Progress report on Westland Petrel projects (POP2021-08) and (POP2022-07) investigating burrow occupancy, foraging behaviour and at-sea movement

Kate Simister, Samhita Bose, Johannes Fischer and Graeme Taylor

Department of Conservation, Wellington and Westport

Introduction

Research on Westland petrels (*Procellaria westlandica*) has been undertaken by a range of individuals and agencies across the past few decades with Te Papa staff having a lead role (Waugh et al 2015). Projects looked at species demography, population estimates and tracking studies. The Department of Conservation has supported previous research projects and has now taken over the leadership of the research programme for this species. The current field work is led from the Buller District Office and carried out by Kate Simister to monitor annual breeding success in the study colony at Scotchman's Creek, near Punakaiki.

The new funding made available under the CSP programme has allowed the work programme to expand to cover a range of new projects not previously attempted with this species. These include:

1. Understanding burrow occupancy rates in this species to determine how burrow mapping and nest counts can be related to numbers of breeding pairs. In particular how the status of apparent non-breeding birds occupying nest sites changes over time (e.g. are these pairs skipping breeding attempts, failed breeders or do these birds lack a partner?)
2. Investigating the diving behaviour of Westland petrels using time-depth records (TDR's) to determine their risk profile from fisheries methods such as surface and bottom long-lines.
3. Carry out multi-year tracking of adult birds using Global Location Sensing (GLS) tags to determine extent of time spent within the New Zealand EEZ and elsewhere in the Southern Hemisphere.
4. Track juvenile birds to determine if they migrate to seas beyond New Zealand.
5. Testing of different tag attachment methods for GPS or Argos PTT tags

Westland petrels are winter breeders and this progress report updates work from the 2022 season and part way through the 2023 breeding season. Funding for the project will extend across the current 2023 season. As tags are still being recovered from birds that were attached in 2022, we are only providing a preliminary progress report at this stage. A final report will be provided in 2024.

Methods

Monitoring of burrow occupancy and breeding outcomes

Assessing nest occupancy rates is a critical component of being able to accurately estimate population size in burrowing seabird communities (Parker & Rexer-Huber 2015). This is

because the breeding birds are not easy to count due to burrow complexity (length, bends in tunnel, multiple chambers) and there are normally more available burrows in a colony than actual birds sitting on eggs. In Westland petrels, reported occupancy rates have varied between 21% and 52% (Waugh et al. 2003, 2015) which has quite an impact on total population estimates based on numbers of burrows counted. This aspect of the project involved setting up trail cameras to observe activity in and around burrow entrances. The purpose was to understand what was happening at sites that looked active but had no evidence of breeding attempts. The burrow nest chambers were checked with a burrowscope or using a digital camera with a flashlight to confirm the presence of an egg between May and July. The same burrows were then checked for a chick in November near the end of the breeding season. Burrowscoping has been a standard monitoring method in this species but finding a way to identify individual birds at the surface close to burrow entrances has required some development of new methods. Colour-band combinations were tested but were not easy to observe once covered in mud. Applying numbered temporary tags on the back feathers (Fig. 1) showed the most promise and the latter method is being used in the 2023 burrow assessment.

Fig. 1. Numbered tag attached by tape to back feathers of Westland petrel to identify birds visiting burrows during trail camera monitoring.

TDR attachment and retrieval

A total of 46 adult Westland Petrels were equipped with time-depth recorders (TDRs) during various phenological stages over the course of the 2022 and 2023 breeding periods (Table 1). During the 2022 incubation period, 10 DST milli F-TD TDRs (Star-ODDI, Garðabær, Iceland) were deployed, during the 2022 chick-rearing period, 20 CT G5 long life TDRs (CEFAS Technology, Suffolk, UK) were deployed, and during the 2023 pre-laying and incubation period 16 CT G5 long life TDRs were deployed. Star-ODDI TDRs were programmed to record depth at 2-sec intervals. However, these TDRs did not allow for conditional programming and as such started recording when they were deployed on birds, regardless of whether those birds were out at sea. Consequently, the internal memories of the Star-ODDI TDRs filled up rapidly, impeding longer (e.g., > 1 month) deployments. Consequently, CEFAS TDRs were deployed, which allow for conditional programming based on saltwater immersion, resulting in data only being recorded when birds are out at sea. Therefore, CEFAS TDRs were programmed to record depth and temperature at 1-sec intervals for the first month, after which they switched to 2-sec intervals. All birds were captured at and returned to their breeding burrows for TDR deployments and retrievals. All birds equipped with TDRs were also equipped with GLS tags (see relevant section and Fig. 2). The sex of birds equipped with TDRs was determined genetically, using collected contour feathers and PCR primers specific to the CHD-W gene (Norris-Caneda & Elliott 1998).

Table 1. Summaries of TDR deployments, retrievals, and datasets obtained (as per early July 2023).

