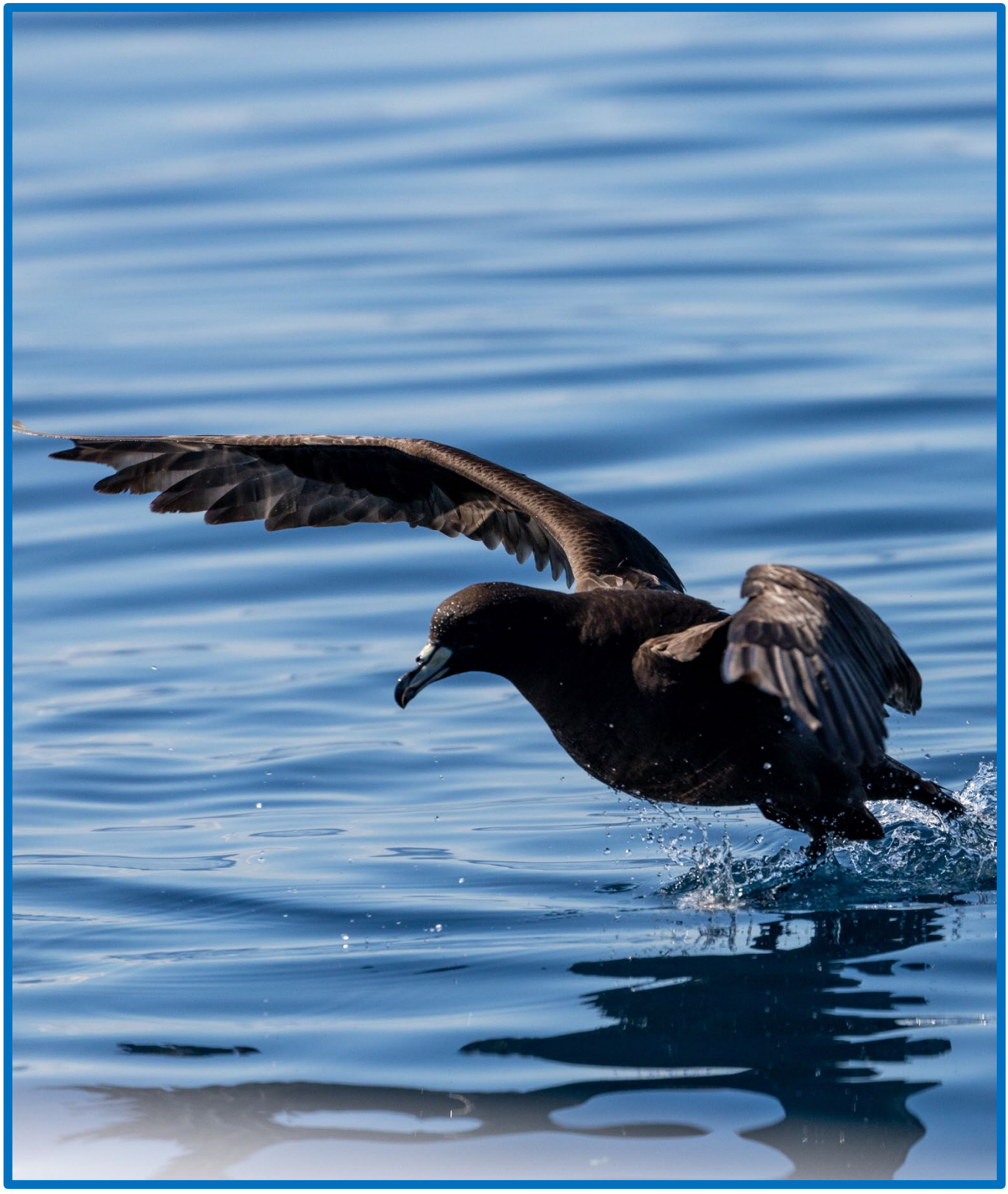
At-sea capture work for tākoketai/black petrels (*Procellaria parkinsoni*) 2021-2024



At-sea capture work for tākoketai/black petrels (*Procellaria parkinsoni*) 2021-2024

Burgin, D.

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

Document Quality Assurance:

This report was prepared by Wildlife Management International Limited for Department of Conservation as partial fulfilment of the contract (POP2022-01 Black petrel population monitoring – at-sea component) dated 25 October 2022.	
Citation: Burgin, D. (2024). *At-sea capture work for tākoketai/black petrels (*Procellaria parkinsoni*) 2021-2024*. Unpublished Wildlife Management International Technical Report to the Department of Conservation, Wellington.	
Authors:	Dan Burgin, Co-Operations Manager
Reviewed by:	Elizabeth Bell, Managing Director
Use and Reliance: This report has been prepared by Wildlife Management International Limited (WMIL) on the specific instructions of our Client. It is solely for their use for the purpose for which it is intended in accordance with the agreed scope of work. WMIL does not accept any liability or responsibility in relation to the use of this report contrary to the above, or to any person other than the Client. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from external sources, it has been assumed that it is accurate, without independent verification, unless otherwise indicated. No liability or responsibility is accepted by WMIL for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.	

Version History:

Version	Authors	Date	Reason for edition
1	Burgin, D.	18 July 2024	First draft.

Cover image: Tākoketai/black petrel (*Procellaria parkinsoni*) at-sea, March 2023 © Dan Burgin, WMIL.

CONTENTS

EXECUTIVE SUMMARY

This report summarises all of the results from the at-sea capture work targeting tākoketai/black petrels (*Procellaria parkinsoni*) that was undertaken between 2021 and 2024 by Wildlife Management International Ltd. (WMIL). This work was undertaken as part of research under the Department of Conservation's (DOC) Conservation Services Programme (CSP), project '*POP2022-01-Black petrel research – at-sea component'*.

Between 2021 and 2024 WMIL staff were able to undertake six catching trips over 15 days out in the Hauraki Gulf, north-east of the Marotere/Chicken Islands group, and north of Aotea/Great Barrier Island. Tākoketai were lured in initially using a mixture of fish berley to the back of the boat and a hand cast net (6ft) was used as the primary method of catching. The cast net was pulled tight once over the bird to seal them inside and pulled back on to the boat carefully. The range of the thrower was anywhere between 0.5 – 6 metres depending on conditions. Each bird was given a unique metal band if not already banded, marked with correction fluid to help distinguish it as a captured bird, and then carefully released over the side of the boat. Capture ran from sunrise to sunset, with rest periods for the capture team built into steaming between capture locations and meal breaks. All banding data were then uploaded to the online DOC FALCON banding database, under the "*Black petrel research (including other seabirds)*" project.

Additionally, accurate counts were taken of all bird species seen at all locations and uploaded to eBird as part of complete checklists via the eBird app to support the wider ornithological dataset and research.

Over this three-year period a total of 463 tākoketai were caught from the back of the boat using a hand cast net. This total included 22 previously banded birds from Aotea, Te Hauturu-o-Toi/Little Barrier Island (hereafter Hauturu), or banded previously at-sea, representing 4.8% of total captures. This includes eight tākoketai that were caught for the first time since fledgling, the youngest being five years old at time of capture, and the oldest being eight years old at time of capture. The highest number of tākoketai caught over a single trip, was during the 3-day trip in March 2024 where a total of 142 tākoketai were caught altogether (including recaptures). This trip also had the highest day capture tally of 75. Certain areas were targeted during all trips due to their successful capture rates, these were namely north of the Mokohinau islands and north-east of Aotea.

