Kororā/Little Blue Penguin Project

CURRENT TRENDS AND KEY THREATS

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EXECUTIVE SUMMARY

Western Bay Wildlife Trust (WBWT) is committed to the protection of Kororā/Little Blue Penguins (*Eudyptula minor*) in the Western Bay of Plenty, particularly in Mount Maunganui. Key members of our team were involved in kororā rescues during the M/V Rena Oil Spill Disaster on 5th October 2011 and the post-oil spill monitoring/research that followed, leading to the establishment of WBWT.

- Monitoring by WBWT has been crucial in monitoring the health and reproductive success of our local kororā colonies and in identifying their continuous and constantly evolving threats. Despite being subject to large amount of human disturbance, kororā continue to return and reproduce at rates comparable to or greater than other locations.
- WBWT has been instrumental in rescuing more than 100 distressed seabirds, working in collaboration with the Animal Rescue Rehabilitation Centre (ARRC). WBWT has successfully rehabilitated and released six kororā between December 2021-February 2023. Kuaotunu Bird Rescue (Coromandel), Birdcare Aotearoa (Auckland) and Penguin Rehab & Release (Tasmania) have provided valuable expertise and guidance to WBWT.
- Predators, domestic pets, rubbish, burrow competition and habitat loss are currently the most important land-based threats and starvation is likely the primary at-sea threat, but watercraft strike is also of concern.
- Ongoing observations and actions by WBWT have ensured remedial and preventative action is taken, such as regular monitoring sessions and clean up days significantly reducing rubbish blocking burrows and/or potential entanglement.
- The majority the threats relate to human activities that can be mitigated with targeted management. With the uncertainty of climate change and rising sea levels, a proactive management approach is necessary to sustain the colony.

Whilst there have been some improvements towards enhancing habitat and a growing awareness within the community regarding the importance of sustaining native species, WBWT remain concerned for the future of our local kororā, given the multitude of land-based threats, alongside the uncertainty of climate change and associated reduced food and habitat availability due to warming oceans and rising sea levels.

The purpose of this report is to inform local government, stakeholders and the community on the current trends and threats to our local kororā and to provide a baseline document to guide future research and develop collaborative management. The report identifies key threats to the kororā population via the following:

- Population monitoring of kororā on Moturiki and Mauao
- Rescue and rehabilitation by WBWT and its collaborators
- Identification of predation and competition issues at key sites
- Summary of habitat issues

Current land management practices are identified, and recommendations provided to develop a Site Specific Species Management Plan to be formulated in association with Tauranga City Council, Department of Conservation and local iwi.

POPULATION MONITORING

WBWT aims to understand kororā population trends, identify at-sea issues and leading causes of mortality of our local seabirds and shorebirds to provide management guidance and heighten community awareness to sustain these populations.

WBWT currently holds a long-term wildlife permit (August 2017- July 2027) for the Western Bay of Plenty Region; to undertake native bird and reptile rescue across the region and to monitor population trends of kororā colonies based on Mauao, Moturiki and Motuotau Islands, which are home to a large number of kororā in the Bay of Plenty region.

Monitoring of Adult Health and Survival and Reproduction occurred between 2017 and 2022 to improve our understanding of threats and population dynamics of kororā at Moturiki and Mauao.

METHODS

Site Location

Mauao is a Significant Natural Reserve and home to a large population of kororā that inhabit the rocky shores of the mountain, grass slopes and forested areas (Fig. 1). Mauao has been the primary site to monitor adult health and survival and a small number of burrows are monitored to assess chick health. Moturiki Island is a small rocky outcrop off Mount Maunganui Main Beach, classified as a Recreational Reserve and Significant Ecological Area (Fig. 1). It has been our key site for monitoring the reproductive success of kororā and chick health. They primarily inhabit boulders, caves, and crevices around the outskirts of the island, artificial structures and a small number of burrows are found within vegetated areas.

Figure 1. Kororā monitoring sites in Mount Maunganui; Mauao (green) and Moturiki Island (blue) (Google Earth, 2022).

Adult Health & Survival Monitoring

Night monitoring of adults returning to shore was primarily conducted during 2017-2019, to assess adult health and survival and continue marking the population. Night monitoring methods were adapted from Sievwright (2014). Multiple teams were spread across the sites, each with an experienced leader and undertaken for a period of two hours. Birds were captured coming ashore and immediately placed into a bag to be weighed, scanned and microchipped (if found unmarked) with twink placed on top of the head before release, to avoid recapture (Fig. 2). Microchips (Passive Insertion Transponders or PIT-Tag) were used to mark birds. Brands used were Swiss Plus ID 8mm (2017-2019) and Trojan 8mm (from 2019).

Figure 2. Adult kororā captured coming ashore after dusk on Mauao, with twink marked on head to avoid recapture, November 2018 (Image: Paul Cuming).

Birds within reach inside breeding burrows during nest monitoring 2019-2021, were scanned for a microchip with a long RFID scanner and their unique number was recorded. Unmarked birds within reach were carefully extracted, weighed, the bill depth and width measured and were marked with a microchip. Occasionally we found an adult returning to shore after dusk, whilst undertaking nest monitoring and we were able to capture, weigh and microchip it if it was unmarked.

Reproduction Monitoring

BURROW DISTRIBUTION

Nest monitoring occurred during four breeding seasons (June-March) 2019 to 2022 on Moturiki Island, with the breeding season defined as the calendar year it starts. On Moturiki, previously known burrows were checked regularly (weekly/fortnightly/monthly) for nesting activity and searches were conducted for new burrow sites throughout the seasons. Nest activity and contents were checked using a torch, hand-held digital camera or burrowscope. Burrows were identified as active by the presence of guano, tunnelling (old nest material found at the nest entrance) or presence of nest material (sticks/leaves) and/or live birds (adults, eggs, chicks).

On Mauao, occasional checks were completed primarily to microchip chicks in 2020-2022. A two-day conservation dog survey was also completed on Mauao to revisit previously known burrows and locate new burrows in mid-November 2020. Searches to locate seabird burrows (kororā/little penguin and oi/grey-faced petrel) were undertaken around the rocky coastline below the main base track, some of the grass areas above base track and in the vegetation (Sim 2020). Presence of live birds was recorded if easily found, however some burrows were too deep to determine burrow occupancy and/or nest contents.

BURROW OCCUPANCY

A total of 38 active and non-active burrows were checked weekly, fortnightly and/or monthly in 2019, 51 in 2020, 63 in 2021 and 2022 to determine burrow occupancy on Moturiki Island. Active-breeding burrows had pairs attempt to breed (presence of eggs or chicks). Active-nonbreeding burrows had kororā present, but no evidence of breeding.

BREEDING SUCCESS

During the 2019-2022 seasons burrows were monitored weekly, fortnightly and/or monthly on Moturiki Island to determine breeding success (hatching, fledging and egg success). In 2019, 20 breeding burrows were monitored, 32 in the 2020 season, 36 in 2021 and 30 in 2022. Hatching success (proportion of chicks hatched from eggs laid), egg success (proportion of chicks fledged from eggs laid), fledging success (proportion of chicks fledged from chicks hatched) and chicks fledged per pair were calculated.

LAY, HATCH, FLEDGE DATES

Not all nests were checked regularly (weekly or fortnightly), therefore lay dates, hatch dates and fledge dates were approximated by various calculating methods: If fledge dates were known, lay dates were calculated by subtracting 90 days (35 days incubation and 55 days chick rearing). If the hatch date was known (by the presence of one or both freshly hatched chicks), 35 days (length of incubation) was subtracted to estimate lay dates. Fledge date was calculated halfway between the last sighting of the chick and the first record of an empty nest provided the chick was at least seven weeks old at the last sighting or had lost most of its down. Alternatively, the fledge date was calculated 55 days after the known hatch date or 90 days after the known lay date.

CHICK HEALTH

Chicks of accessible burrows on Mauao and Moturiki were microchipped aged at 6-8 weeks (Fig. 3) according to DOC best practice guidelines. Chicks were weighed, body condition scored on a scale of 1-3 determined by keel muscle coverage (1= reduced muscle mass, 2= adequate muscle, 3= good muscle coverage) and bill length/depth was measured to monitor changes over time.

Figure 3. Kororā chicks in a breeding burrow on Moturiki Island, November 2021.

Key Threats

Threats based data has been collected and collated from an array of sources and includes both current and historical observations. Rescue and rehabilitation data is based on data that has been recorded/available at the time of writing and there has been many more cases than listed in this report (J. Graham, pers comm, 2022), as such estimates of minimum numbers has been included. This has highlighted the need for consistent and accurate long term data collection on threats; particularly by-law breaches and reports of distressed/deceased wildlife. Rescued kororā that were deceased on arrival, died in care or reported deceased along beaches/harbours have been collected for necropsy investigation under the WBWT Mortality Research Project Wildlife Authority.

Research Limitations

Some nests could not be accessed due to health and safety concerns because the terrain was inaccessible, steep and/or slippery or to prevent further erosion to the area. Frequency of nest checks for some burrows was reduced due to being in a busy public location or subject to tidal inundation during large swells. All suitable habitat with previously known burrows on Mauao was unable to be surveyed in 2020, due to time constraints. Nest distribution searches on Moturiki were also limited in 2019 due to time constraints. The north-eastern side of Moturiki island was not surveyed 2019-2021 due to health and safety concerns with steep cliffs and unstable terrain, although there are known breeding burrows there. Frequent rain throughout 2020, 2021 and particularly 2022, made consistent monitoring challenging. Some kororā were found within inaccessible burrows and could not be identified, reducing the accuracy of marking data. Regular scanner failure, where potentially marked birds could not be identified in 2022 resulted in limited marking data available for the season. Unfortunately, due to delays in permit processing there was a few years gap in data collection, following on from the post-Rena study and we could not accurately understand the survival of marked birds. Survival rates could not be directly compared to historic data due to reduced survey efforts, therefore represent a minimum. Covid-19 lockdown procedures also disrupted monitoring in 2021. Sample sizes for adult mean mass obtained during the 2020-2022 seasons and mean chick mass during the 2019-2022 seasons was limited.