Year	Time frame	Phenology	TDR make; model	*n* deployed	*n* retrieved	*n* datasets obtained	Sex (F; M)
2022	Jul	Incubation	Star-ODDI; DST milli F-TD	10	9 (90%)	9 (100%)	4; 5
2022	Aug-Oct	Chick-rearing	CEFAS; CT G5 long life	20	14 (65%)	14 (100%)	5; 8
2023	May-Jul	Pre-laying and incubation	CEFAS; CT G5 long life	16	TBD (≥4; 25%)	TBD (≥3; 75%)	TBD (1; 2)

All TDRs were deployed on the tarsi of Westland Petrels using custom-made (3D-printed or cast-mold) plastic mounts, which were secured to the leg of the bird using rubber straps and superglue (Fig. 2; Shaffer et al. 2006). Different mounts were developed to fit the different TDR models. In addition, different rubber materials were used between deployments. Specifically, the longer deployments during 2022 resulted in the black neoprene rubber straps disintegrating (potentially due to an interactive effect of superglue, seawater, and UV-light) and causing considerable tag loss during the chick-rearing stage ($n \geq 5$). The disintegration of the rubber was particularly evident on the areas of overlap, causing potential pressure points (Fig. 3) Consequently, a more durable ethylene polypropylene (EDPM) rubber was used in 2023, which was guaranteed glue-, UV- and seawater-proof. All TDRs were non-transmitting devices, and therefore had to be recovered for data to be obtained, and at the time of writing (early July 2023), at least 26 TDR datasets were obtained.

Fig. 2. A Star-ODDI TDR attached to a Westland Petrel using a custom-3D printed mount, next to a GLS tag on the other leg. Credit: K. Simister

Fig. 3. A CEFAS TDR in a cast-mould mount showing where the neoprene rubber straps disintegrated. Credit: K. Simister.

TDR data analyses

In this report, only preliminary data summaries in the form of averages of individual daily maxima and overall maxima of dive depth (in m) are presented as data collection is still ongoing. However, the collected data will be subject to extensive analyses during an MSc student program to investigate vertical foraging behaviour (e.g., dive frequency, average dive depth, maximum dive depth, dive duration, descent rate, dive profile etc.) of Westland Petrels. Such detailed insights will allow comparisons with the vertical foraging behaviour of other *Procellaria* petrels in Aotearoa (e.g., Black Petrels *Procellaria parkinsoni* and White-chinned Petrels *Procellaria aequinoctialis*) as well as to sink rates of surface longline and bottom longline fishing gear (e.g., Frankish et al. 2021), ultimately providing novel insights into bycatch vulnerability.

GLS Tag Deployment

A total of 50 Intigeo C330s Global Location Sensing (GLS) tags (Migrate Technology Ltd., Cambridge, England) were deployed on adult Westland Petrels in July 2021. Each GLS tag was attached to the bird's metal leg band using 2 weather resistant plastic cable ties (Thomas & Betts Black Nylon Weather-Resistant Cable Tie) to minimise the movement of the tag against the metal band and prevent any damage to the tags. Tags were programmed to Mode 6B which recorded light every minute for Migrate Technology saltwater immersion on a constructed scale every 20 minutes and sea surface temperature (SST) in degrees Celsius (° C) when immersed in saltwater for >20 minutes. Additional GLS tags and recovered tags were redeployed in 2022 (see Table 3).

GLS tag analysis

The locations from four recovered GLS tags (2 male and 2 female) were plotted using an iterative forward step selection probability algorithm in the probGLS package (Merkel 2016) in R (Core Team 2015). The algorithm uses light temperature and activity (dry/wet) data recorded by the loggers to predict the probable location of the birds. To increase the accuracy of locations, the distribution range of Westland petrel was defined by 120°E and 50°W longitudes as the western and eastern most limit for Westland petrel distribution 0°S and 65°S as the latitudinal limits. A maximum flight speed of 40m/s (SD= 7) was used to further increase the accuracy of the locations.

Fig. 4. GLS tag on leg of Westland petrel

Satellite PTT trackers on juvenile Westland petrels

Ten transmitting PTT devices were deployed on juvenile Westland petrels in December 2022. The PTT devices were of two types – Lotek Sunbird solar-powered transmitting tags (Lotek, Newmarket, Ontario, Canada) weighing 2.8 g (2.3 x 1.5 x 0.8), and TAV 2617 battery powered (Telonics, Mesa, Arizona, USA) weighing 17g (6.4 x 2.1 x 1.0). All tags were deployed as a standard tail mount following the DOC AEC approved Standard Operating Procedures for tail mounts on birds.

All these devices were pre-programmed to maximise the number of locations transmitted each day, while operating within the constraints of the power required to transmit the locations (hourly during the daytime and every 4 hours at night for solar-powered devices) or to maximise the operating lifespan of the device (2 locations every alternate day for the battery powered TAV 2617s).

Fledglings were selected that were roaming towards take-off spots, had no chick down remaining, good feather condition, good body weight, no health issues or quiet demeanours, primary feathers longer than secondary and strong well developed central tail feathers. Both types of tags were attached as tail mounts, the Sunbird tags were mounted and tied onto a taped base plate, the TAV

2617 tags were taped directly onto the feathers. All tags looked secure on the birds at the time of release.