The most successful times of day for capture of tākoketai was found to be in the first 1.5 hours after first light and the last two hours before dark. This was maximised by getting to those locations for first light, and before dusk, to be ready to catch tākoketai. It is important to clarify that all tākoketai (and any other species) that were captured and processed were not harmed during any stage of the project. During the March 2022 trip, three tākoketai were found to have apparent evidence of fish-hook damage to their bills. This species is known to be at great risk from commercial fisheries within New Zealand's Exclusive Economic Zone and aligns with what has been seen at the breeding colony on Aotea during burrow monitoring

The highest count of tākoketai was 50 individuals behind the back of the vessel on 8 April 2021, 17 km east of the Marotere islands. 77% of checklists (n=71) had low numbers of tākoketai (1-10), and the average number of tākoketai on each checklist was nine. Large congregations over 50 were never encountered. What WMIL also noticed was that on average across all trips, roughly 1 in up to 20 tākoketai were banded behind the boat, indicating a low percentage of birds being seen to be banded (0.05%), and this is reflected in the recapture totals. This is interesting in light of discussions with other researchers undertaking at-sea capture work who have found one in four tākoketai encountered being banded within the Tasman Sea (R. Clarke, *pers. comm*). The process of clarifying whether an individual tākoketai is banded or not can be

difficult if not caught and only seen in flight. With that in mind, to understand the proportion of banded versus unbanded individuals detected at sea, further work would need to be undertaken specifically focusing on this aspect.

This at-sea work was undertaken alongside the regular tākoketai colony checks on Aotea and Hauturu undertaken by WMIL and Auckland Council, with focused night work expeditions being undertaken on Aotea over the same period (2021-2024) to target recaptures. These were intensive searches covering 6-8 hours (9.15 pm to 5.15 am) each night. Over the three-year period 41 night surveys were undertaken, and 427 birds were caught (including recaptures). Of these, 219 were already banded and 83 of those were returned chicks. The percentage of banded tākoketai caught out of all captures is far lower for the at-sea work (4.8%) compared to intensive colony work (51.3%), as is the percentage of returned tākoketai chicks (1.9% vs 19.4%). The percentage of returned tākoketai chicks out of all the individuals caught is slightly higher from at-sea work (40.9%) compared to the intensive colony night work (37.9%), however the number of banded tākoketai caught per day/night is higher for the intensive colony night work (n=5.3) compared to the at-sea work (n=1.5).

The high number of newly banded individuals represented the bulk of captures compared to the 4.8% recaptures and indicates the large amount of work needed to recapture previously banded individual tākoketai at-sea. Importantly as part of this work WMIL did not specifically target banded tākoketai when behind the vessel, rather capturing as many as possible in a non-biased way by not targeting a banded tākoketai over an unbanded one if they were both behind the vessel.

WMIL feel that the use of the cast net is an incredibly effective way of safely capturing many tākoketai in a relatively short period of time, as shown by the results of this work. Whilst other methods are available and should be explored, the use of a cast net has proven very effective in capturing 463 tākoketai over 15 days at-sea, equating to an average of 31 tākoketai a day. Ensuring competent and strong throwers is essential to fully utilise this capture method, and with a range of 0.5 - 6 metres from the back of the vessel, it provides a large scope to catch tākoketai behind vessels. Importantly it provides an effective and safe method of capture and recapture that can benefit and support terrestrial work at the colony sites to inform population estimates, as well as demographic work.

Given the amount of time and resources required for at-sea work, as well as the potential for it to be cancelled due to poor weather or swell conditions, the nocturnal searching at the colony can be of higher cost-benefit. Considering the current financial constraints DOC and many conservation agencies face, if one method needed to be considered over the other, future work could gain far more from more intensive nocturnal work at the Aotea and Hauturu colony sites. However, WMIL would still support and recommend that further at-sea work for tākoketai is undertaken alongside colony work, if the funding and capacity exists, to continue to better understand their at-sea ecology and chick survival rates. WMIL believe that this at-sea work was, and can continue to be, a fantastic additional component to the colony based tākoketai monitoring, to increase our understanding of this Nationally Vulnerable species.

WMIL recommends that:

- Future at-sea trips are undertaken with the following focus:
    - Run trips throughout the breeding season to intentionally coincide with key stages of the breeding cycle; return to the colony/pair bonding, egg laying, incubation, chick rearing and chick fledging.
    - Explore the logistics of undertaking capture during both day and night to compare capture rates and activity over these time periods.

    - Expand the work away from the breeding colonies to extend the dataset beyond the Hauraki Gulf, notably further into the South Pacific Ocean, and even over into the Tasman Sea.
    - Undertake trips up north to assess associations between tākoketai and false killer whale pods, and possibly other cetaceans.
    - Run trips in alignment with intensive nocturnal surveys at the Aotea and Hauturu colony sites to be able to continue to not only compare the efficacy of the two methods, but also increase the coverage for detecting previously banded tākoketai and to enhance population trend models and risk analyses.
    - Counts of all seabirds encountered are entered into eBird checklists to complement the New Zealand dataset and relative abundance models for this species and more.
    - Budgets are updated to better reflect increased cost of fuel, food, travel, accommodation, bait and boat charter.

- Additionally, WMIL recommends exploring collaborations with other stakeholders and/or researchers for other data that could be collected from tākoketai when captured. This could include, but is not limited to, morphometric measurements, blood and/or feather samples. This could inform wider knowledge regarding the species and broader research goals.
- Nocturnal effort is prioritised at the Aotea and Hauturu study colonies to recapture returning tākoketai and enhance population trend models and risk analyses.

At-sea capture work for tākoketai/black petrels (*Procellaria parkinsoni*) 2021-2024.

1. INTRODUCTION

Between 2021 and 2024 Wildlife Management International Ltd. (WMIL) staff undertook six at-sea catching trips targeting tākoketai/black petrels (*Procellaria parkinsoni*) in the Hauraki Gulf, namely north-east of the Marotere (Chicken) Islands group, and north of Aotea/Great Barrier Island under contract to the Department of Conservation (DOC) Conservation Services Programme (CSP) (Figure 1). Tākoketai have a threat classification of Nationally Vulnerable (Robertson et al. 2021) and have been monitored continuously by WMIL since 1995/1996 at their primary breeding colony on Aotea (Bell et al. 2024). The aims of this study were to first pilot this capture method for this species in April 2021. After concluding it was a viable method, the aim of the study was then to recapture returnee tākoketai (namely chicks) in the waters surrounding the two known breeding colonies: Te Hauturu-o-Toi/Little Barrier Island (hereafter Hauturu) and Aotea. This information could then potentially be used to assess if apparent low juvenile survival is biased by dispersal away from study colonies and support risk analyses to assist with reducing long term fisheries bycatch risk. Gaining further knowledge of tākoketai at sea is essential to increase our understanding of their biology (Ballance 2007).

Additional work was planned for the east coast of Te Tai Tokerau/Northland, to work with Far Out Ocean Research Collective and capture tākoketai associating with false killer whale (*Pseudorca crassidens*) pods. However, due to the view by local Iwi that the DOC engagement and consultation process regarding this at-sea work was insufficient WMIL were unable to undertake capture trips at this location. Although specific engagement with local iwi about at-sea work within their rohe did not occur, DOC engage with Te Ohu Kaimoana regarding all work in the marine environment and hold wider engagement with Iwi and other stakeholders across all research projects undertaken in the CSP programme.

Te reo Māori names are used throughout the document for all bird species and locations after the first use (e.g., tākoketai/black petrel or Aotea/Great Barrier Island).

1.1 Key objectives and outputs

This research was carried out as part of the DOC CSP 'black petrel population monitoring project' (POP2022-01).

The key objectives for all seasons were:

1. To monitor key demographic parameters at the breeding colony on Hirakimata/Mt Hobson summit, Aotea, of the threatened tākoketai/black petrel to reduce the uncertainty or bias in estimates of risk from commercial fishing.
2. **Capture tākoketai at-sea to determine the proportions of unbanded versus banded birds. This information will be used to assess if apparent low juvenile survival is biased by dispersal away from study colonies.**
3. Conduct nocturnal searches of the Hirakimata colony for recruits (i.e., birds banded as chicks returning to the colony to breed).