Adult Health & Survival Monitoring

BIRDS CAPTURED

Kororā were monitored during winter (June/July/Aug) and spring monitoring nights (Sep/Oct/Nov), with a total of 116 captures (total no. birds caught, including recaptures) on Mauao in 2017-2019 and 49 on Moturiki Island in 2019. The highest numbers of kororā were captured during spring on both Mauao (n= 33) and Moturiki (n = 37). There was a slight decrease in the number captured on Mauao in spring 2019 (n = 26), compared to 2017 (n=33) and 2018 (n =33), however a slight increase from winter 2018 (n=10) to winter 2019 (n= 14). No kororā were caught in autumn (March) 2019 on either Mauao or Moturiki; the first time no kororā were caught during monitoring. On a trip to Motuotau Island in September 2018, notably fewer numbers of birds were present than previously observed during 2012-2014 post-Rena monitoring (J. Graham & P. Cuming, pers comm, 2019).

BIRDS MARKED COMING ASHORE 2017-2019

During 2017-2019 night monitoring on Mauao and Moturiki, a total of 26 individuals were recovered from the post-Rena oil spill study; including 16 control birds, four unknown origin and five oiled-rehabilitated kororā and one chick that (Sievwright 2014) that fledged naturally in January 2012. 101 individuals were microchipped during the current survey period (2017-2019), with five individuals recaptured to-date. Further research and increased monitoring efforts are needed to accurately assess survival data and to compare with historic data.

MARKED BREEDING BIRDS 2019-2022

During 2019-2022 reproduction monitoring, 36 breeding individuals in monitored burrows on Moturiki Island could be identified via microchip. Of these 36 kororā, 27 (75%) were microchipped in the present study during night monitoring or reproductive monitoring (2017-2022) and nine (25%) were microchipped during the Rena study (Sievwright, 2014). Of the marked birds monitored during the 2012 Rena study on Moturiki Island, a higher proportion (8/28 or 29%) of control birds are observed still breeding, compared to oiled-rehabilitated birds (1/16 or 6%). It is possible that there are more oiled birds still breeding on Moturiki but may be within inaccessible burrows and cannot be scanned to check for identification.

ADULT BODY MASS 2017-2022

Overall mean body mass of adult kororā captured coming ashore or from burrows, on Mauao and Moturiki Island during 2017-2022 has gradually decreased from 2017 (968g) to 2022 (856g) (Fig. 4); however, sample sizes during 2020-2022 were significantly reduced and may not give an accurate representation of the colony. The highest mean mass (1050g) was during spring 2018 and lowest during spring 2020 (855g) and 2022 (856g). Lower masses during spring are expected, as breeding season peaks and chick rearing energy expenditure is required. In 2013, adult body mass decreased from 963g in winter (June/Jul/Aug) to 858g in spring (Sep/Oct/Nov), as found in Sievwright (2014). Overall mean body mass of adult kororā in Mount Maunganui appears to be lower than in other colonies in Australia and New Zealand, consistent with Sievwright (2014).

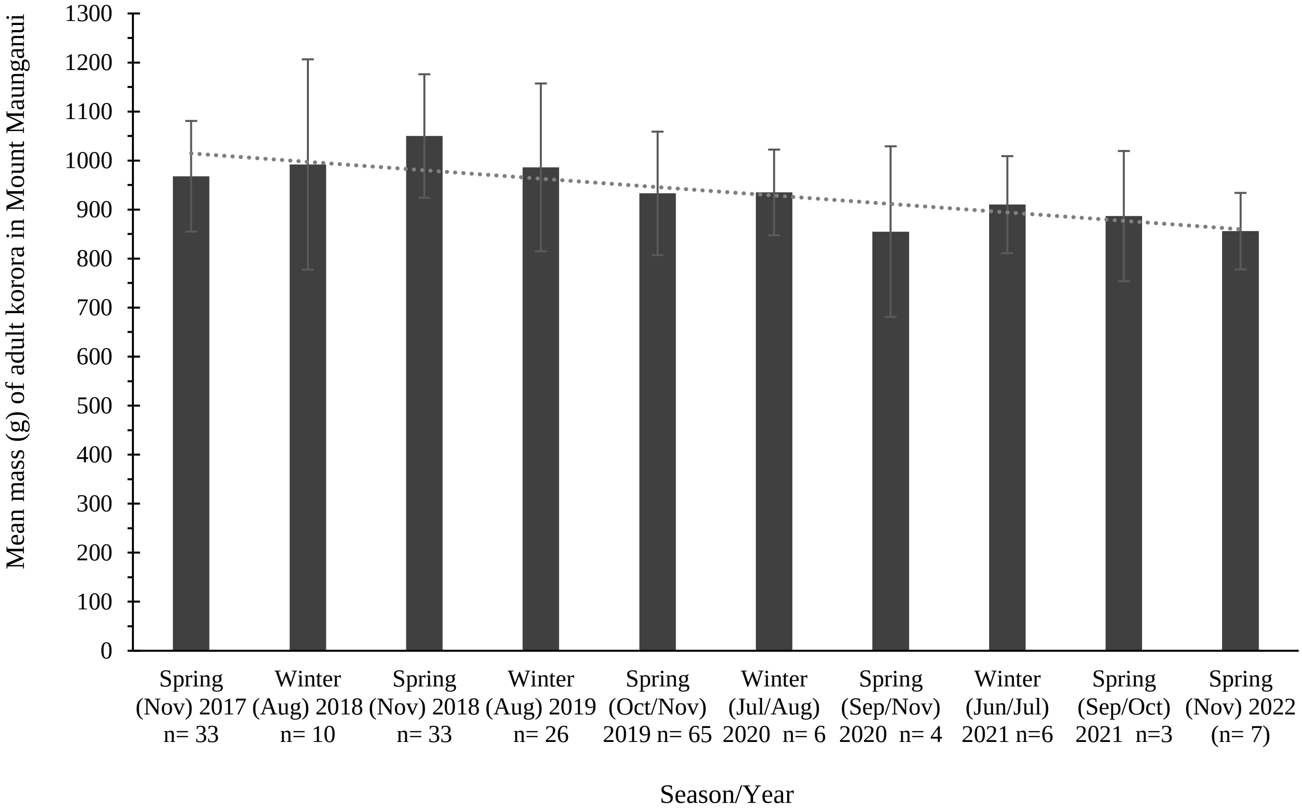

Figure 4. Mean body mass of adult kororā captured coming ashore or from burrows on Mauao and Moturiki Island 2017-2022.

Lower body masses could be related to the severe oceanic conditions as these impact prey species. Strong La Niña conditions persisted throughout 2010-2011, 2013-2014, 2017-2018 and 2020-2022 (Fig. 5). Local climatic conditions, such as increased air and wind temperatures, could have also contributed to lower masses, however further research is needed.

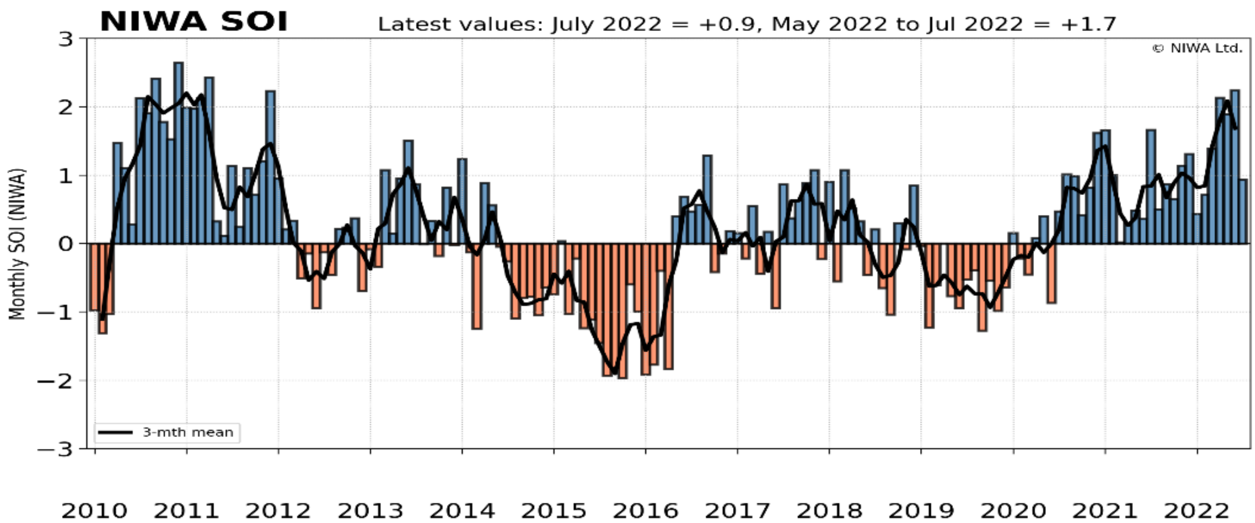

Figure 5. Southern Oscillation Index showing strong La Niña conditions (>1) in 2010- 2012, 2013, 2017-2018 and 2020-2022 (Noll, 2022).

Reproduction Monitoring

BURROW DISTRIBUTION ON MAUAO & MOTURIKI

Mauao

Burrow distribution was compared across the 1998, 2012 and 2020 surveys undertaken on Mauao (Fig. 6). In 2020, 48 burrows were located on Mauao during a conservation dog survey and an estimated 95% were active breeding burrows (Sim, 2020). Unfortunately, there was insufficient survey time to cover all Mauao to gain an accurate number of breeding pairs, but we were able to observe previously known burrows from the 2014 Rena study that were no longer active and identify some new burrows. Nest distribution was similar to the 74 burrows found on Mauao during the 2012 breeding season (Sievwright 2014). Fewer burrows were located on the southern and south-western sides of Mauao in 2012 (Sievwright, 2014) than those found in 1998 (Winter, 2000), but more burrows were located on the northern and north-western sides in 2012 and 2020 (Sim, 2020) compared to 1998.

This difference could be due to the high exposure of the south and south-western sides to shipping traffic and recreational fishing. We have found a lot of fishing line accumulated in these areas and most burrow entrances were filled with fishing lines, ropes, or nets. There was a marked increase in number of burrows located in 2012 (Siewright, 2014) from 1998 (Winter, 2000). The 2020 results were slightly lower than those from 1998, however a small portion of the mountain was not surveyed in 2020, an area where burrows were identified previously.