Testing tag attachment methods

In June 2023 we got approval from the DOC Animal Ethics Committee to test out a range of different tag attachment methods including wing harness, back mounted tape on tags, leg loop harnesses and tail mounted tape on tags. We applied dummy tags (made by DOC electronics team) from plastic housing, waterproof resin and added weights to mimic future deployments of i-gotU GPS tags or similar size GPS tags. The results of this trial will be reported back in 2024. If a suitable attachment option is found, we plan to redeploy another batch of Argos PTT tags on Westland petrel fledglings in December 2023.

Results

Monitoring nest occupancy and breeding success

The status of a selection of Westland petrel burrows was monitored at the Scotchman's Creek study site across three separate breeding seasons. The number of additional study nests under close observation increased in 2021 and 2022 with the new CSP funding. Trail cameras were used to monitor a selection of these nests to look at bird activity levels and the different bird behaviours associated with each nest site. This work is being expanded on in 2023 after trials of different bird marking methods were tested to see which ones gave the best ability to monitor individual bird behaviour. Back mounted numbered tags taped on adult Westland petrels seem to have the best visibility on the trail camera images/videos. These results will be reported in 2024 after the camera footage is analysed.

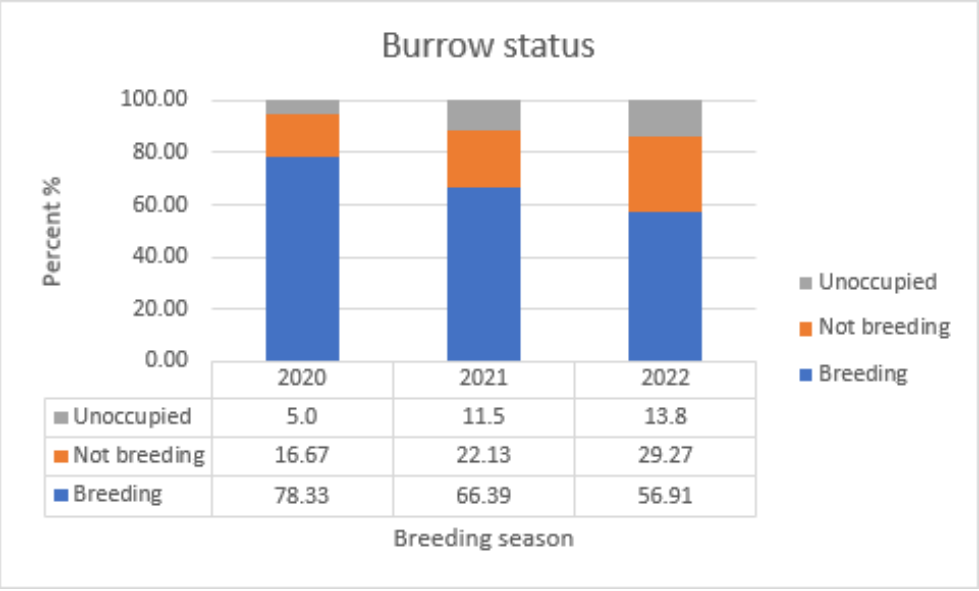

Fig. 5. Status of a sample of Westland petrel nests across three seasons (sample size 2020 n=60, 2021 n=122, 2022 n=123)

It is clear from Fig. 5 that the number of birds attempting to breed varies annually and occupancy rates will not be static from year to year. This was also observed by Waugh *et al*. 2015. The higher occupancy level in 2020 probably reflects burrows chosen for past studies with confirmed breeding pairs. The last two seasons represent a more random selection of burrows to be monitored. All future burrow counts undertaken for assessing total population size will need to determine burrow occupancy rates across a selection of different colony sites rather than rely on past estimates of occupancy rates.