In addition to this work covered by the DOC CSP contract, Objective 3 was funded by Hauraki Gulf Conservation Trust, Hauraki Gulf Forum, Ministry of Primary Industries (Fisheries NZ) and DOC.

Objective 2 is reported here only. Objectives 1 and 3 are reported on separately (Bell et al. 2022; 2023; 2024).

Earlier reports summarising previous trips (Crowe & Burgin 2021; Burgin 2022; 2023) are on the DOC CSP website. This report summarises the results from all the at-sea work between 2021-2024.

Burgin, D (WMIL), 2024.

1.2 Study Site

Catching trips targeted areas within the Hauraki Gulf around the Marotere and Mokohinau Island groups, as well as the waters surrounding the known breeding sites of tākoketai on Hauturu and Aotea. Figure 1 shows the catching locations for all trips undertaken between 2021-2024.

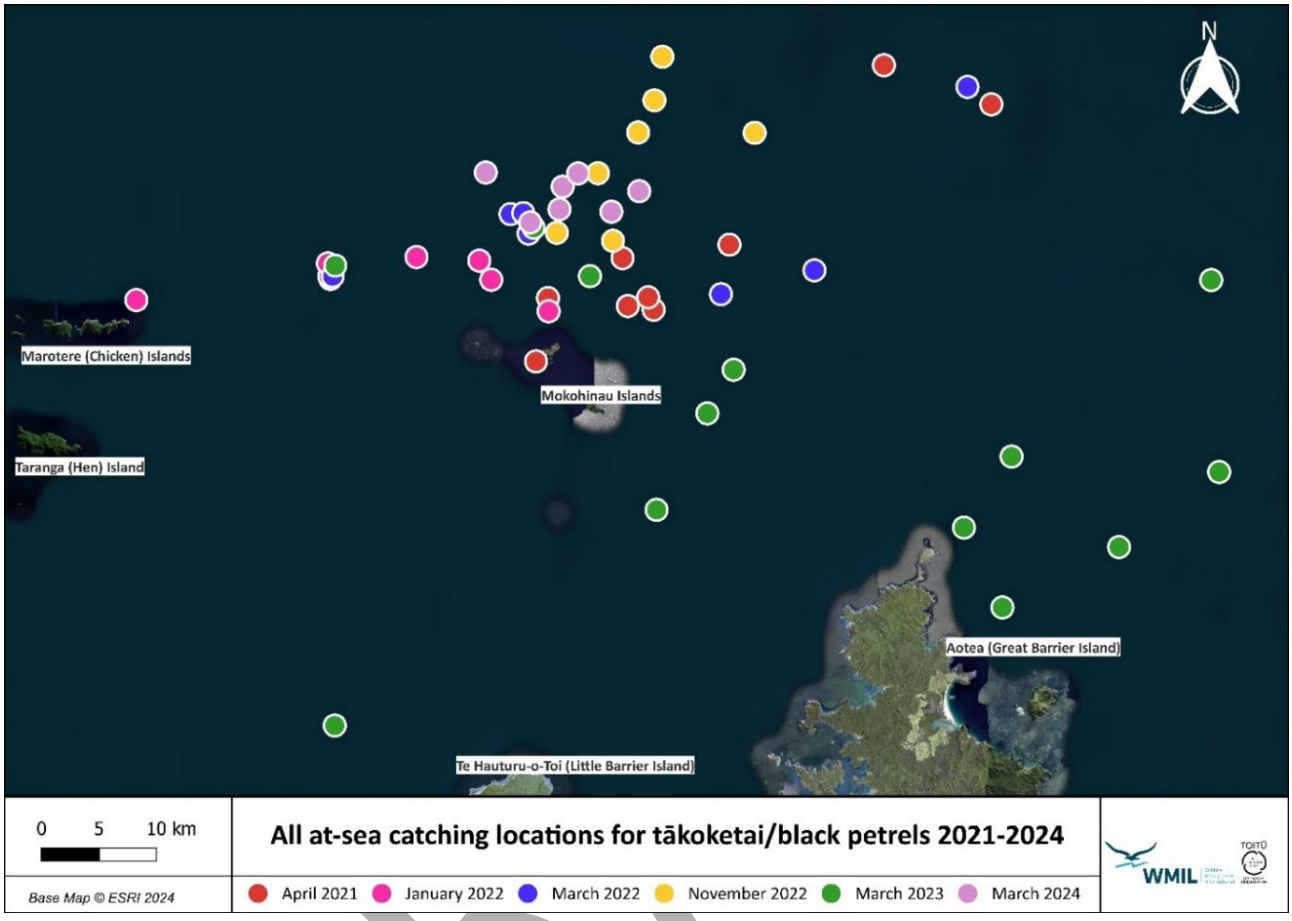


Figure 1: *At-sea catching locations for all trips undertaken between 2021 and 2024. Points are coloured based on trip date. Locations are within the waters surrounding the known breeding sites of tākoketai/black petrels on Te Hauturu-o-Toi/Little Barrier Island and Aotea/Great Barrier Island.*

1.3 Trip Dates

Table 1 summarises all the at-sea trips undertaken by WMIL, with any key notes.

Table 1: *Trip dates for all at-sea work, 2021-2024*

Date	Notes
6-8 April 2021	
26 January 2022	*Limited to just one day due to poor weather and swell conditions either side of this date developing late.*
16-19 March 2022	*Could not be extended due to poor weather and swell conditions developing late.*
13-14 November 2022	*Could not be extended due to poor weather and swell conditions later developing late.*
28 February-2 March 2023	
6-8 March 2024	

2. METHODS

2.1 Tākoketai Capture

Tākoketai were lured in initially using a mixture of fish berley which was sealed in a netted bag or plastic case and placed in the water off the back of the boat once the engine had been turned off. It was connected by a rope and left to create a 'slick' of fish oil and small pieces of bait as an attractant. This worked well to attract tākoketai to the back of the boat and once tākoketai were flying around the back of the boat, chopped up fish, and small pieces of fish burley were then thrown on to the surface of the ocean as a further attractant. This also allowed targeted throws to lure tākoketai in closer to the back of the boat to ensure they were within range of the cast net thrower.

A hand cast net (6 ft) was used as the primary method of catching birds. Two nets were available on some trips, and each was thrown by one person from the back of the boat and over the top of a tākoketai, whilst the other team members threw bait and/or helped with processing the birds. The range of the thrower was between 0.5 – 6 metres with the further distance dependent on suitable conditions. The cast net was pulled tight once over the bird to seal them inside and pulled back on to the boat carefully. Tākoketai were then carefully retrieved from the net by hand (Figure 2) and placed into an individual drawstring bag for processing. Each bird was given a unique metal band if not already banded, marked with correction fluid to help distinguish it as a captured bird, and then carefully released over the side of the boat. Any banded birds had their unique band number taken, before being marked with correction fluid, and released as above.

Figure 2: *Tākoketai/black petrel in hand after retrieval from the cast net.*

Any newly found (unbanded) tākoketai were assumed to be 2 years old, as this is the minimum age this species could be when detected out in the ocean during this work, without further understanding of the individual's age. For recaptured individuals from colony sites, assumptions are also made for the age of adults found as non-breeding, or breeding, at a colony for the first time. It is assumed that a non-breeding individual tākoketai captured for the first time is at least five years old, and a breeder found for the first time is at least eight years old. These represent the necessary assumptions that WMIL incorporates into the aging of birds found at-sea and/or at the colony sites.