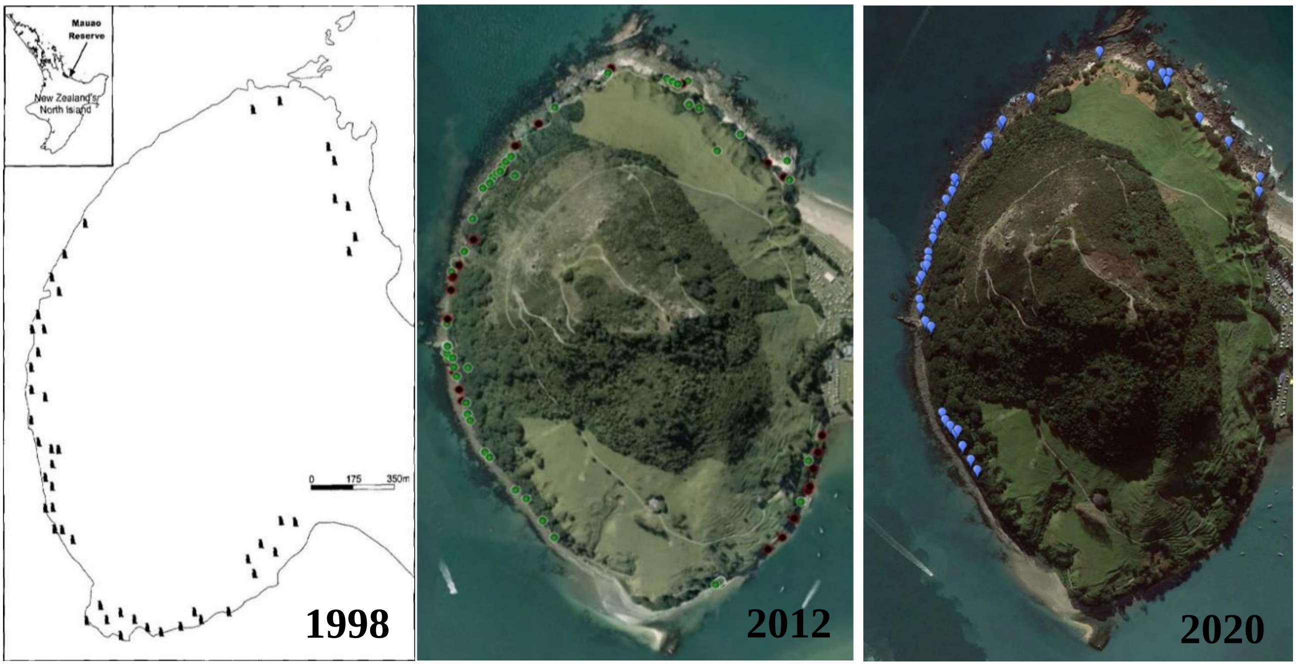

Figure 6. Minimum number of kororā burrows located on Mauao in 1998 (Black) (Winter, 2000), 2012 (Red=active- not monitored & Green= active-monitored) (Sievwright, 2014) and 2020 (Blue) (Sim, 2020). (Google Earth, 2022).

It is possible that the 2020 burrow numbers have increased since 1998, however there may be fewer than in the 2012 season. More intensive searches are needed to gain a more accurate count of breeding burrow numbers. The minimum number of active burrows found was less than 2012, however the minimum number of breeding burrows was similar to 2012 (Table 1).

Table 1: Minimum number of kororā burrows located in 1998, 2012 and 2020 on Mauao.

Year	Minimum no. of active burrows (Incl. breeding burrows)	Minimum no. of breeding burrows
1998[1]	49	-
2012[2]	74	51
2020[3]	48	46

[1]Winter, 2000, [2]Sievwright, 2014, [3]Sim, 2020

Moturiki

Burrow distribution on Moturiki appears to have changed over the past three decades, with most kororā now occupying burrows on the rocky outskirts of the north-western side of the island (Fig. 7). The number of burrows on the eastern side of Moturiki Island declined between 2000 and 2012, as previously reported in McLuskie (2016). The decline on the south-eastern side continues with fewer nests in 2021, than in 2012. These burrows were in an areas subject to high levels of human disturbance. The majority of new burrows were found behind fenced and/or within vegetated areas that were less exposed to human disturbance. Unfortunately, the north-eastern side of the island was not surveyed in 2019-2022 and it is likely there were still active breeding burrows in this area. The minimum number of active burrows was similar across the three surveys (Table 2).

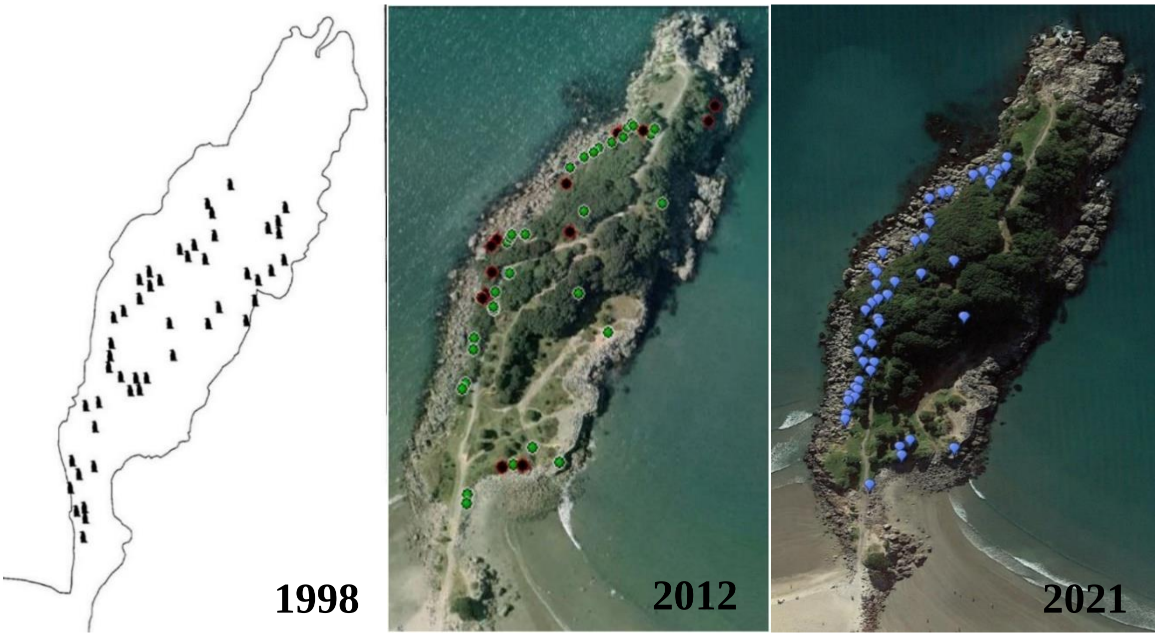

Figure 7. Minimum number of kororā burrows located on Moturiki in 1998 (Winter, 2000), 2012 (Red=active- not monitored & Green= active-monitored) (Sievwright, 2014) and 2021. (Google Earth, 2022).

Table 2: Minimum number of kororā burrows located in 1998, 2012 and 2021 on Moturiki Island.

Year	Minimum no. of active burrows (Incl. breeding burrows)	Minimum no. of breeding burrows
1998[1]	48	-
2012[2]	49	32
2021	51	36

[1]Winter, 2000, [2]Sievwright, 2014

BURROW OCCUPANCY ON MOTURIKI

To determine trends in burrow occupancy we compared activity of monitored burrows during the 2019-2022 breeding seasons (Fig. 8). The number of active breeding burrows increased from 55% in 2019 to 65% in 2020 and then declined to 57-54% in 2021 and 2022. The number of burrows found with non-breeding birds (Active- Nonbreeding) increased from 5% in 2019 to 24% in 2021 then decreased down to 11% in 2022, however the number of inactive burrows increased. The increase in non-breeding adults ashore in burrows during the day could be a lack of mates or adverse weather conditions. Non-breeding by a pair may also be caused by food shortage resulting in fewer breeding attempts. It could also be an indication of juveniles returning to start breeding. Of 32 burrows used for breeding in the 2013 season (Sievwright, 2014), nine (28%) were found inactive throughout the 2019-2022 seasons.

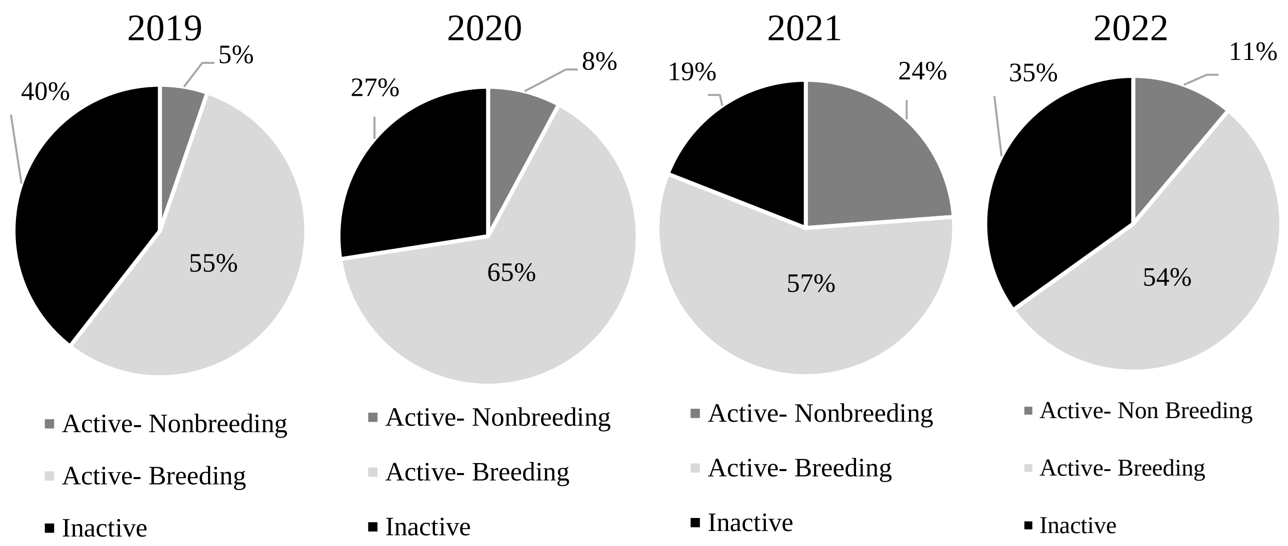

Figure 8. Occupancy status of monitored kororā burrows during 2019, (n=38), 2020 (n=51), 2021 (n=63) and 2022 (n=63) breeding seasons on Moturiki Island.

NEST SITE FIDELITY

Nearly half of the marked individuals (15/35 or 43%) occupied the same burrow for two or more consecutive breeding seasons, with four of those individuals found breeding in the same burrow as during the 2012 post-Rena study (Sievwright, 2014). One individual, however, was found breeding in a different burrow in each of breeding seasons during 2019-2021, with 2/3 clutches successful.