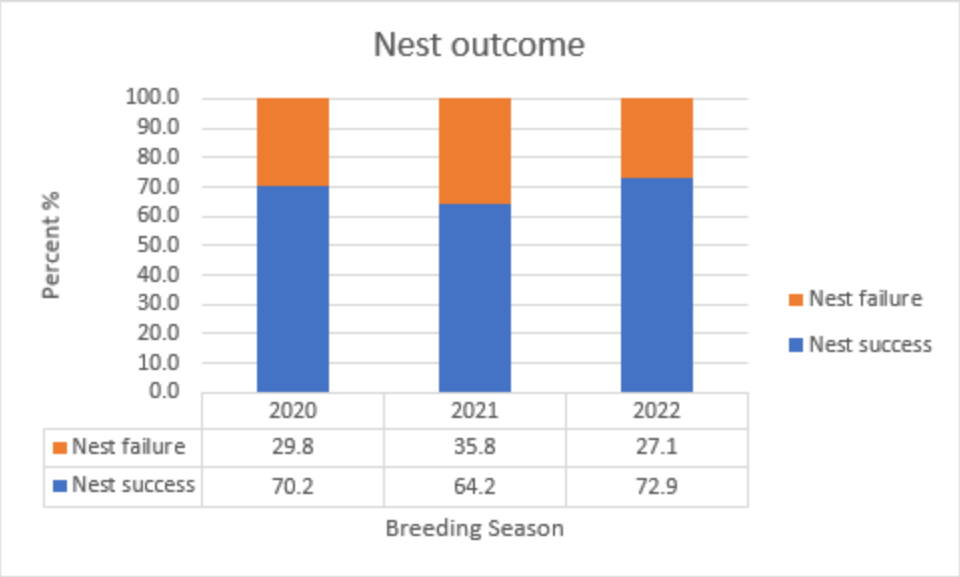

Fig. 6. Nest outcomes (=breeding success) from those nests with eggs confirmed laid in each season monitored from 2020 to 2022 (sample size 2020 n=47, 2021 n=81, 2022 n=70)

Breeding success (Fig. 6.) has stayed fairly high across the three study seasons. There is little evidence to suggest that attachment of tracking tags and devices in 2021 and 2022 had any effect on breeding success compared to the 2020 when no tags were deployed. Waugh *et al.* (2015) reported that the mean breeding success across all years, 1995–2003 and 2012, was 0.607. Breeding success in our study period from 2020-22 was higher than the longer-term average.

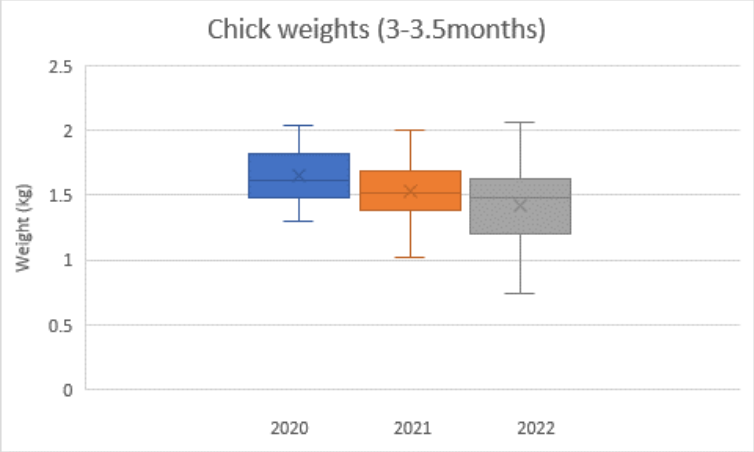

Fig. 7. Chick weights at banding prior to departure in three seasons (sample size 2020 n=29, 2021 n=50, 2022 n=43)

Weights of chicks (Fig. 7) at the study colony has declined over the past three seasons. This is likely to be a result of the marine heatwaves observed in the Tasman Sea in recent years and the three successive seasons with La Nina conditions. However concurrent studies on marine productivity and biomass changes at different trophic levels are necessary to understand the actual relationships between chick weights and condition compared to food availability.

TDR Dive depths on Westland petrels

Mean daily maximum dive depths for Westland Petrels across years and phenological stages averaged at 2.2 m. Total maximum dive depth across years and phenological stages averaged at 7.7 m. The deepest dive recorded was 14.0 m. Preliminary analysis suggests that Westland Petrels perform shallower dives during pre-laying and incubation compared to the dives they performed during chick-rearing. This signal was clear in both the mean daily maximum dive depth (1.8 vs. 2.5) and the total maximum dive depths (6.0 vs. 9.2). The variation in dive depth between incubation and chick-rearing indicates different foraging behaviours conducted by Westland Petrels during self-provisioning and chick-provisioning. Further in-depth analyses will be required to gain more detailed insights into this data.

Table 2. Summaries of dive depth data collected during the 2022 and 2023 breeding periods. Dive data are presented in means ± SE (min-max).

Year	Time frame	Phenology	TDR make; model	Recording freq. (sec)	Mean daily max. (m)	Total max. (m)
2022	Jul	Incubation	Star-ODDI; DST milli F-TD	2	1.8 ± 0.2 (1.2-2.9)	6.3 ± 0.7 (2.7-10.0)
2022	Aug- Oct	Chick-rearing	CEFAS; CT G5 long life	1	2.5 ± 0.2 (1.4-3.9)	9.2 ± 0.7 (5.8-14.0)
2023	May-Jul	Pre-laying and incubation	CEFAS; CT G5 long life	1	1.6 ± 0.6 (0.9-2.9)	5.1 ± 2.7 (1.8-10.5)

GLS Tag Deployment

We recovered 47 of the 50 tags deployed in 2021 (94%) during the 2022 breeding season. One of the birds lost its GLS tag and 2 birds were not resighted in the area in the subsequent season. Another 29 GLS tags were deployed for short term tracking on breeding adults during the breeding season of 2022 to identify movement and foraging areas during incubation and brood guard stage. Of these tags, 21 out of 29 tags (72.41%) were retrieved after 2 months. Finally, 54 additional GLS tags were deployed in July 2022 on adult birds to collect year-round data.