During capture two morphometric measurements were also taken (head bill length and bill width) from a sample of tākoketai to indicate sex. Capture ran from sunrise to sunset, with rest periods for the capture team and skipper built into moving between capture locations and meal breaks.

All banding data were then uploaded to the online DOC FALCON banding database, under the "*Black petrel research (including other seabirds)*" project.

2.2 Tākoketai Counts

Accurate counts were taken of all bird species seen, including tākoketai, at all locations. These were all uploaded to eBird (Sullivan et al. 2009) as part of complete checklists to attempt to understand the proportion of banded vs unbanded tākoketai seen at sea, as well as support the wider the ornithological dataset and research.

3. RESULTS

Key results are presented below for all of the trips undertaken and an overall analysis is also presented for all at-sea work undertaken by WMIL since 2021. Ages of individuals are listed as correct to the date when the individuals were caught, and so it is important to note that some of these individuals may be even older now.

3.1 Total captures of tākoketai/black petrels from all at-sea trips

A total of 463 tākoketai were caught over all trips undertaken since April 2021. Of these, 438 were newly banded and 22 were recaptures of individuals previously banded at a terrestrial colony, or at-sea, representing 4.8% of total captures. Note that during the March 2022 trip three tākoketai were already banded earlier in the trip. This has been left in the total caught value for March 2022 and the entire period, but removed from the recapture totals as they were only recently banded days/hours prior. Table 2 summarises all captures for all trips undertaken since 2021, with recapture and newly banded values presented. Figure 3 shows all captures weighted by total tākoketai caught for all trips across the survey area.

The highest number of tākoketai caught over a single trip, was during the 3-day trip in March 2024 where a total of 142 black petrels were caught altogether (recaptures included).

Table 2: *Total captures for tākoketai/black petrels during all at-sea capture trips, 2021-2024.*

At-sea Trip	Number of tākoketai/black petrel caught			
	Total caught	Recaptures (Previously Banded)	New (Un-banded)	Percentage previously banded (%)
April 2021	55	1	54	1.8
January 2022	17	0	17	0.0
March 2022	130*	5*	122*	3.9
November 2022	39	2	37	5.1
March 2023	80	7	73	8.8
March 2024	142	7	135	4.9
TOTAL	**463**	**22**	**438***	**4.8**

**During the March 2022 trip three tākoketai were already banded earlier in the trip. This has been left in the total caught value for March 2022 and the entire period, but removed from the recapture totals as they were only recently banded days/hours prior.*

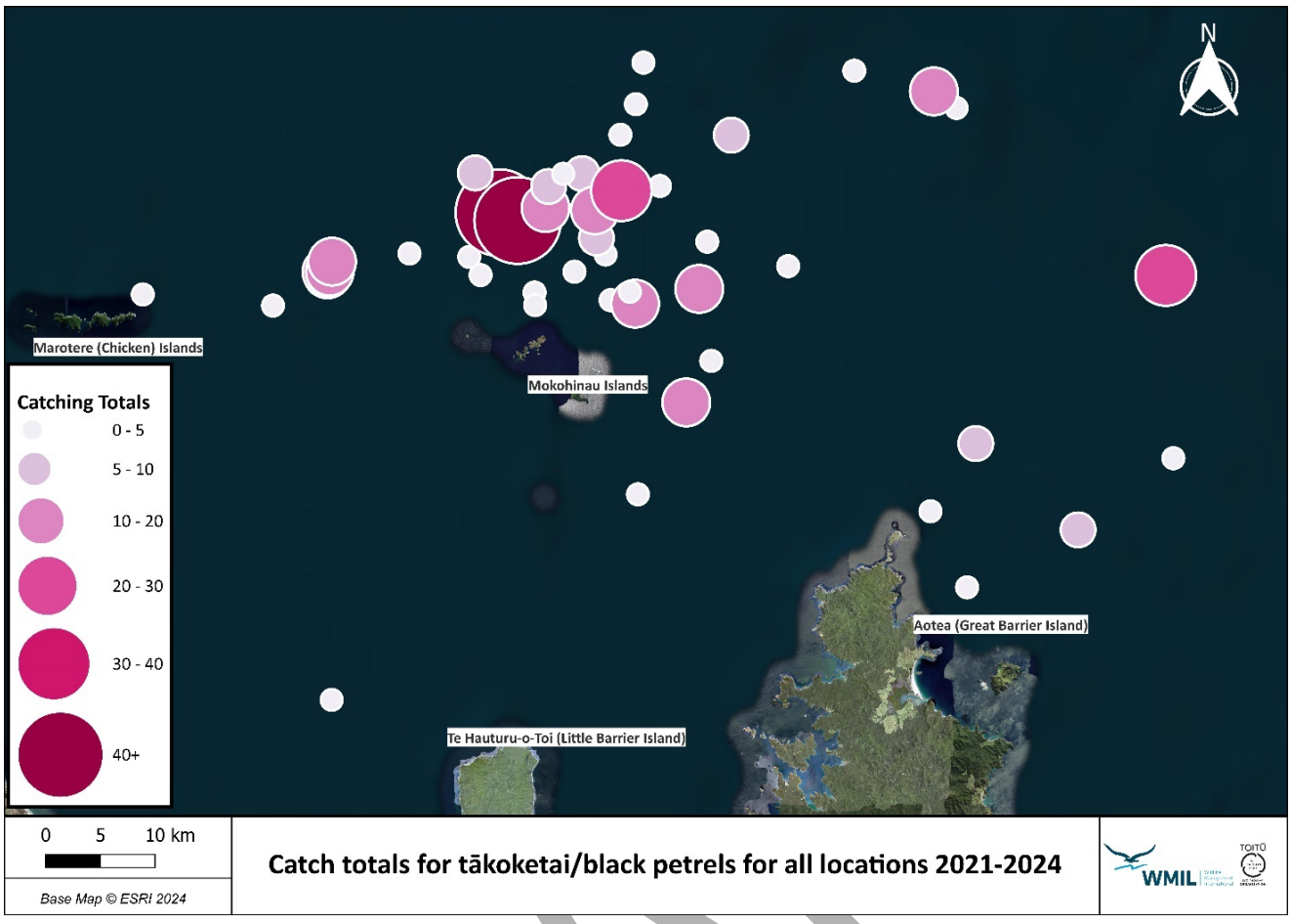


Figure 3: *Catch totals for tākoketai/black petrels for all locations, 2021-2024.*

Where possible, only one bird was targeted at a time, but on occasion multiple birds (2-3) were caught together. This was unavoidable due to the behaviour of the congregations of seabird species targeting the bait, notably toanui/flesh-footed shearwaters (*Ardenna carneipes*).

3.2 Time Captured

Time of capture was taken for all but one trip (January 2022) to understand best times of capture for tākoketai. Over 20% of tākoketai (n=67) were caught between 07:00-09:00AM and a further 23% (n=72) between 17:00-19:00PM with lower numbers periodically caught during the remaining interim daytime periods (Figure 4). Afternoon activity fluctuated with some periods such as 12:00-13:00 having 8% of tākoketai captures. No catching was undertaken outside of these times, i.e., through the night and would require further work to understand capture rates at this time.