MATE FIDELITY

In 2021, just over a third (38%) of all identifiable pairs (marked male and female) remained intact (same partners) from the 2020 season (Table 3). Just over a third were widowed (partner missing) (38%) and a quarter (25%) were divorced (changed partners). One pair has remained together for all three seasons, despite moving to a different burrow. At the beginning of all three breeding seasons (June/July) prior to egg-laying, occasionally different pairing was observed but later original pairs found together again. Intact pairs produced the highest number of chicks, followed by widowed pairs and divorced pairs produced the least number of chicks, although sample size was very limited and may not be an accurate representation of pair bond breeding success.

Table 3: Mate fidelity and chick production on Moturiki Island in the 2021 breeding season.

Season	Pair Status	No. Pairs	Mean Chicks Per Pair
2021 (*n=8*)	*Intact*	3	2
	Divorced	2	0.5
	Widowed	3	1

LAY, HATCH, FLEDGE DATES

During 2019-2022 lay dates ranged from the 4 August-15 December for first clutches; an extended lay period was due to one pair, which laid a single egg in December 2020 and subsequently abandoned (Table 4). Mean lay dates ranged from 7-19 September for 2019-2022; 2019-2020 were similar to the 2012 season (9th Sep) (Sievwright, 2014) but eggs were laid somewhat later (19-Sep) in the 2021 and 2022 seasons. Neighbouring pairs laid eggs around the same time in all three breeding seasons. Seven pairs laid a second clutch following first clutch failure (replacement clutch) in the 2019 season, four pairs in the 2020 season, only one pair in the 2021 season. During 2022, six pairs laid replacement clutches, however all failed. A clutch of two abandoned eggs was found during daytime monitoring in 2021, but the eggs remained viable and eventually hatched. Eggs have been reported to survive unattended for up to five days (Peter Dann pers. comm. as cited in Numata et al. 2000).

Table 4. Lay dates, hatch dates and fledge dates of kororā on Moturiki Island during 2019-2022 breeding seasons.

Nest Activity	Laying Dates	Mean lay-date	Hatching Dates	Mean hatch-date	Fledge Dates	Mean fledge-date
1st Nesting Attempt						
2019-2020	16 Aug- 03 Oct (n = 20)	**07-Sep**	20 Sep- 17 Oct (n = 17)	**06-Oct**	21 Nov-19 Dec (n = 9)	**05-Dec**
2020-2021	4 Aug- 15 Dec (n= 32)	**03-Sep**	08 Sep- 13 Nov (n = 26)	**02-Oct**	2 Nov- 23 Dec (n = 23)	**24-Nov**
2021-2022	30 Aug- 23 Oct (n= 36)	**19-Sep**	07 Oct- 19 Nov (n = 28n)	**04-Nov**	28 Nov-24 Dec (n = 25)	**15-Dec**
2022-2023	15 Aug- 30 Oct (n= 31)	**19-Sep**	07 Oct- 05 Dec (n= 21)	**21-Oct**	25-Nov- 30 Jan (n= 17)	**15-Dec**
2nd Nesting Attempt						
2019-2020	20 Sep- 21 Nov (n = 7)	**19-Dec**	17-Oct- 19-Dec (n = 6)	**30-Dec**	19 Dec- 13 Feb (n= 6)	**28-Jan**
2020-2021	6 Oct- 22 Oct (n = 4)	**14-Oct**	2 Nov- 20 Nov (n = 3)	**09-Nov**	23- Dec (n =1)	-
2021-2022	23- Oct (n = 1)	-	29- Nov (n = 1)	-	31- Jan (n = 1)	-
2022-2023	02 Nov- 25 Nov (n= 6)	**14-Nov**	-	-	-	-

BREEDING SUCCESS

Overall breeding success in the four seasons of this study (2019-2022) on Moturiki Island was lower than 2012 from Mauao and Moturiki pooled data, as reported by Sievwright (2014) (Table 5). Hatching success was similar between 2019-2021 and declined in 2022, with all seasons lower than the 2012 season (Sievwright, 2014). Fledging success was highest during the 2022 season, compared to all other seasons, however, egg success was the lowest and similar to 2019. Egg success was slightly higher during 2020 and 2021, but also lower than the 2012 season (Sievwright, 2014). The number of chicks fledged per pair has seen a gradual decline from 2019-2022 and all four seasons of chick production during this study were lower than 2012 (Sievwright, 2014), possibly due to pairs failing to re-lay following first clutch failure or second clutches failing (see Table 4).

Table 5. Breeding success of kororā on Moturiki Island during 2019-2022 breeding seasons in comparison to 2012 on *Mauao and *Moturiki *pooled data.

Breeding Season	No. Pairs	No. Eggs	No. Chicks	No. Fledged	Hatching Success	Fledgling Success	Egg Success	Chicks Per Pair
2019-2020	20	54	39	26	0.72	0.67	0.48	1.30
2020-2021	32	71	51	42	0.72	0.82	0.59	1.31
2021-2022	36	76	56	44	0.74	0.77	0.58	1.22
2022-2023	31	68	36	29	0.53	0.81	0.43	0.94
***2012-2013**[1]	28	56	49	38	0.88	0.78	0.68	1.36

Source: [1] (Sievwright, 2014).

At least 50% of pairs fledged two chicks in the 2019-2021 breeding seasons, about 20% fledged one chick and about a quarter fledged no chicks (Table 6). In the 2022 season, about 40% fledged two chicks and nearly half of pairs fledged no chicks (Table 6).

Table 6. Chicks produced per kororā pair on Moturiki Island during the 2019-2021 breeding seasons.

Chicks Produced Per Pair	None	1 Chick	2 Chicks
2019-2020 (*n = 20*)	5 (25%)	4 (20%)	11 (55%)
2020-2021 (*n = 32*)	8 (25%)	6 (19%)	19 (56%)
2021-2022 (*n = 36*)	10 (28%)	8 (22%)	18 (50%)
2022-2023 *(n= 31)*	14 (45%)	5 (16%)	12 (39%)

CHICK HEALTH

Pre-fledging chicks had the highest mean mass in 2019 (Table 7). Pooled data (Mauao and Moturiki) showed a decrease in mean mass and reduced body condition in 2020-2022 compared to the 2019 season. Chick development in 2020-2022 was much slower than observed in 2019, with a delay in feather development and the overall body size of chicks appeared smaller. Similar patterns of delayed feather growth have been observed in rescue chicks from Tasmania (K. Grieveson, pers comm, 2022). This is a possible indication that the 2020-2022 seasons were relatively poor food years for kororā during La Niña conditions, compared to non-La Niña years. Persistent La Niña conditions in 2010-2012 (Fig. 5) may have also been contributing factors resulting in similar chick masses (759g) in the 2012 season (Sievwright, 2014).

Table 7. Kororā chick mass and body condition from Mauao and Moturiki Island during the 2019-2021 breeding seasons. Body condition score (BCS) is recorded on a scale from 1-3 with 1 the lowest and 3 the highest body condition.

Site	*Season (*La Niña Year)*	*Mean mass (g)*	*BCS*	*Est. Mean Age (Days)*
Moturiki	2019-2020 (*n = 10*)	951	2.40	46
Moturiki	*2020-2021 (*n* =6)	841	2.00	45
Moturiki	*2021-2022 (*n = 15*)	755	1.93	44
Moturiki	*2022-2023 (*n = 6*)	748	2.17	43
Mauao	*2020-2021 (*n = 8*)	714	1.88	48
Mauao	*2021-2022 (*n = 4*)	818	2.00	50
Mauao	*2022-2023(n = 2)	835	2.50	41
Pooled	*2020-2021 (*n = 14*)	768	1.93	47
Pooled	*2021-2022 (*n = 19*)	768	1.95	46
Pooled	*2022-2023 (*n = 8*)	769	2.25	43

In 2019, we observed moulting adults present with growing chicks on two occasions. Both pairs had failed their first nesting attempt, likely due to predation and re-laid late in the season. In one burrow, a moulting adult was identified by microchip as a parent bird, moulting with its growing chicks (Fig. 9). The chicks eventually fledged, indicating that one parent had continued to feed the chicks.

Figure 9. Moulting parent kororā in the burrow with its growing chicks, January 2020.

BREEDING FAILURE

A quarter of all pairs failed to produce any chicks during 2019-2021 and nearly half during 2022 (Table 6). Starvation of dead chicks found (2021) and disappearances of eggs and chicks most likely due to predation (2019 and 2020) and egg abandonment (2022) are probably the main causes of reproductive failure (Fig. 10). Most of the affected burrows were on rocky substrate, so it was easy to determine that they were empty, and the eggs or chicks had disappeared. The disappearances occurred during peak chick hatching and rearing in September-October and neighbouring burrows were often affected at the same time. These burrows were easily accessible by predators because they were shallow and had a wide enough entrance for predators such as stoats, ferrets or cats to crawl into.

Some chicks may have died of causes other than predation and were subsequently ejected from the nest by the parents or scavenged by predators. Some eggs failed to hatch for unknown reasons, and some were found outside the nest and had been either deliberately or accidentally ejected from the nest. Two downy chicks appear to have drowned when their burrow was flooded by large sea swells in 2021 and one in 2022. Tidal inundation of exposed burrows is likely the main reason for egg disappearance in 2022.