Out of the total 68 tags retrieved by 2022, 11 tags could not be downloaded. All 11 tags are from the batch of 50 we received from Migrate Technology in 2021. There was no apparent water damage/ abrasion on the tags. The tags have been sent back to Migrate Technology to download the data and investigate high level of failure of the tags.

Table 3. Summary of GLS tag deployments on Westland petrels 2021 and 2022

Year	Stage	Number deployed	Number retrieved	Retrieval %	Length of tracks (days)
2021	Chick rearing / Migration	50	47 (one was lost and 2 birds were not recaptured)	94	321.98 (SD 33.324)
2022	Incubation	29	21	72.4	27.85(SD 6.3)
2022	Chick rearing / Migration	54	Some retrieved but many still on birds		

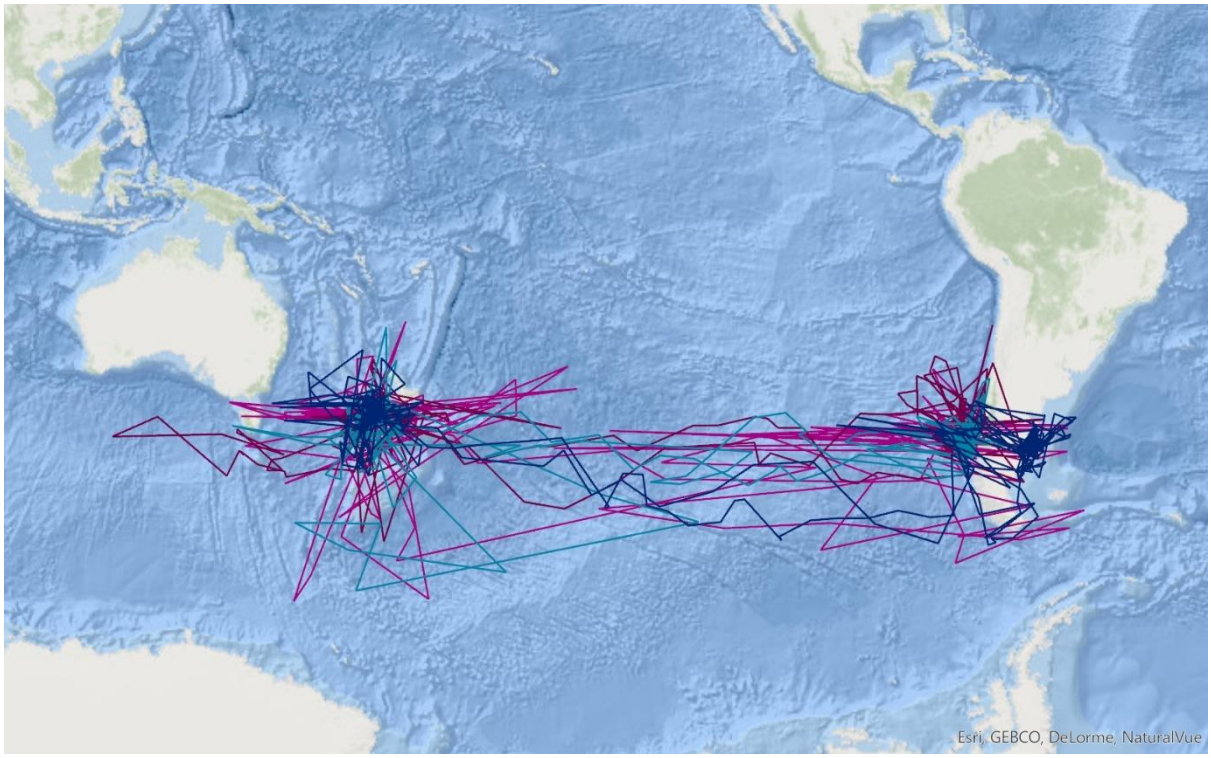

Fig. 8. Tracks from four different Westland petrel adults across the annual cycle (2 males and 2 females)