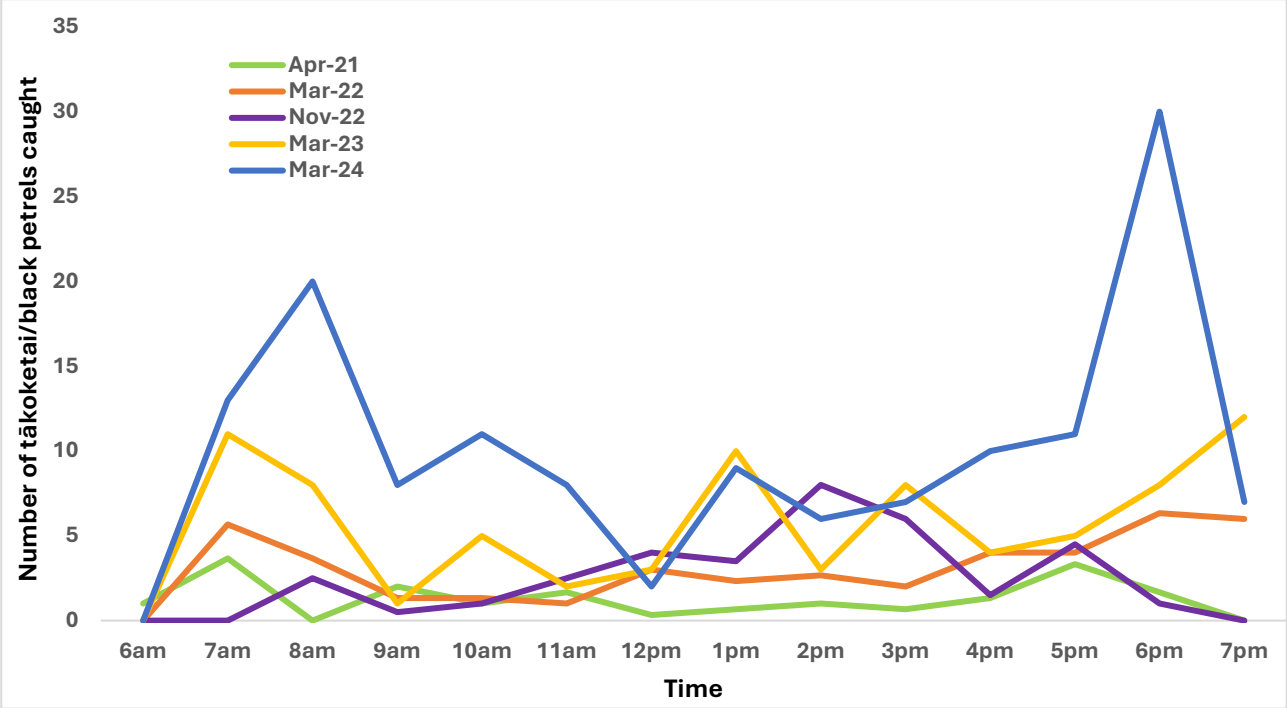


Figure 4: *Time of capture for tākoketai/black petrel for at-sea work 2021-2024 (excluding January 2022 trip).*

3.3 Recaptures

Recaptured tākoketai details are listed below in Table 3 from all at-sea trips undertaken between 2021-2024. This includes eight tākoketai that were caught for the first time since fledgling, the youngest being five years old at time of capture, and the oldest being eight years old at time of capture.

Table 3: *Recapture details for tākoketai/black petrels from all at-sea trips between 2021-2024.*

Trip	Band Number	Age	Sex	Colony	When banded	Notes
April 2021	**H-41287**	9+	Unknown	Hauturu	As a non-breeder in January 2017.	First recapture of this individual.
March 2022	**H-41175**	6	Unknown	Hauturu	As a chick in April 2016.	First recapture of this individual since fledging.
March 2022	**H-46254**	8+	Unknown	Hauturu	As a breeder in December 2022.	Last seen as breeder in study burrow.
March 2022	**H-42021**	11+	Male	Aotea	As a non-breeder on the surface in January 2016.	Last seen on egg in study burrow.
March 2022	**H-44567**	8+	Unknown	Aotea	As breeding adult in February 2022.	Last seen with chick in study burrow.
March 2022	**H-42733**	5	Unknown	Aotea	As a chick in April 2017.	First recapture of this individual since fledging.
November 2022	**H-42654**	13+	Unknown	Aotea	As an adult in a random burrow during conservation dog surveys in February 2017.	First recapture since seen in a random burrow with a chick.

Trip	Band Number	Age	Sex	Colony	When banded	Notes
November 2022	**H-42970**	5	Male	Aotea	As a chick in May 2017.	First recapture of this individual since fledging.
March 2023	**H-34779**	24+	Unknown	Aotea	As a non-breeding adult in December 2004.	Last seen in a study burrow on an egg.
March 2023	**H-39587**	8	Unknown	Aotea	As a chick in April 2015.	First recapture of this individual since fledging.
March 2023	**H-33671**	29+	Male	Aotea	As a breeding adult in December 2022.	Last seen in a study burrow on an egg.
March 2023	**H-44140**	11+	Unknown	Aotea	As a breeding adult in January 2020.	Last seen on the surface clacking but has been found breeding in a study burrow before.
March 2023	**H-46046**	4+	Unknown	Unknown	At-sea in April 2021	First resighting of this individual.
March 2023	**H-41673**	7	Unknown	Aotea	As a chick in May 2016.	First recapture of this individual since fledging.
March 2024	**H-42712**	7	Unknown	Aotea	As chick in May 2017	First recapture of this individual since fledging.
March 2024	**H-25631**	20	Unknown	Aotea	As chick in April 2000	Seen in 2003 in a burrow as a non-breeder on Aotea.
March 2024	**H-41506**	16+	Male	Aotea	As a breeding adult in December 2015.	
March 2024	**H-41625**	13+	Male	Hauturu	As non-breeding adult in December 2015.	
March 2024	**H-47719**	5+	Unknown	Aotea	As an adult on surface at night February 2024.	Unknown breeding status.
March 2024	**H-42718**	6	Unknown	Aotea	As chick in May 2017.	First recapture of this individual since fledging.
March 2024	**H-41183**	7	Unknown	Hauturu	As chick in April 2016.	First recapture of this individual since fledging.

3.4 Daily Capture Rates

Table 4 summarises the daily capture rates of tākoketai and the averages from all trips undertaken by WMIL since 2021.

The average daily capture rate of tākoketai for each trip is highly variable from as low as 17 per day in January 2022 to 47 per day in March 2024. The average daily capture rate of tākoketai over all trips was 31 birds per day, calculated as 463 tākoketai over 15 days cumulatively.

Table 4: *Average daily capture rates for tākoketai/black petrels during all at-sea capture trips 2021-2024.*

Day	April 2021	January 2022	March 2022	November 2022	March 2023	March 2024	Overall average
Day 1	3	17	38	9	16	31	19

Day 2	7	***N/A****	48	30	29	75	38
Day 3	45	***N/A****	44	***N/A****	35	36	40
Average Daily Capture	**18**	**17**	**43**	**20**	**27**	**47**	**29**
TOTAL	**55**	**17**	**130**	**39**	**80**	**142**	**77**

** No catching was undertaken on this day*

3.5 At-sea versus colony (land) capture rates

This at-sea work was undertaken alongside the regular tākoketai colony checks on Aotea and Hauturu undertaken by WMIL and Auckland Council. Focused night work to target returnees was also undertaken on Aotea over the same time period (2021-2024). These were intensive searches covering 6-8 hours (21:15PM to 05:15AM) each night, and over the three-year period 41 night surveys were undertaken. Table 5 summarises key analyses for capture, recapture and returnee rates for the at-sea work and intensive colony night work undertaken between 2021-2024. This is also presented in Bell et al. (2024). The percentage of banded tākoketai caught out of all captures is far lower for the at-sea work (4.8%) compared to intensive colony work (51.3%), as is the percentage of returned tākoketai chicks (2.0% vs 19.4%). The percentage of returned tākoketai chicks out of all the individuals caught is slightly higher from at-sea work (40.9%) compared to the intensive colony night work (37.9%), however the number of banded tākoketai caught per day/night is higher for the intensive colony night work (n=5.3) compared to the at-sea work (n=1.5).