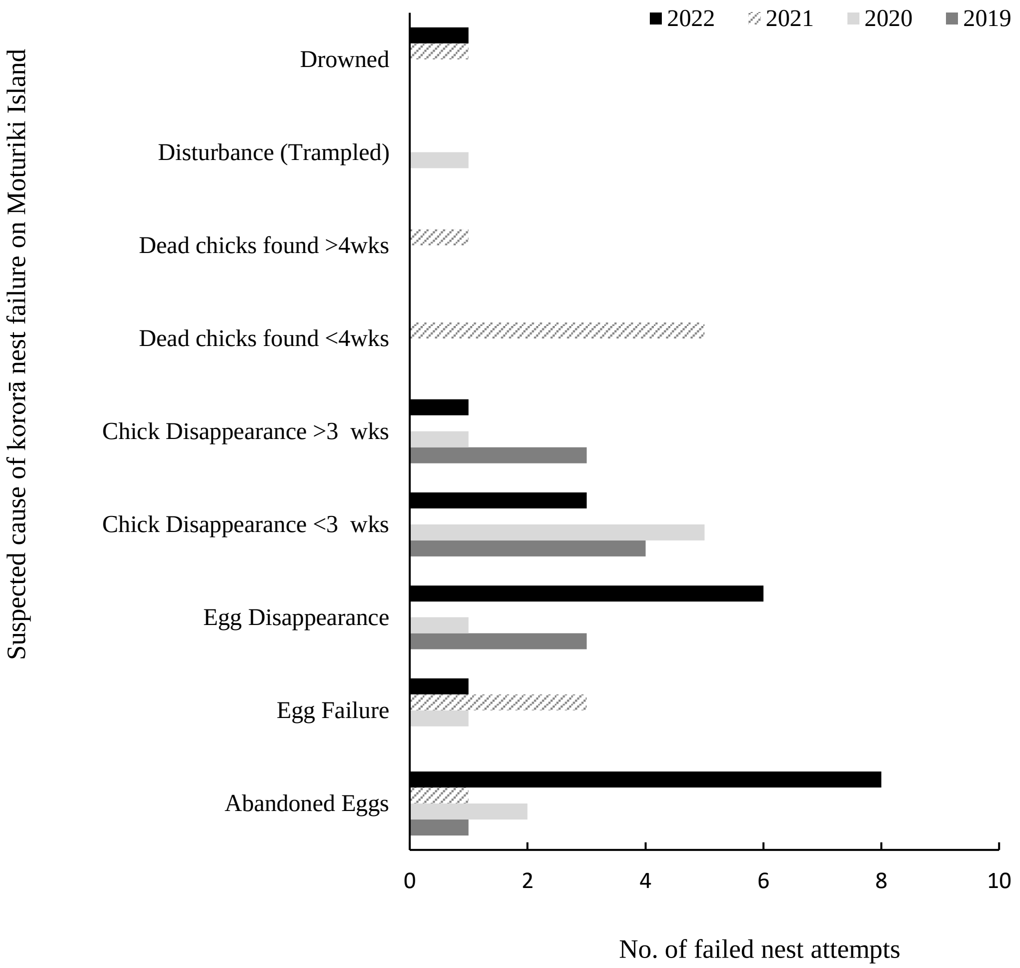

Figure 10. Suspected cause of nest failure observed in kororā nest attempts during 2019 (n=27), 2020 (n=36), 2021(n=37) and 2022 (n=37) breeding seasons on Moturiki Island.

Prior to installation of a protective barrier in 2020, one nest was accidentally collapsed by a member of the public, when a foot penetrated the roof and crushed at least one egg (Fig. 11). The nest was subsequently abandoned.

Figure 11. Trampled burrow with abandoned eggs (one crushed) on Moturiki Island, October 2020.

During the 2021 season, six dead chicks were found inside burrows – the first record of this kind since the study began in the 2019 season, the likely cause of death was starvation (Fig. 12). One of the dead chicks was due to fledge (ca. 8 weeks old and most feathers developed) and was found severely emaciated at 350g. At six weeks the same chick weighed only 590g, compared to its sibling of 800g. In previous seasons, chicks' disappearance was attributed to predation, Sievwright (2014) has reported starvation as the cause of death of four chicks from the 2012 season. Two dead chicks were retrieved from their burrow at Moturiki Island and will be examined during our mortality research project.

Figure 12. Deceased emaciated kororā chick found inside a burrow on Moturiki Island in November 2021.

During 2022, on three separate occasions, remains adult kororā were found wedged in rocks near burrow habitat (Fig. 13). This was an unusual observation for this site and the likely cause of death is unknown, however could be related to predator activity or harsh ocean conditions.

Figure 13. Kororā carcasses found in-between rocks during the 2022 breeding season on Moturiki Island.

Reduced breeding attempts, lower chick masses and fewer chicks per pair during the 2019-2021 seasons may be related to La Niña conditions and increased SST (Table 8) (Cannel et al. 2012; Johnson & Colombelli-Négrel, 2021), but the difference between chicks per pair in this study is marginal and could not be attributed to ocean conditions. An increase in non-breeding birds could indicate adults sheltering during the day, birds pairing and/or lack of food availability resulting in reduced breeding attempts. It is likely that high land temperatures and other environmental variables could also be contributing factors in reduced breeding success, starvation and increased mortality and requires further investigation (Johnson & Colombelli-Négrel, 2021; Stahel and Gales, 1987).

Table 8. Burrow occupancy, chick production and health in kororā/little penguins based in Mount Maunganui, North Island, NZ and associated ocean conditions (Southern Oscillation Index & Sea Surface Temperature) 2019-2021.

Breeding Season (July-February) * La Niña	**Ocean Conditions**		**Productivity**			**Chick Health**			**Burrow Occupancy**	
Year	**SOIRM** (Rolling 3 month average)	**Mean SST** (Northern North Island)	**n**	**Chicks per pair**	**Replacement clutches** (Second clutch following first clutch failure)	**n**	**Mean Mass (g)**	**Body Condition Score (1-3)**	**n**	**Non-breeding bird occupancy rate %**
2019	-0.41	0.34	20	1.30	7	10	951	2.4	38	5
*2020	0.76	0.59	32	1.31	4	14	768	1.93	51	8
*2021	0.94	1.13	36	1.22	1	19	768	1.95	63	24

SUMMARY

Adult Health and Survival	• In 2017-2019, 116 kororā were captured on Mauao in 2017-2019 and 49 on Moturiki Island in 2019. The highest numbers of kororā were captured during spring vs winter. • No kororā were caught in autumn (March) 2019 on either Mauao or Moturiki; the first time no kororā were caught during monitoring. In 2018, notably fewer numbers of birds were present on Motuotau Island than previously observed during 2012-2014 post-Rena monitoring (J. Graham & P. Cuming, pers comm, 2019). • 26 individuals were recovered from the post-Rena oil spill study; including 16 control birds, four unknown origin and five oiled-rehabilitated kororā and one chick that that fledged naturally in January 2012 (Sievwright 2014). • 101 individuals were microchipped during night monitoring (2017-2019), with five individuals recaptured to-date. • 36 marked breeding birds were found, with a large proportion marked during 2017-2022 and about a quarter marked during the post-Rena study, of which seven were previously breeding birds (Sievwright, 2014). • A higher proportion of control birds are observed still breeding, compared to oiled-rehabilitated birds from the 2012 post-Rena study, although many variables could have influenced this and further research is required. • Overall adult mean body mass has steadily decreased from 2017-2022, although sample size was limited in most recent years.
Reproduction	• Burrow distribution on Mauao has decreased on the Southern/Southwestern areas and increased on the Northern sides. 48 active burrows were located on Mauao in 2020 (Sim, 2020). • Burrow distribution on Moturiki decreased on eastern side from 2000-2012 and the Southeastern side 2000-2021. Burrows are mostly distributed along the western sides, with a small number reappearing within vegetated and fenced off areas. 51 active burrows were found in 2021, similar to previous studies (Winter, 2000; Sievwright, 2014); a minimum of 36 were used for breeding. • The number of active breeding burrows on Moturiki increased in 2020 compared to 2019 and then declined in 2021 and 2022. Non-breeding bird burrow occupancy gradually increased from 2019 to 2021 and decreased in 2022, when an increase in inactive burrows was observed. • Nearly half of the marked individuals 2019-2021 occupied the same burrow for two or more consecutive breeding seasons, with some individuals found breeding in the same burrow as during the 2012 Rena Study (Sievwright, 2014). In 2021, just over a third of all identifiable pairs remained intact from the 2020 season. Just over a third were widowed and a quarter were divorced. • Mean egg lay dates shifted two weeks later in 2021 and 2022 to 19th September. • Overall breeding success in 2019-2022 has decreased compared to 2012 (Sievwright, 2014). • 2022 had the lowest chicks produced per pair recorded for the Mount Maunganui colony. • Mean chick mass and body condition decreased in 2020-2022 compared to 2019 and chick development appeared slower with delays in feather growth and overall body size appeared smaller. • During 2019, an adult was found inside its burrow with its growing chicks, that went onto fledge-indicating one parent bird raised the chicks for the remainder of their development. • A quarter of all pairs failed to produce any chicks 2019-2021, with predation and starvation the likely causes. Egg abandonment and suspected chick drowning, and human trampling also occurred. In 2022, egg abandonment and tidal inundation were likely causes of failure. Six dead chicks were found inside burrows for the first time during this study, in 2021. • Reduced breeding attempts, lower chick masses, fewer chicks per pair and deceased chicks in burrows may be related to La Niña conditions and increased Sea Surface Temperatures.

RESCUE & REHABILITATION

RESCUE

WBWT aims to improve current rescue outcomes of kororā, through education and increased rescue and rehabilitation efforts by collaborating with local organisations involved in wildlife response and treatment. WBWT holds a rescue permit and since 2011 our team has undertaken over one hundred kororā rescues and in 2015 we established the 0800 SICK PENGUIN rescue hotline to improve rescue response. WBWT also has a long-term permit (August 2021- August 2031) to investigate seabird and shorebird mortality and has collected 75 specimens to-date from rescued birds that did not survive or reports of deceased birds washed ashore.

Rescues and/or reports of deceased penguins occurs mostly between September and April with peak numbers between December and February, coinciding with peak fledging, pre-moult and post moult periods. There are also more people on beaches and distressed penguins are more likely noticed and reported. Higher than usual call volumes in 2020/2021 and 2017/2018 were consistent with increased Sea Surface Temperatures (Fig. 14). Rescuers observed and received multiple reports of deceased kororā washed ashore across the entire Western Bay of Plenty coastline over the 2017/2018 summer period (Graham, pers. comm). Increased call volumes in 2016 were inconsistent with SST trends, however had the highest mean wind speed (4.5m/s) between 2015-2021 spring/summer seasons. In spring/summer of 2021, 13 kororā rescues were attended by WBWT and 77% (10/13) were found in a weak/exhausted state.