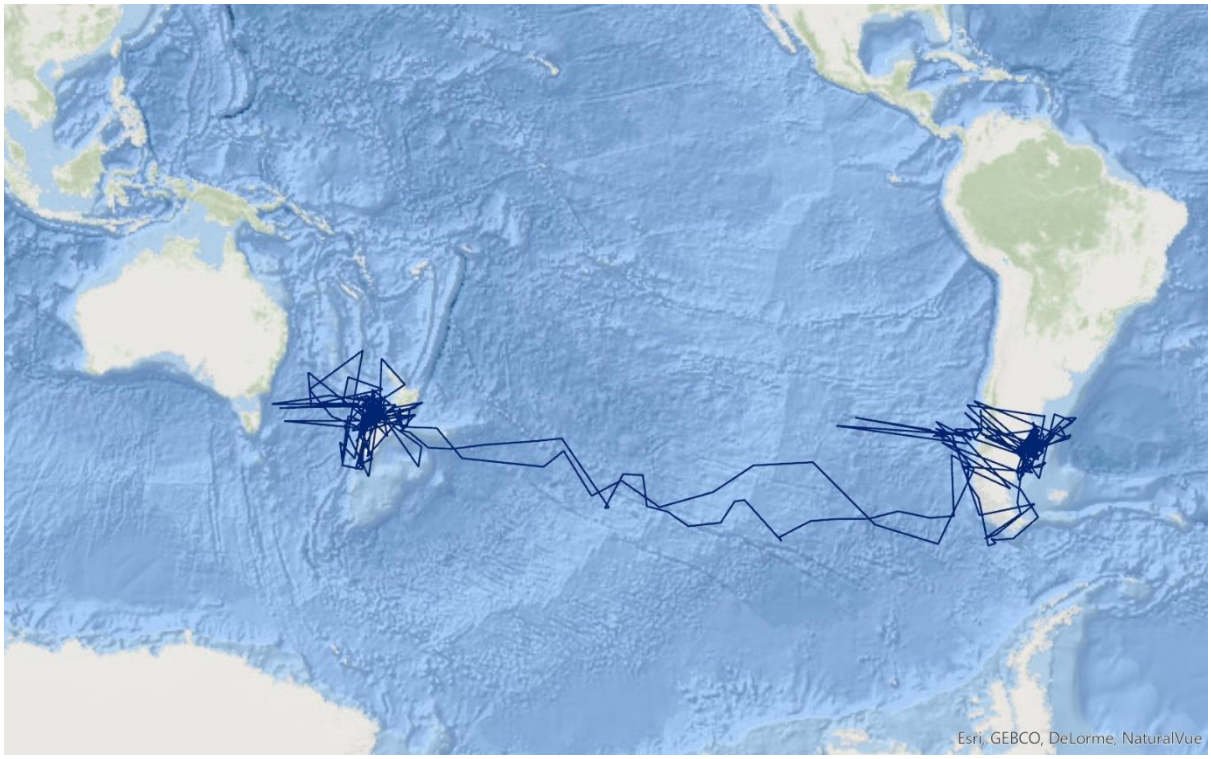

Fig. 9. Annual track of a male Westland petrel showing a prolonged visit to seas off Argentina.

Fig. 8 provides some sample tracks from the GLS deployments. We are yet to fully analyse the tracking datasets but these show the typical annual pattern (Landers *et al.* 2011). Of interest was the

movement of a male Westland petrel (Fig. 9) that probably went through Drake Passage and visited the South Atlantic Ocean off the coast of Argentina.

Tracking juvenile Westland Petrels

Ten Westland petrel fledglings had PTT tags attached for tracking the movements in their first few months at sea or longer. Unfortunately, the tags which weighed <1% of the bird's body weight did not perform as expected. Only seven of the tagged birds definitely made it out to sea (Figs. 10 and 11). The other tags were possibly pulled off by birds prior to departure.

Based on the programming of the tags, the battery powered device should have transmitted for about a year and solar-powered devices should have continued operating and transmitting location data till the birds moulted. But all the devices were lost from the bird within 3 weeks of deployment truncating the tracking effort.

One of the TAV 2617 tags was definitely lost even before the bird fledged as the tag continued to transmit from the general area of the study site for about a month (Fig. 12). The tag could not be recovered due to the low accuracy of the locations received from the tag.