Table 5: *At-sea versus intensive colony work on land comparison for key criteria of tākoketai/black petrel captures and recaptures, 2021-2024.*

Criteria	At-Sea work	Intensive Night Colony Work (Land)/Aotea
Number of day/night surveys	15	41
Number of adult tākoketai caught	463	427
Number of newly banded tākoketai	438	208
Total number of banded tākoketai caught	22	219
Number of returned tākoketai chicks caught	9	83
Number of tākoketai caught per day/night	30.7	10.4
Number of newly banded tākoketai caught per day/night	29.2	5.1
Number of banded tākoketai caught per day/night	1.5	5.3
Number of returned tākoketai chicks caught per day/night	0.6	2.0
% of banded tākoketai out of all birds caught	**4.8%**	**51.3%**
% of returned tākoketai chicks out of all birds caught	**1.9%**	**19.4%**
% of returned tākoketai chicks out of all banded birds caught	**40.9%**	**37.9%**
% of unbanded tākoketai out of all birds	**94.6%**	**48.7%**

3.6 Post-release condition

It is important to clarify that all tākoketai (and any other species) that were captured and processed were not harmed during any stage of the project. The few birds that were found to be very wet after capture, were given time to dry out completely in an individual cloth bag before release. All birds were seen to fly away normally, and often returned to continue foraging on the discards in the water. Many 'twinked' tākoketai followed the boat between catching locations on the same day, or even across days of trips as evidenced by recapture of three at-sea banded individuals during March 2022.

3.7 Evidence of fish-hook damage

During the March 2022 trip, three tākoketai were found to have apparent evidence of fish-hook damage to their bills. Figure 5 shows one individual with clear damage to the bill assumed to have been sustained from a fishhook, potentially from a conflict with a commercial or recreational fishing vessel. This species is known to be at great risk from commercial fisheries within New Zealand's Exclusive Economic Zone (Richard & Abraham 2013; Whitehead et al. 2019). This aligns with what has been seen at the breeding colony on Aotea during burrow monitoring (E. Bell, WMIL, *pers. comm*.).

Figure 5: *Assumed evidence of previous fish-hook capture and subsequent damage to bill of tākoketai/black petrel, March 2022.*

3.8 Counts of tākoketai

As part of this work, all observations of tākoketai at, and between, capture locations were collated into counts via checklists in eBird to gather data on frequency and abundance of all bird species. This was also used to attempt to understand the proportion of banded vs unbanded tākoketai seen at sea.

Counts were often best estimates undertaken alongside the capture work, and it is important to note that the length of the checklist in both distance and time varied depending on how successful the capture location proved to be, how much the vessel was drifting, and the level of activity. The average distance of a checklist was 2.15km.

93 checklists containing counts for tākoketai were gathered over the six expeditions and uploaded to eBird. Figure 6 shows all count locations plotted with proportional size displayed for the total tākoketai counted. 77% of checklists (n=71) had low numbers of tākoketai (1-10), and the average number of tākoketai on each checklist was nine. Large congregations over 50 were never

encountered. The single highest tākoketai count was 50 individuals behind the back of the vessel on 8 April 2021, 17km east of the Marotere Islands. Only one bird within this group was found to be banded when captured that evening representing just 0.02%, however not all 50 individuals were caught so more banded individuals could have been present but not detected.

On average across all trips, roughly 1 in up to 20 tākoketai were banded behind the boat, indicating a low percentage of tākoketai being seen to be banded (0.05%), and this was reflected in the recapture totals.

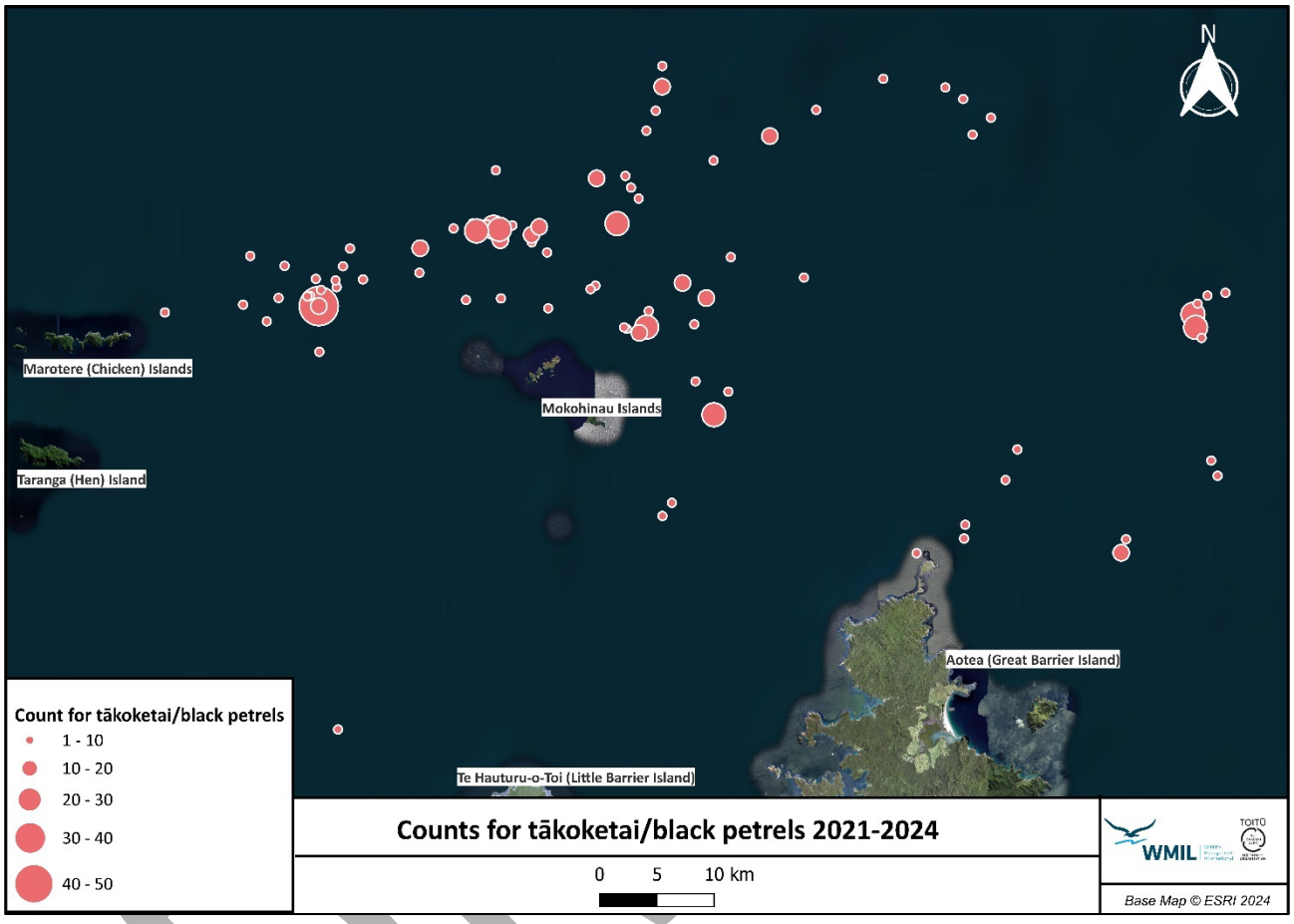


Figure 6: *At-sea counts for tākoketai/black petrels, 2021-2024.*

4. DISCUSSION

4.1 Capture rates using cast net

The high number of newly banded tākoketai over all of these trips (n=438), has increased the banding totals across the two breeding colonies. However, this high number of newly banded individuals represented the bulk of captures compared to the 5% recaptures and indicates the large amount of work needed to recapture previously banded individual tākoketai at-sea. Importantly as part of this work WMIL did not specifically target banded tākoketai when behind the vessel, rather capturing as many as possible in a non-biased way by not targeting a banded tākoketai over an unbanded one if they were both behind the vessel.