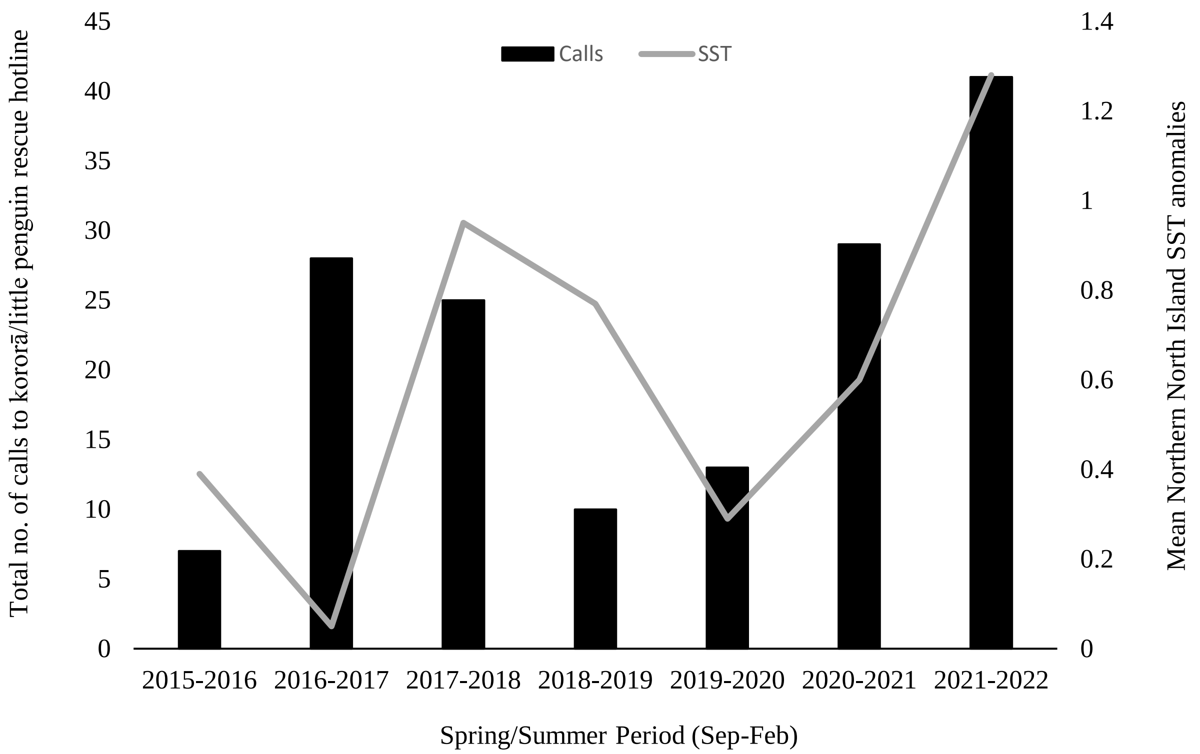

Figure 14. Calls to Western Bay Wildlife Trust kororā/little penguin rescue hotline, based in the Bay of Plenty, NZ during 2015-2022 spring/summers (Sep-Feb).

Over half of deceased kororā specimens (57%) collected between 2021-2022 spring/summer (n=21) (including failed rescues), were found in an emaciated condition upon external examination and suspected to have died of starvation, however further research is needed to confirm cause of death. Nearly half (43%) were emaciated fledglings. Fledglings reported or rescued were usually found between 300-400g (Fig. 15) and adults less than 650g. This is consistent with trends in Australia with starvation is reported to be the main reason for birds requiring rehabilitation (Philip Island Nature Parks, 2021; Grieveson, 2022. Hocken (2000) found starvation as the leading cause of mortality in kororā washed ashore in Otago during 1994 to 1998.

Figure 15. One of twelve emaciated Kororā/litte penguins found over the 2021/2022 spring/summer period in the Bay of Plenty. A recent fledgling weighing 335g washed ashore weak and dehydrated, Waihi Beach, January 2022.

Starvation could likely be linked to reduced prey capture success during periods of increased SST (Carroll et al. 2016) that occurred in the Northern North Island resulting in increased hotline call volumes and emaciated kororā washing ashore in the Bay of Plenty, however due to limitations of methodology it cannot be accurately concluded that starvation was the primary cause of death until further research is undertaken. Disruption to marine ecosystems during 2010/2011 has been previously linked to a significant marine heatwave in Western Australia (Salinger et al, 2016) including an increased number of dead little penguins found washed ashore that had died of starvation (Caputi et al. 2014).

One of our primary concerns of increased ocean temperatures is the decrease in adult survival, particularly if we continue to see high numbers of emaciated fledglings and low juvenile recruitment. A population model demonstrated a 9% decrease in survival of adult king penguins for a 0.26°C warming in the Southern Ocean (Le Bohec et al, 2008). Little is known about the prey species of the Mount Maunganui kororā/little penguin colony. Further research is needed to investigate the diet of kororā in the Bay of Plenty to find out whether not just sea temperature but also dredging and fishing activities impact breeding success and survival.

REHABILITATION

There is a growing need for rescue and rehabilitation of our native species, particularly as the frequency of unfavourable conditions increase, such as warming oceans and increased frequency/intensity of storm events. Consistent messaging when distressed kororā are reported by public is also needed to prevent delays in rescues and improve the likelihood of successful outcomes. Often birds that are found are hypothermic, exhausted and emaciated and if they have come ashore during the day, have likely suffered prolonged sun exposure and heat stress. Members of the public are increasingly concerned with current advice/lack of instructions and help offered when they report distressed wildlife. This has the potential to raise the issue of wildlife neglect if injured/sick birds are exposed to stressful conditions, such as human/dog interference and/or extremes in temperature.

WBWT successfully rehabilitated six kororā between December 2021-February 2023. There were at least five other critical birds during this time that were unable to be stabilised and didn't survive passed 72 hours due to emaciation and severe dehydration. WBWT have seen two cases of avian pox wash ashore at Waihi Beach. The most recent case in 2022 was an emaciated juvenile with lesions on both flippers and a small number on the feet (Fig. 16), confirmed as probable early stages poxvirus and starvation as the likely primary cause of death by Massey University (Hunter, 2022).

Figure 16. Emaciated juvenile kororā with avian pox lesions found washed ashore in Waihi Beach, February 2022.

We have also found two chicks from Moturiki Island with poxvirus during their six-week-old health check, which were subsequently uplifted for rehabilitation (Fig. 17). Despite lesions needing treatment, chicks were otherwise in good health. No further presence was confirmed within the colony; however, it was noted their burrow was situated beside a large rock pool full of breeding mosquitos.

Figure 17. Kororā chicks found with avian poxvirus lesions on the bill, flippers and feet during six-week old health check on Moturiki Island, November 2022.

In 2021, WBWT in collaboration with Kuaotunu Bird Rescue and ARRC successfully rehabilitated a significantly underweight fledgling (320g) that was found by a member of public on the Athenree mudflats and reported to DOC (Fig. 18). This was the first time a rescued kororā survived after being found at such a low mass, however had relatively small statute and was rescued whilst still relatively bright and alert. The bird was released after five weeks of care and was marked with a microchip to ensure rehabilitation outcomes can be measured.

Figure 18. Emaciated (320g) kororā fledgling rescued by from Athenree harbour mudflats in December 2021, rehabilitated with WBWT and Kuaotunu Bird Rescue and successfully released at Anzac Bay, January 2022.

In 2023, WBWT successfully rehabilitated another significantly underweight juvenile (430g), one underweight mid-moult adult (640g) and one moulting dog attack victim (Fig. 19).

Figure 19. Three rehabilitated kororā swimming to prepare for release. One underweight juvenile, one underweight moulting adult and one moulting dog attack victim. Released Shark Alley (next to Moturiki Island), February 2023.

COMPETITION & PREDATION

BURROW COMPETITION

Large numbers of rock pigeons occupy the cliffs, caves and burrows of Moturiki Island (Fig. 20). This population has grown rapidly in the past decade and is encroaching on kororā and tarāpunga (red-billed gull) breeding habitat (Fig. 21).

Figure 20. Rock pigeons flying off Moturiki Island cliffs December 2021 (top) and November 2022 (bottom).

Figure 21. Rock pigeon nesting in a kororā burrow (top) and colony roosting on Moturiki Island cliffs in tarāpunga habitat *(bottom), December 2021.*

Pigeon occupancy in kororā breeding burrows increased from 2019 to 2021 and occupancy changed from presence in only inactive burrows to presence in both active and inactive burrows (Table 9). Overall occupancy decreased slightly in 2022, however frequent use of active breeding burrows was still observed.

Table 9: Rock Pigeon presence observed roosting or nesting in known kororā burrows on Moturiki Island, during the 2019-2022 breeding seasons.

Kororā breeding season on Moturiki Island	2019-2020	2020-2021	2021-2022	2022-2023
No. Inactive Breeding Burrows Occupied by Rock Pigeons	7	8	10	5
No. Active Breeding Burrows Occupied by Rock Pigeons	0	2	7	5
Total	**7**	**10**	**17**	**10**

Adult rock pigeons and their chicks have been observed actively sharing penguin burrows or within the vicinity of burrows, whilst penguins were present, particularly pre-fledged chicks and/or moulting adults (Fig. 22). Over the past three breeding seasons we have observed an increased presence of external parasites (fleas and mites) within burrows on Moturiki, we suspect this is due to a combination of warmer/humid weather conditions and the presence of pigeons occupying the burrows year-round. Rock pigeons also carry high loads of parasites (Foronda et al, 2004) and are known as disease vectors, that could transfer parasites and diseases to kororā.

Fig. 22. Juvenile rock pigeon sitting in a kororā burrow next to an adult moulting (left) and directly in front of a chick (right) on Moturiki Island, January 2022.

The impact of rock pigeons competing with seabirds has gained interest and a recent study found pigeon competition to be the most frequent cause of nest failure in Bulmer petrels (Rodríguez et. al, 2022). One of WBWT's additional concerns is the energy required of breeding kororā to remove pigeon nests to initiate their own nest building. Penguins returning to burrows that have had rock pigeons present, appear to have removed the contents of rock pigeon nests (small twigs/sticks) and replaced them with their own nest materials (large sticks/dried leaves).

PREDATION

WBWT manage pest control for mustelids and rats using traps and bait stations throughout Moturiki and contribute to the network of pest control lines on Mauao. Trail cameras are used to monitor pest species interactions and dog bylaw breaches are monitored intermittently along the Marine Parade Boardwalk, Mount Main Beach and Shark Alley.

Mustelids & Rodents

Two male weasels were caught on Moturiki Island in August 2020 and August 2021 at the same trap location, with both specimen's stomach contents found containing rock pigeon feathers (Fig. 23). A mustelid dog survey undertaken in October 2020 found no evidence of mustelids inhabiting the island or nearby Mt Drury however it is likely that they will visit from time to time and being prepared with a variety of traps is the best means of catching them (Ghaemaghamy, 2020).

Figure 23. Two male weasels caught on Moturiki Island, August 2020 and August 2021 at the same trap location. Both weasels stomach contents were found containing rock pigeon feathers.

Presence of rodents (rats and mice) roaming in vegetation and visiting kororā burrows has been captured via trail camera surveillance (Fig. 24).