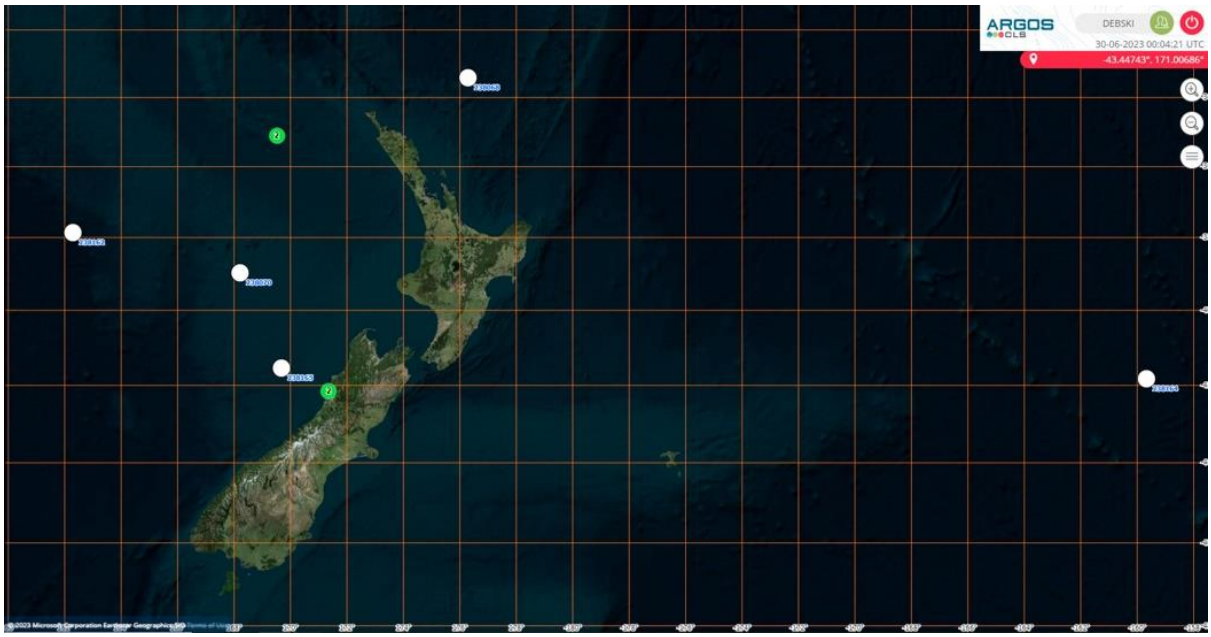

Fig. 10. Last recorded locations from 9 of the 10 tags deployed on juvenile Westland petrels. The 10th tag was dropped off by the bird before fledging and detailed location of the tag is shown in Fig 12.

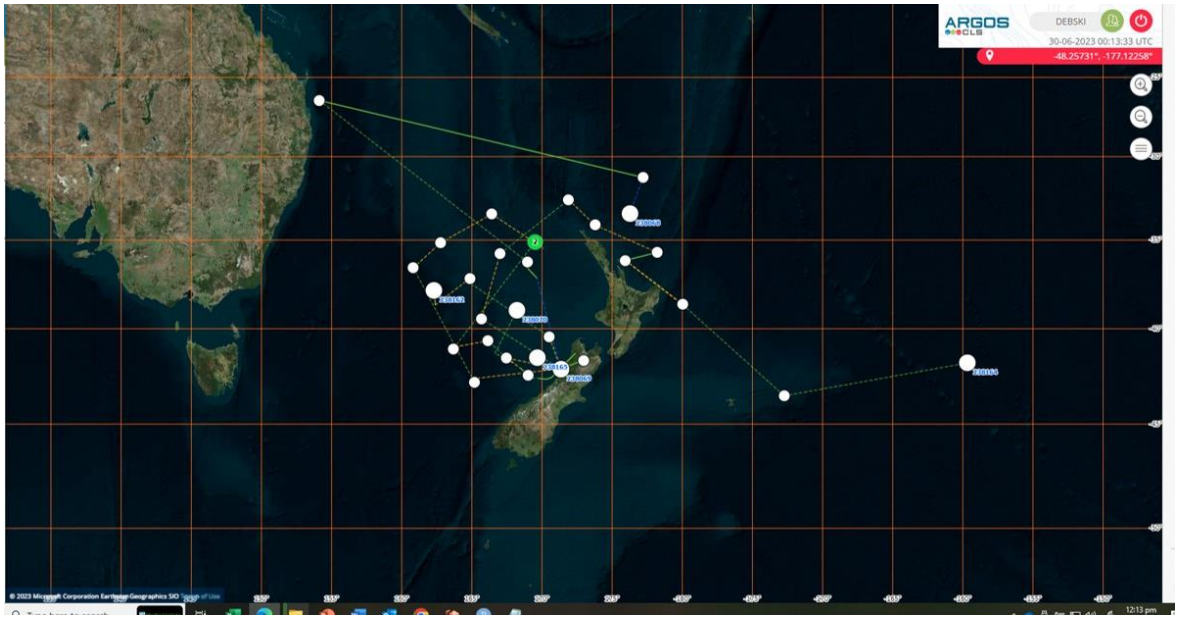

Fig. 11. Apparent tracks of Westland petrel fledglings (note position off Queensland will be a low-quality fix and should be ignored).