Certain areas were targeted during all trips due to their successful capture rates namely north of the Mokohinau Islands and north-east of Aotea (Figure 3). Over the six trips new areas were constantly targeted around the known primary breeding colonies to help spread coverage of the capture effort, but also to try increase capture rates. Some of these locations proved successful, whilst others proved unsuccessful and are shown in Figure 3 as white dots where less than five individuals were caught. During any future work, it would be worthwhile exploring beyond the reaches of the Hauraki Gulf, spreading effort into the far north, as well as possibly exploring much further out into the Pacific

and Tasman Oceans to target tākoketai across their known at-sea range, particularly during breeding (Freeman et al. 2010) in order to try increase capture rates. Extending at-sea capture to be undertaken during the winter period across their range in the Pacific towards South America would also be of immense value.

As mentioned previously, additional work was planned for the east coast of Te Tai Tokerau/Northland, alongside Far Out Ocean Research Collective in order to try capture tākoketai associating with false killer whale (*Pseudorca crassidens*) pods as documented before by Pitman and Ballance (1992). Due to the view by local Iwi that the DOC engagement and consultation process regarding this at-sea work was insufficient, WMIL were unable to undertake capture trips at this location. Future at-sea capture work could focus on this association, as seabirds are known to associate with sub-surface predators to feed on the prey items they force to the surface (Pitman & Ballance 1992), and so presents a valuable research area to gain further clarity on, and not just for false killer whales but other cetaceans.

4.2 Capture method

WMIL feel that the use of the cast net is an incredibly effective way of safely capturing a high number of tākoketai in a relatively short period of time, as shown by the results of this work. Whilst other methods are available and should be explored, the use of a cast net has proven very effective in safely capturing 463 tākoketai over 15 days at-sea, equating to an average of 31 tākoketai a day. Capture rates have improved as WMIL continued to gain more experience, as should be expected with refining a method like this over time. Ensuring competent and strong throwers is essential to fully utilise this capture method, and with a range of 0.5 - 6 metres from the back of the vessel, it provides a large scope to catch tākoketai behind vessels (Figure 7). Importantly it provides an effective and safe method of capture, and recapture, that can benefit and support terrestrial work at the colony sites to inform population estimates, as well as demographic and other streams of work.

Figure 7: *Campbell Maclean waiting to throw the cast net over a tākoketai/black petrel landing to take bait thrown by Trevor Jackson, February 2023, WMIL.*

The use of a smaller vessel to get closer to tākoketai sitting away from the main vessel could be explored, as the cast net method would still work. The cast net was very effective albeit restricted to the back of the vessel but could still be thrown far in most weather and swell conditions, with the only

requirement being an experienced and competent handler/thrower to utilise the net to its full effect working alongside an experienced skipper, such as Trevor Jackson (El Pescador Charters) (Figure 7).

Ultimately WMIL support this method as a pivotal tool to permit capture for at-sea research for tākoketai and other seabird species in Aotearoa to help provide a valued perspective on their ecology away from breeding areas.

It is important to note that the capture of species other than tākoketai was often unavoidable due to their associations with feeding tākoketai behind the back of the boat. Despite this, WMIL feel the capture of other seabird species helped provide support for other research and were pleased to see the applicability of this capture method to other seabird species, notably toanui, but also including species as small as takahikare-raro/New Zealand storm petrel (*Fregetta maoriana*) to the larger toroa/albatross (*Thalassarche* spp.). This could prove invaluable in further increasing our understanding about the at-sea ecology of these species.

4.3 Capture time

The most successful times of day for capture of tākoketai was found to be in two key periods around first light and the last two hours before dark. This was maximised by getting to those locations for first light, and before dusk, to be ready to catch tākoketai. It was also found that during the afternoon, if there were few tākoketai around, once those around the boat had been captured, marked, and released, moving on to a new site or indeed waiting for new tākoketai to come in were both effective.

No capture effort was made throughout the night, yet this species is a known scavenger with possible nocturnal foraging to forage on, or capture, bioluminescent squid, on and just below the surface (Imber 1976; Bell 2016). Whilst the majority of foraging is undertaken during the day between sunrise and sunset, tracked male tākoketai did undertake 12.6% of dives at night (Bell 2016) suggesting additional activity at night. Further at-sea capture work could therefore attempt to establish the optimum time to capture this species by undertaking at-sea capture for tākoketai at night and day to compare the rates and explore this behaviour further.

4.4 At-sea vs on-land captures

A key outcome here is that the at-sea work seems to capture mostly unbanded birds, compared to the intensive land effort. The number of returned chicks caught per day/night is lower at-sea compared to on-land (0.6 vs 2.0), and so is the number of banded birds caught per day/night (1.5 vs 5.3) despite the number of birds caught per day/night at-sea being nearly three times higher than the land work (30.7 vs 10.4). This is likely a result of being away from the terrestrial breeding colony, and encountering both the wider population of tākoketai outside the sampled colony area that are banded, as well as a higher chance of interacting and/or intercepting non-breeders who have yet to return to a colony. Estimates of tākoketai suggest there could between 11,000 and 38,000 birds (Spear et al. 2005; Richard & Abraham 2015) with many of these out at sea, and importantly most will not have been banded. The colony is a significant source of banded individuals and so has a higher chance of encountering banded tākoketai, particularly with calling birds attracting additional birds in. In comparison when at sea, the chumming brings in the birds from a far wider area, and many of these birds may be non-, or pre-breeders who have yet to establish a site on land at a colony.

With this in mind, WMIL believe that the at-sea work can be a fantastic additional component to targeting recaptures and can be beneficial for a variety of research questions. As Table 5 shows, the recapture rate overall is not as effective as targeted nocturnal work at the colony itself, but provided valuable resights of returnees including chicks sighted for the first time since fledging. Further at-sea work should target beyond the Hauraki Gulf, and nocturnal work on land could target beyond the study colony area on Aotea to increase the detection rates and gather data in these areas to complement this dataset.

It is important to holistically add in the logistics of this work to this review too. Given the amount of time and resources required for at-sea work, as well as the potential for it to be cancelled due to poor

weather or swell conditions, the nocturnal searching at the colony can be of higher cost-benefit. Considering the current financial constraints DOC and many conservation agencies face, if one method needed to be considered over the other, future work could gain far more from more intensive nocturnal work at the Aotea and Hauturu colony sites. However, WMIL would still support and recommend that further at-sea work for tākoketai is undertaken alongside colony work, if the funding and capacity exists, to continue to better understand their at-sea ecology, chick survival rates and much more.

4.5 Counts of tākoketai

The counts of tākoketai at and between catching locations provided a coarse indication of numbers at-sea. However, it wasn't the core focus of this work and WMIL are aware that more banded individuals could have been present but not detected when undertaking counts and trying to ascertain the proportion of banded versus unbanded tākoketai. A low proportion of banded tākoketai were caught and seen during all expeditions, which is interesting considering discussions with other researchers undertaking at-sea capture work who have found one in four tākoketai encountered being banded (25%) within the Tasman Sea (R. Clarke, *pers. comm*).

The process of clarifying whether an individual tākoketai is banded or not can be difficult if not caught and only seen in flight. Sometimes individuals flew around the vessel without landing and then disappeared, and with the primary focus being on trying to catch those tākoketai on the water, that clarity on whether it was banded or not was often unobtainable.

With that in mind, to understand the proportion of banded versus unbanded individuals detected at sea, further work would need to be undertaken specifically focusing on this aspect. There may also be a possible need to assess whether individually marked Darvic bands would support this analysis better than an individual metal band by increasing visibility of the band. This has been trialled in the past before by Mike Imber with colour bands for tākoketai depending on the location of their natal colony (WMIL, unpublished data), however would require a lot of effort and limitations and assumptions would still exist.