Figure 24. Rodent inside kororā burrow on Moturiki Island whilst chicks present, November 2022.

Domestic Cats & Dogs

Domestic cats have visited the island numerous times throughout the past three breeding season and left trails of countless rock pigeon and common diving petrel carcasses (Fig. 25). A cat was identified via trail camera caching the carcasses; a minimum of 12 birds, including both rock pigeons and common diving petrels were found cached inside a rocky crevice in October 2020 (Fig. 26).

Figure 25. Domestic cat hunting on Moturiki Island with a common diving petrel, September 2021.

Fig. 26. Rock pigeon carcasses retrieved from a cat cache on Moturiki Island, October 2020.

Trail camera surveillance has identified kororā retrieving carcasses from a cat's cache, to use as nesting material (Fig. 27). This has been observed for two consecutive breeding seasons (2020 & 2021) and we presume it is the same penguin or breeding pair. Similar behaviour has been observed in Erect Crested Penguins on Bounty Islands, collecting bones and decomposing animals for nest material (Mattern & Wilson, 2019). We are uncertain if this behaviour poses any additional risk (potential disease transfer & predator attraction) or benefit to kororā (increased insulation, drainage and softer nest substrate). In 2020, the nest was trampled and abandoned, however in 2021 the pair hatched two chicks, one emaciated chick died close to fledging, and one went onto fledge.

Figure 27. Kororā incubating eggs on a nest built of rock pigeon and common diving petrel carcasses on Moturiki Island, September 2021.

We have observed multiple breaches of the dog by-law over the past few years, with dogs on and off leash in the shark alley zone and on Moturiki island and Mount Maunganui Main Beach (Fig. 28). Dogs playing around the rocks and being walked over Moturiki Island poses an immense risk to the kororā colony.

Figure 28. Domestic dogs running off-leash within the dog by-law zone on Moturiki Island (Images: Supplied)

We estimate there to be a minimum of six breaches per day (42 per week), based on an average sighting of three breaches over a four-hour period. Unfortunately, the highest number of bylaw breaches also coincides with the most vulnerable time for kororā, such as the presence of pre-fledging chick and moulting adults. Bylaw breaches likely triple during peak holiday periods in November-February and July. On 30 December 2022 following the release of rehabilitated kororā, a minimum of 25 dog breaches had occurred within the shark alley zone and boardwalk opposite Mt Drury before 10.30am.

Tallied records of bird rescues from ARRC and WBWT for the period 2010-2021 indicate at least 40 kororā may have sustained injuries that could be consistent with dog attacks (confirmed or possible dog attacks) in the Bay of Plenty, with most of these occurring during December (Fig. 29). This is a minimum representation only, as many are likely not found or reported. Dog attack wounds are often fatal for kororā (Fig. 30).

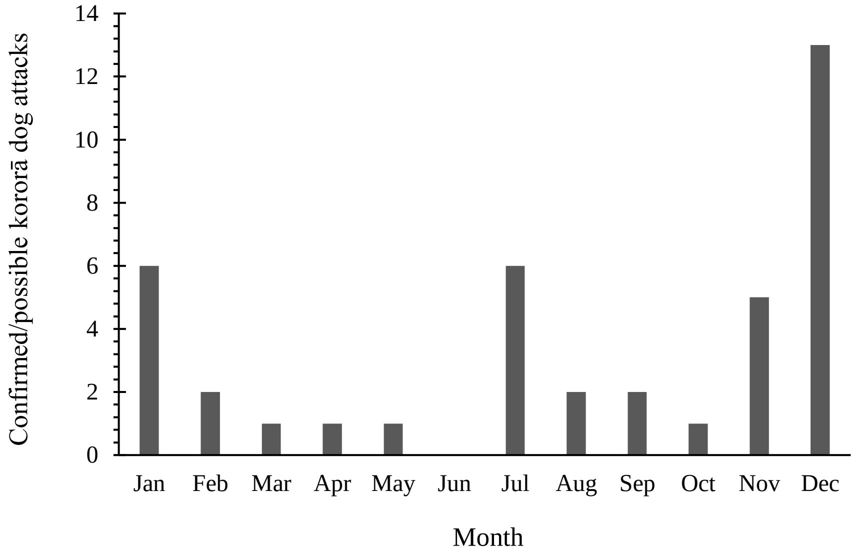

Figure 29. Occurrence of confirmed and/or possible dog attacks (n=40) of kororā in the Bay of Plenty, 2010-2021 (ARRC, 2017; WBWT, 2022).

Figure 30. Rescued kororā with a dog attack wound being assessed at ARRC, November 2015. (Image: Julia Graham).

HABITAT RESTORATION

REVEGTATION

Kororā occupy their burrows year-round, with a small period (approximately April-June) when they spend more time at sea and are not found within their burrows as frequently (post-moult and pre-breeding). Consequently, sustained land management measures are necessary throughout the year to provide protected habitat to support kororā populations. WBWT have been involved with planting and restoration of Moturiki since 2014, levering for addition protective barriers to focus public use on existing pathways and protecting restoration plantings to enable species reoccupation.

Revegetation from planting days held since 2014 have started to flourish on Moturiki Island, offering a much-needed refuge for wildlife. Following installation of protective barriers restricting public access, seedlings are now thriving, less rubbish is accumulating, new kororā nests have been discovered and some previously inactive burrows have been reoccupied, particularly at higher elevations (Fig. 31). Native bird species are also occupying areas protected from human disturbance, such as Tōrea pango (variable oyster catchers) nesting in vegetation, Oi (grey-faced petrel) observed returning frequently at the onset of breeding seasons (July/August) during 2020-2022 (Fig. 31) and Kuaka (common diving petrel) are found every year.

Figure 31. Kororā (top) and Oi (bottom) occupying habitat protected by barriers on Moturiki Island, August 2021.

The positive correlation between burrows at higher elevations and protective barriers suggests that extending the protective barriers to enable native plant restoration, will further support the establishment of kororā and other native species to this area. This is particularly needed where there is heavy foot traffic, eroded slopes and minimal vegetation on the upper slopes of Moturiki.

Another method to mitigate the impacts of limited habitat is to install artificial nest boxes. This would also address the threats of climate change related storm impacts and sea levels changes that are already contributing to burrow abandonment and breeding failure as a result of tidal inundation during large swells and storm events. Moturiki and Mauao have been frequently closed off to public in recent years (2021-2023), due to high swells covering the island. Fortunately, majority of these occurred prior to egg-laying and post fledging, however moulting kororā would have been extremely vulnerable during Cyclone Gabrielle in February 2023. On Mauao the majority of kororā burrows are found below the base track and are exposed to large wash outs, with swells breaching the main base track (Fig. 32). On Moturiki a large number of burrows are exposed to ocean conditions, particularly large swells and during recent extreme weather events majority of kororā habitat has been inundated (Fig. 32).

Figure 32. Large oceanic swells inundating breeding habitat on Mauao (left), May 2021 and Moturiki Island (right) (Images: Gracie Healey & Vicki Woodcraft).

Moturiki and Mauao could offer suitable habitat for the installation of some nest boxes at higher elevations, as protective barriers have allowed for reduced disturbance and the regeneration of vegetation is ongoing. Ratz (2019) has found that the installation of artificial nest boxes contributes to improved breeding success and recruitment and there are numerous sites across New Zealand (Oamaru, Dunedin, South Island West Coast, Wellington, Tiritiri Matangi Island) and Australia (Penguin Island, Phillip Island) with nest box colonies that are widely used by kororā.

Due to the highly public nature of Mauao and Moturiki, the establishment of nest boxes would need to be discrete and tamper-proof, however suitable sites have been identified by WBWT. Artificial nest boxes have been previously trialled on Mauao, however were unsuccessful with long-term occupancy, potentially due to their positioning in a landslip prone area or ample availability of natural burrows at the time.

POLLUTION

Rubbish

WBWT frequently remove rubbish from kororā habitat whilst undertaking monitoring rounds, primarily fishing and drinking related and facilitate regular clean up days to reduce accumulation in burrows. Rubbish pollution is an ongoing problem with about 50% of burrows containing one or multiple types of rubbish, such as plastic bags and bottles, miscellaneous small plastics, fishing line and broken glass (Fig. 33). On the western side of Mauao in particular, discarded fishing line is a problem with it sometimes blocking burrow access of kororā. On Moturiki, some chicks have hatched on broken glass and were raised in nests containing plastic, bottles, cans, rubbish and large amounts of fishing line (including with hooks and lures still attached). We found one breeding adult in its burrow with fishing line wrapped around its foot whilst guarding its chick. Fortunately, we were able to untangle most of the fishing line but could not remove it all because it was too far back inside the burrow.

Figure 33. Rubbish removed from kororā burrows on Moturiki Island and Mauao during breeding season 2019-2022.

We have also found two deceased penguins entangled in fishing line on Moturiki Island, one reported by public at the front of the island and one penguin that was rehabilitated during the Rena Oil Spill, that was strung up on a branch outside its burrow in 2016, starved to death (Fig. 34).

Figure 34. Adult kororā that was one of the rehabilitated Rena Oil Spill birds, found entangled in fishing line strung on a branch and starved to death outside its burrow on Moturiki Island, August 2016.

Microplastics are also an increasing concern; a recent study on Moturiki found 26.7% of kororā faecal samples contained plastic microparticles that were likely from the consumption of prey species that had consumed plastic particles (David, 2021). More research is needed to understand the impact of microplastics on the health of kororā and the wider environmental effects, such as microplastic deposition and accumulation within the soil and how that may affect microorganisms and plants.

Wrecks/Spills

Between 2014-2022, Maritime NZ received 131 spill incident reports from diesel, oil, bilge and the unknown contaminants entering the Tauranga Harbour (MaritimeNZ, 2022). WBWT has been involved in post-spill/wreck operations that occurred near kororā breeding habitat, by searching for contaminated wildlife, clearing rubbish (Fig. 35), and providing advice to external parties responsible for clean ups to minimise wildlife harm.

Figure 35. WBWT team cleaning up boat wreck debris found near kororā breeding habitat on Mauao, February 2020.

During the 2015 Mobil Oil Spill, large amounts of contaminated seagrass washed ashore on Mauao and four oiled penguins were found (Julia Graham, pers. comm. 2022). We still find small particles of rubbish from the Rena Oil Spill embedded deep between boulders and crevices during monitoring rounds.

