – resident, breeding (see main section).

Grey duck (pārera, *A. superciliosa*) – 6 records of up to 4 birds by OSNZ teams 2002 to 2015.

Australasian shoveler (kuruwhengi, *Spatula rhynchotis*) – pair (ex-captivity) released November 2000 (did not persist).

New Zealand scaup (pāpango, *Aythya novaeseelandiae*) – resident, breeding (see main section).

New Zealand dabchick (weweia, *Poliocephalus rufopectus*) – 1 from 20 November 2014 to 28 May 2015 (authors, *pers. obs* and eBird), 1 on 2 January 2021 (eBird), 1 on 4 & 12 December 2021 (eBird), 1 from 25 July 2022 to 9 January 2023 (BDB and eBird), 1 from 6 to 17 March 2023 (eBird).

Pied stilt (poaka, *Himantopus himantopus*) – 1 on 29 July 2021 (eBird).

Spur-winged plover (*Vanellus miles*) – rare visitors (Zealandia).

Red-billed gull (tarāpunga, *Chroicocephalus novaehollandiae scopulinus*) – 1 on 10 July 1995 (OSNZ), 2 on 24 September 2019 (eBird), 2 on 29 July 2021 (eBird).

Southern black-backed gull (karoro, *Larus dominicanus*) – regularly present (see main section).

Little shag (kawaupaka, *Microcarbo melanoleucos*) – regularly present, breeding (see main section).

Black shag (māpunga, *Phalacrocorax carbo*) – regularly present, breeding (see main section).

Pied shag (kāruhiruhi, *P. varius*) – regularly present, breeding (see main section).

Little black shag (kawau tūī, *P. sulcirostris*) – regularly present (see main section).

Kōtuku (white heron, *Ardea alba*) – 1 in 2000 (Zealandia).

White-faced heron (matuku moana, *Egretta novaehollandiae*) – 1 in 2005 (Zealandia), 1 on 12 March 2013 (eBird), 1 on 2 February 2020 (eBird).

Royal spoonbill (kōtuku ngutupapa, *Platalea regia*) – 1 in October 2010 (Zealandia), 5 on 6 November 2012 (Zealandia), 1 on 20 September 2017 (BDB), 2 on 12 December 2021 (eBird).

Pūkeko (*Porphyrio melanotus*) – 1 during April to July 2012 (BDB), 1 to 5 from 2 to 11 February 2020 (eBird).

Australian coot (*Fulica atra*) – 2 on 13 November 2016 (eBird), 1 on 15 & 29 July 2021 (BDB & eBird), 2 on 31 March 2022 (eBird).

Sacred kingfisher (kōtare, *Todiramphus sancta*) – analysed as part of the forest bird community (Miskelly 2018).

Welcome swallow (warou, *Hirundo neoxena*) – analysed as part of the forest bird community (Miskelly 2018).