5. CONCLUSIONS

WMIL believe that this at-sea work was, and can continue to be, a fantastic additional component to the colony based tākoketai monitoring, to increase our understanding of this taonga species. This continues to be pertinent in light of the threats this Nationally Vulnerable seabird (Robertson et al. 2021), and many other seabirds face (Whitehead et al. 2019), notably bycatch from commercial and recreational fisheries (Richard & Abraham 2013), introduced predators (Bell & Sim 2000; Bell et al. 2023) and climate change (Bell et al. 2023).

6. RECOMMENDATIONS

WMIL recommends that:

- Future at-sea trips are undertaken with the following focus:
    - Run trips throughout the breeding season to intentionally coincide with key stages of the breeding cycle; return to the colony/pair bonding, egg laying, incubation, chick rearing and chick fledging.
    - Explore the logistics of undertaking capture during both day and night to compare capture rates and activity over these time periods.
    - Undertake trips up north to assess associations between tākoketai and false killer whale pods, and possibly other cetaceans.
    - Expand the work away from the breeding colonies to extend the dataset beyond the Hauraki Gulf, notably further into the South Pacific Ocean, and even over into the Tasman Sea.

  - Run trips in alignment with intensive nocturnal surveys at the Aotea and Hauturu colony sites to be able to continue to not only compare the efficacy of the two methods, but also increase the coverage for detecting previously banded tākoketai and to enhance population trend models and risk analyses.
  - Counts of all seabirds encountered are entered into eBird checklists to complement the New Zealand dataset and relative abundance models for this species and more.
  - Budgets are updated to better reflect increased cost of fuel, food, travel, accommodation, bait and boat charter.

- Additionally, WMIL recommends exploring collaborations with other stakeholders and/or researchers for other data that could be collected from tākoketai when captured. This could include, but is not limited to, morphometric measurements, blood and/or feather samples. This could inform wider knowledge regarding the species and broader research goals.
- Nocturnal effort is prioritised at the Aotea and Hauturu study colonies to recapture returning tākoketai and enhance population trend models and risk analyses.

7. ACKNOWLEDGEMENTS

This project was funded by DOC CSP (partially funded through a levy on the quota owners of relevant commercial fish stocks). Auckland Council also kindly provided funds to support this project.

- An unmeasurable amount of thanks to Trevor Jackson (El Pescador Charters) for taking the WMIL team out to these areas, anchoring within the Mokohinau Islands or Aotea and getting us home safely. Trev tirelessly assisted with bait preparation and processing of tākoketai, fitting us into his busy schedule and doing all of that with a smile on his face.
- Thank you to Mike Bell (Toroa Consulting), Patrick Crowe (now DOC), Simon Lamb, Campbell Maclean, Keegan Miskimmin, Lydia Titterton, Hinewai Bell (WMIL) and Gaia Dell'Ariccia (Auckland Council) for their involvement with the fieldwork over the years.
- Finally, many thanks to Graeme Taylor (DOC) for his support of this project.

8. REFERENCES

Ballance, L.T. (2007). Understanding seabirds at sea: why and how? *Marine Ornithology*, 35: 127:135.

Bell, E.A.; Sim, J.L. (2000). Surveying and monitoring of black petrels on Great Barrier Island, 1998/99. Published client report on contract 3089, funded by Conservation Services levy, Department of Conservation, Wellington. 23p.

Bell, E.A. (2016). Diving behaviour of black petrels (*Procellaria parkinsoni*) in New Zealand waters and its relevance to fisheries interaction. *Notornis*. 63: 57-65.

Bell, E.A.; Welch, M. & Lamb, S. (2022). Key demographic parameters and population trends of tākoketai/black petrels (*Procellaria parkinsoni*) on Aotea/Great Barrier Island: 2021/2022. Unpublished Wildlife Management International Ltd. Technical Report to the Conservation Services Programme, Department of Conservation, Wellington.

Bell, E.A.; Lamb, S. & Maclean, C. (2023). Key demographic parameters and population trends of tākoketai/black petrels (*Procellaria parkinsoni*) on Aotea/Great Barrier Island: 2022/23. Unpublished Wildlife Management International Ltd. Technical Report to the Conservation Services Programme, Department of Conservation, Wellington.

Bell, E.A.; Lamb, S. & Ray, S. (2024). Key demographic parameters and population trends of tākoketai/black petrels (*Procellaria parkinsoni*) on Aotea/Great Barrier Island: 2023/24. Unpublished Wildlife Management International Ltd. Technical Report to the Conservation Services Programme, Department of Conservation, Wellington.

Burgin, D. 2022. Summary report for at-sea capture work for tākoketai/black petrels 2022. Unpublished Wildlife Management International Technical Report to the Department of Conservation, Wellington. 18p.

Burgin, D. 2023. Preliminary report for at-sea capture work for tākoketai/black petrels 2023. Unpublished Wildlife Management International Technical Report to the Department of Conservation, Wellington. 11p.

Checklist Committee (OSNZ). (2022). Checklist of the Birds of New Zealand (5th edition). Ornithological Society of New Zealand Occasional Publication No. 1. Wellington: Ornithological Society of New Zealand.

Crowe, P.; & Burgin, D. (2021). At-Sea Black Petrel Captures April 2021 Trip Report. Unpublished Wildlife Management International Technical Report to the Department of Conservation, Wellington. 4p.

Freeman, R.; Dennis, T.; Landers, T.; Thompson, D.; Bell, E.; Walker, M.; Guilford, T. (2010). Black Petrels (*Procellaria parkinsoni*) Patrol the Ocean Shelf-Break: GPS Tracking of a Vulnerable *Procellariiform* Seabird. PLoS ONE. 5(2): e9236.

Imber, M.J. (1976). Comparison of prey of the black *Procellaria* petrels of New Zealand. *New Zealand Journal of Marine and Freshwater Research*. 10: 119-30.

Pitman, R.L.; Balance, L.T. (1992). Parkinson's petrel distribution and foraging ecology in the eastern Pacific: aspects of an exclusive feeding relationship with dolphins. *The Condor*. 94: 825-835.

Richard, Y.; Abraham, E.R. (2013). Risk of commercial fisheries to New Zealand seabird populations. New Zealand Aquatic Environment and Biodiversity Report 109. Wellington: Ministry for Primary Industries Manatu- Ahu Matua.

Richard, Y.; Abraham, E.R. (2015). Assessment of the risk of commercial fisheries to New Zealand seabirds, 2006–07 to 2012–13. New Zealand Aquatic Environment and Biodiversity Report 162. Wellington: Ministry for Primary Industries Manatu- Ahu Matua. 85p.

Robertson, H.A.; Baird, K.A.; Elliot, G.P.; Hitchmough, R.A.; McArthur, N.J.; Makan, T.D.; Miskelly, C.M.; O'Donnell, C.F.J.; Sagar, P.M.; Scofield, R.P.; Taylor, G.A.; Michel, P. (2021). Conservation status of birds in Aotearoa New Zealand, 2021. New Zealand Threat Classification Series 36. Department of Conservation, Wellington. 47p.

Sullivan, B.L.; Wood, C.L.; Iliff, M.J.; Bonney, R.E.; Fink, D. & Kelling, S. (2009). eBird: a citizen-based bird observation network in the biological sciences. *Biological Conservation* 142: 2282-2292.

Whitehead, E.A.; Adams, N.; Baird, K.A.; Bell, E.A.; Borrelle, S.B.; Dunphy, B.J.; Gaskin, C.P.; Landers, T.J.; Rayner, M.J.; Russell, J.C. (2019). Threats to Seabirds of Northern Aotearoa New Zealand. Northern New Zealand Seabird Charitable Trust, Auckland, New Zealand. 76pp.