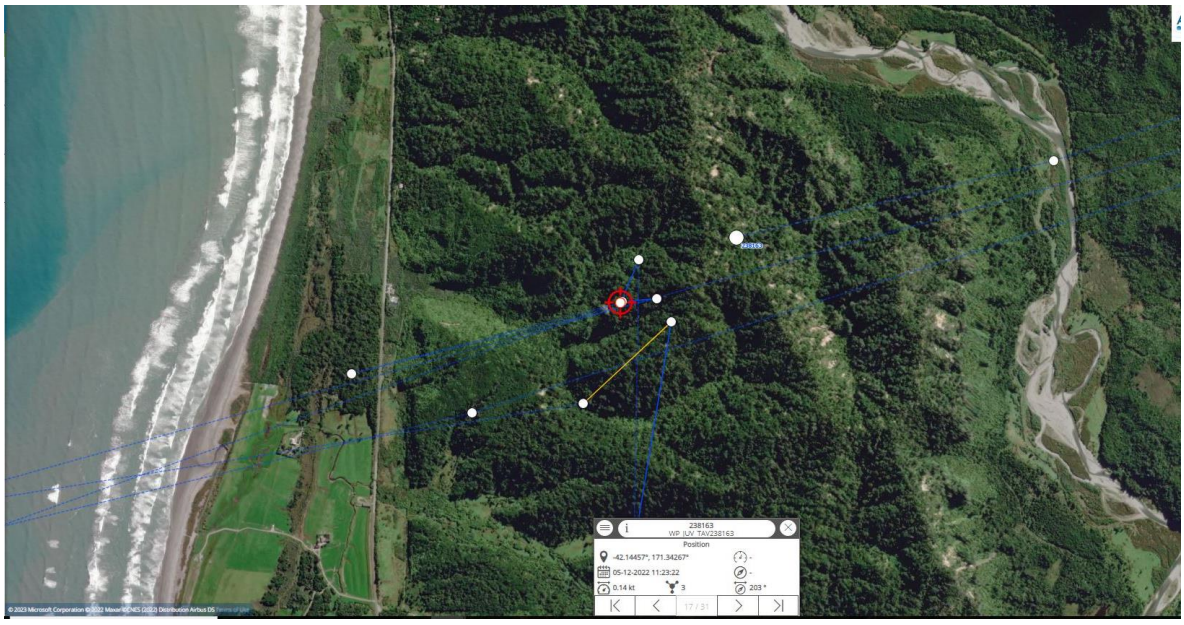

Fig. 12. Location fixes from a tag dropped before the bird departed to sea. The Grade 3 marked location is probably very close to where the tag came off.

The positions we did obtain provided some new insights on the movements of Westland petrel juveniles at-sea. All the birds departed out into the Tasman Sea and those that kept transmitting went well out to sea beyond the EEZ and into the deeper waters of the Tasman Sea. They then began to head north and north-east. None flew south towards Foveaux Strait or the higher wind areas below New Zealand. Nor did any attempt to go through Cook Strait like their parents. Instead, they tracked up past the Three Kings Islands at the top of the North Island and then headed south-

east out from the North Island east coast. The bird that made the longest movement before the tag failed or was lost reached 160W in the South Pacific Ocean and past the Louisville Ridge. It appeared to be on its way to South America. The reason why all the tags failed early is uncertain. The same types of tags have lasted for several months or over a year on other seabirds. We think it is likely the birds damaged the tag (pulled out the antenna or ripped the tag off the tail feathers). Testing of tag attachments on adults will hopefully provide better insight as to what might have happened and provide a more suitable method to use next season.

Testing of tag attachment methods June 2023

After the problems experienced with satellite tag retention on the fledgling Westland petrels, we applied to the DOC AEC to test a range of different tag attachment methods. The following table summarises the trial deployments of dummy tracking tags on Westland petrel adults.

Attachment type	Status	Proposed sample size	Actual sample size	Comments
Wing harness	Incubating	10	6	3 with bungee cord and 3 with silicone sleeve passed through teflon ribbon.
Leg loop harness	Incubating	10	0	Leg loop harness did not work on these birds as they have smooth legs situated backward. The harness slid down the back as soon as the harness was deployed
Back feather mount	Incubating	10	5	
Tail feather mount	Incubating	10	5	

It became clear in the trial that leg loop harnesses as used on seabirds such as gulls and skuas and a wide range of wading bird species and raptors would not work on this species. The main problem was the birds have short legs with very little knee bump to stop the tag slipping. The remaining test tags are currently still out on birds and results will not be known until end of July 2023.

Acknowledgements

Thanks to Matt Charteris for assistance with attaching and retrieving tags from Westland petrels and with the trail camera deployments. The project was jointly funded from levies from the New Zealand Fishing Industry under the Conservation Services Programme and from crown funding to Department of Conservation.

References

Frankish, C.K., *et al.* 2021. Movements and diving behaviour of white-chinned petrels: Diurnal variation and implications for bycatch mitigation. Aquatic Conservation: Marine and Freshwater Ecosystems 31: 1715-1729.

Landers, T., M. Rayner, R. Phillips, and M. Hauber 2011. Dynamics of seasonal movements by a trans-Pacific migrant, the Westland Petrel. The Condor 113:71–79.

Norris-Caneda, K.H. & Elliott, J.D. 1998. Sex identification in raptors using PCR. Journal of Raptor Research 32: 278−280.

Parker, G.C. and Rexer-Huber, K. 2015. Literature review of methods for estimating population size of burrowing petrels based on extrapolations from surveys. Report prepared by Parker Conservation for the New Zealand Department of Conservation, Wellington. 29p.

Shaffer, S.A., *et al.* 2006. Migratory shearwaters integrate oceanic resources across the Pacific Ocean in an endless summer. PNAS 103: 12799-12802.

Waugh, S.M *et al.* 2003. Burrow occupancy in Westland petrels (Procr:llaria westlandica). Notornis 50(3): 123-127.

Waugh, S.M*. et al.* 2006. Demography of Westland Petrels (*Procellaria westlandica*), 1995–2003, Emu - Austral Ornithology, 106:3, 219-226, DOI: 10.1071/MU05065

Waugh *et al.* 2015. Modeling the demography and population dynamics of a subtropical seabird, and the influence of environmental factors. The Condor, 117(2): 147-164.