KEY THREATS SUMMARY

Starvation	• La Niña conditions and increased sea-surface temperature appears to negatively impact kororā in the Bay of Plenty with increased rescue calls and emaciated birds washing ashore, as well as starving chicks- see chick health and breeding failure section.
Habitat Loss	• Large cyclonal swells are becoming more frequent and are inundating kororā habitat, posing risk to eggs, chicks and moulting birds.
Burrow Competition	• A rapidly growing rock pigeon population has increased over the past decade on Moturiki Island and is taking over fauna habitat. Pigeon occupancy in kororā burrows has increased from 2019, with adult rock pigeons and their chicks actively sharing kororā burrows while pre-fledged chicks and/or moulting adults are present. • Increased numbers of external parasites (fleas and mites) within burrows on Moturiki, we suspect this is due to a combination of warmer/humid weather conditions and the presence of pigeons occupying the burrows year-round. Rock pigeons are known disease vectors and could pose risk to native fauna and zoonotic risk to humans. • Rock pigeons are attracting predators and providing a food source; stomach contents of weasels contained rock pigeon feathers.
Predation	• Eggs and chicks have disappeared from burrows, suspected to be likely due to predation- see breeding failure section. • Cats have been observed predating rock pigeons and diving petrels, as well a local community cat creating a cache of bird carcasses on Moturiki Island. Two weasels caught on Moturiki Island over subsequent years, both in August and at the same trap location. • Rodents have been observed via trail camera surveillance.
Dog Attacks	• Dog breaches frequently occur within the dog by-law zone in Mount Maunganui, with the highest number of breaches coinciding with vulnerable chick fledgling and adult moulting times. A minimum of 40 kororā have sustained injuries that could be consistent with dog attacks in the Bay of Plenty region between 2010-2021, with most occurring in December, January and July.
Pollution	• An estimated 50% of kororā burrows contain one or multiple types of rubbish, such as plastic bags and bottles, miscellaneous small plastics, fishing line and broken glass. Chicks have been observed hatching on broken glass and adult kororā have been found entangled in fishing line. • 26.7% of kororā faecal samples from Moturiki Island contained microparticles of plastic that were likely from prey species that had consumed plastic particles (Davis, 2022). • Between 2014-2022, 131 spill incidents of diesel/oil/bilge and unknown contaminants were reported occurring within the Tauranga Harbour (MaritimeNZ, 2022). • Small parts of rubbish from the 2011 Rena Oil Spill can still be found embedded deep between boulders and crevices.

MANAGEMENT RECOMMENDATIONS

This report aims to raise awareness of kororā living within a highly urban environment and to strive for better protection for this regionally important population through formulation of a Site-Specific Species Management Plan. This would incorporate input from all stakeholders and provide standardised operating protocols, enhance communication between all relevant parties and minimise harm/disturbance, whilst ultimately improving breeding success and survival. This section identifies land management issues, current practices and recommendations for improvements. An outline for a Site-Specific Species Management Plan is provided and a list of immediate management actions requiring urgent attention are listed.

Land Management

Routine land management/maintenance by trained and experienced personnel including effective protocols and regulations of recreational activities are necessary to minimise the high risk of disturbance and potential harm to kororā. Management measures include, but are not limited to:

DRAIN CLEARING

At least seven historic drainpipes on Moturiki Island and five on Mauao are consistently occupied by nesting and moulting kororā. When drains are cleared while the birds are present their nest sites will be destroyed, potentially killing eggs and/or chicks and injuring or killing adults. Offering alternative nesting opportunities, such as nest boxes nearby may encourage the birds to relocate from drainpipes. When kororā do occupy drainpipes, breeding attempts appear to be successful with pre-fledging chicks frequently observed over successive years. Adults excavate built up debris to access pipes and allow adequate nest drainage.

WEED MANAGEMENT

Weed eating (string mower) can cause disturbance to any of the burrow-nesting seabirds including kororā. Spraying weed killer potentially exposes the seabirds to poison and poses a potential health risk. We estimate weed spraying of burrows has occurred 30 times over the past decade whilst penguins may have been present (Julia Graham, pers. comm. 2022). Weed mowing has occurred on Moturiki Island whilst chicks were present in 2021, as well as the start of egg-laying in 2022. Weed spraying also occurred as pairs were returning home (Fig. 36).

Figure 36. Weed sprayed kororā burrow during pre-breeding pair-bonding (left) and weed mowed area within close proximity of kororā burrows (right) during the onset of egg-laying on Moturiki Island, 2022.

TREE MANAGEMENT

Significant tree works, such as extensive chain sawing has the potential to cause significant disturbance and should not be undertaken whilst kororā are present. Consultation should be sought to assess disturbance risk, not only to kororā but other native seabird and shorebird species that breed on Mauao and Moturiki Island.

RABBIT CONTROL (BURROW FUMIGATION)

Rabbits have been found in several burrows of kororā and oi. Fumigation of burrows as a method to control rabbits is likely to have a detrimental impact on kororā and oi and is potentially lethal if they are present. This is of particular concern during the breeding season and while kororā are moulting. WBWT recommends consultation to ensure seabird burrow locations are known and a burrowscope to confirm absence of seabirds prior to any fumigation work.

DREDGING

Nearly half of the kororā burrows found on Mauao occur within the Northern Tauranga Harbour zone and main shipping channel (see Fig. 6). Kororā have also been reported coming ashore and calls heard within the Southern Tauranga Harbour areas, including Matapihi, Tauranga Port, Tauranga Marina and The Strand. Port development and dredging has the potential to adversely impact local kororā that forage within the Tauranga Harbour through increased water turbidity, potentially leading to reduced foraging success, survivorship and breeding success (Preston, 2008; Poupart et al. 2017). This may further exacerbate stress due to lack of prey availability in poor food years. Gaining knowledge of kororā movements and foraging territory could help mitigate potential impacts.

EVENTS

Social events with large numbers of people and/or loud noise near kororā habitat can cause stress potentially resulting in breeding failure. Rubbish left behind afterwards is highly likely to accumulate in breeding areas and pose problems – see Pollution section. We have also observed an increase in the frequency of large sound systems being used by public near kororā habitat.

WATERCRAFT (BOATS, JET SKIS, KAYAKS)

Watercraft injury is a known risk to kororā. We have observed a minimum of seven kororā, since 2011 with injuries that appeared to have been caused by collision with watercrafts (Julia Graham, pers. comm. 2022). Jet skis are frequently observed exceeding speed limits travelling within proximity to Moturiki Island.

SITE SPECIFIC SPECIES MANAGEMENT PLAN

Recent collaboration of kororā habitat management with landowners has demonstrated the effectiveness of good communication, leading to successful outcomes for both native species and land management. This has led to discussions of introducing formalised guidelines, such as operating under a Site-Specific Species Management Plan (Table 10). This could ensure all parties are aware of planned works and activities and develop a system to ensure work can be undertaken with the least harm to fauna and ideally support populations to flourish. (Marker & Wind, 2005) has developed a similar protocol for undertaking works in little penguin habitat.

Table 10: Site Specific Species Management Plan Recommendations

Threat	Action	Outcome
Pest Pigeons	Enhanced Rock Pigeon Control	*Reduced burrow competition*
Human Disturbance	Protective Barriers	*Reduced access to burrows* *Reduced nest trampling* *Reduced pollution*
Erosion	Continued Rabbit Control Protective Barriers Re-Vegetation	*Increased burrow occupancy* *Increased number of burrows* *Increased vegetation*
Cats	Cat Management Plan/By-law Education	*Reduced predation events* *Increased breeding success and survival* *Increased public awareness*
Dogs	Shark Alley Permanent Dog By-Law Regular Patrolling/Surveillance Clear and Informative Signage Education	*Reduced dog-bylaw breaches* *Reduced dog attacks* *Increased awareness*
Mustelids & Rodents	Monitoring and targeted trapping Education	*Reduced predation events* *Increased breeding success and survival* *Increased community trapping*
Starvation	Support starving birds through rehabilitation Review the need for a marine reserve around breeding and foraging areas Investigate diet through monitoring, mortality research and foraging territory via tracking	*Increased body mass and reduced mortality* *Increased long term food availability* *Increased understanding of colony specific feeding ecology*
Pollution	Protective Barriers Regular Working Bees Education	*Reduced access to burrows* *Reduced rubbish in burrows* *Increased breeding success and survival* *Increased awareness*
Wrecks/Spills	Site-specific Response Plan	*Improved responsiveness* *Reduced harm*
Habitat Loss	Nest boxes at higher elevations on Mauao and Moturiki	*Increased habitat availability* *Increased nesting opportunities* *Reduced nest flooding*
Land/Water Management & Recreation	Follow recommended guidelines Site Specific Species Management Plan Policies & Procedures Regular communication with WBWT	*Reduced disturbance* *Reduced risk of harm* *Increased breeding success and survival* *Enhanced working relationships*
Water Based Recreation	Education Reporting System	*Reduced watercraft strikes* *Increased survival*

In the interim, it would be advisable to ensure there are no signs of kororā presence or activity and communicate with WBWT to confirm before works commence, at a minimum this includes;

- **Drain Clearing**- No drain clearing whilst kororā present.
- **Weed Management**- No spraying/weed mowing whilst kororā present or alter management methods to incorporate the use of electric weed mowers with reduced noise.
    - Avoid the use of toxic chemicals in fauna habitat.
    - Revegetate areas to reduce the need of weed management and engage volunteers for sensitive habitat requiring maintenance.
    - Protect burrows with natural vegetation and protective barriers.
- **Rabbit Control-** Ensure the use of a burrowscope before rabbit fumigation is undertaken and confirm with WBWT likely/suspected burrows are not used by any seabirds.
- **Dredging**- Understand kororā distribution and foraging territory/diet of local colonies and likely detrimental impacts before port development and dredging work in Tauranga Harbour commences.
- **Events**- Liaise with WBWT of significant works or large planned events near kororā habitat and ensure there is appropriate response to large unregulated events.
- **Watercraft**- WBWT to report watercraft breaches to Maritime NZ.

WBWT PRIORITIES 2023-2025

- Develop comprehensive Site-Specific Species Management Plans in conjunction with Tauranga City Council, Department of Conservation and local iwi with installation of kororā nest boxes as a main priority.
- Enhance current monitoring programme and incorporate Mātauranga Māori
- Improve habitat through regular working bees
- Improve rescue and rehabilitation outcomes

FUTURE RESEARCH RECOMMENDATIONS

- Investigate mortality and impacts of climate change
- Investigate at-sea movements, foraging territory and diet
- Investigate the impact of rock pigeons
- Further research into microplastic ingestion

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