

RADIO- AND SATELLITE-TRACKING WESTLAND PETRELS

PROCELLARIA WESTLANDICA

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SUMMARY

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Two foraging trips of one female and one male Westland Petrel *Procellaria westlandica* partially tracked by radio telemetry, and six foraging trips by three male Westland Petrels tracked by satellite telemetry are reported. We report on the development of Platform Transmitting Terminals (PTTs) suitable for use on burrowing seabirds and on the successful deployment of the modified PTTs. The birds tracked by VHF radio telemetry were recorded around the 200-m depth contour on a few days during their foraging trip but were beyond reception range most of the time. The birds tracked by satellite mostly foraged on the continental slope off the West Coast of the South Island of New Zealand except in one instance where a bird flew through Cook Strait and spent time on the Chatham Rise east of the South Island. The difficulties associated with interpreting satellite tracks for birds that travel relatively short distances at sea are discussed.

INTRODUCTION

It has been suggested (Bartle 1985, 1987) that the recent increase in the Westland Petrel *Procellaria westlandica* population (J.A. Bartle in Marchant & Higgins 1990) is due to an increase in the food supply from offal and other waste discharged from fishing vessels, particularly in the Hoki *Macruronus novae-zelandiae* fishery which operates close to the Westland Petrel's only breeding grounds near Punakaiki, West Coast, New Zealand. As little was known about the diet and foraging patterns of Westland Petrels, we used radio- and satellite-tracking to investigate the time birds spent attending fishing fleets compared to time spent foraging naturally in other areas.

Initially we attempted to determine foraging locations using VHF radio-tracking but a trial study in 1993 showed that Westland Petrels forage beyond the range detectable with VHF technology. In 1995 two PTTs were used (provided by DGN) which were adapted for use with Westland Petrels. Whereas the results of this research will be reported in a subsequent paper, this paper presents details of the VHF transmitter and PTT packaging, testing procedures and deployments, initial assessment of the effects transmitters have on Westland Petrels and descriptions of the tracked flights.

METHODS

Radio-tracking

In 1993 Lincoln University established VHF radio receiver stations on Paparoa Peak (831 m) near Greymouth, and Mt Rochfort (1038 m) near Westport, to investigate movements of New Zealand Fur Seals *Arctocephalus forsteri* (Sinclair 1994).

Theoretically, the maximum distances over which VHF signals could be received by the two stations were 125 km at Mt Rochfort and 112 km at Paparoa Peak (Sinclair 1994). This presented an opportunity to attempt the radio-tracking of Westland Petrels, since their breeding colony is situated midway between the two stations and seal-tracking coincided with part of the Westland Petrel's incubation and chick-rearing period. It was thought that breeding Westland Petrels might forage within radio reception range.

On 8–9 July 1993, ANDF and JAB with assistance from Department of Conservation staff attached radio-transmitters to one female and three male Westland Petrels at their breeding colony. All birds were incubating eggs at the time of deployment. The transmitters were attached to the birds' backs with harnesses which had a weak link which would break if the bird became entangled (Karl & Clout 1987). The dimensions of the VHF transmitters were 60 × 38 × 10 mm. The transmitters weighed 35 g plus harness (total mass c. 37 g), and pulsed at 80 pulses per minute with a 30-ms pulse width. Because the birds weighed between 1170 and 1380 g at the time of deployment, the transmitters were 2.7–3.2% of the birds' masses.

The transmitters were powered by three LTC7PN cells and could have run for 31 days on continuous transmission. However, the birds were only monitored for 10 days (8–18 July) because the seal-tracking programme ended. The birds could not be tracked continuously and were generally monitored at two to four-hour intervals through the night and less often during the day. Transmitters could be detected while birds were in their burrows using a portable four-element Yagi antenna and receiver up to 500 m away. This was used to confirm that birds had left or returned to the colony.

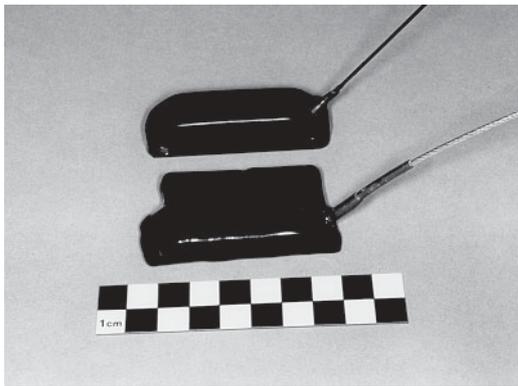


Fig. 1. Standard-shape Microwave Telemetry Nano PTT (above) and low-profile Microwave Telemetry Nano PTT (below).

The bearings of signals received at the radio-tracking stations were plotted so that triangulated positions could be determined. At both stations mountain ranges limited the area over which signals could be received. The potential area of triangulation is shown in Figure 2.

Satellite-tracking

Since radio telemetry was found to be unsatisfactory for tracking Westland Petrels, satellite telemetry was subsequently used. At 28–30 g the Microwave Telemetry Nano PTT was light enough to be carried by Westland Petrels, but its standard shape (65 × 16 × 16 mm) was considered unsuitable for this species due to the height of the package (see Fig. 1).

Westland Petrels use burrows up to 2 m in length with entrances often only 15–20 cm high into which birds must squeeze. We thought it necessary to use a PTT that would not hinder birds' access to their burrows, nor be susceptible to being scraped against the tunnel roof, or entangled in exposed roots in the burrow. Similarly, the PTT attachment needed to be designed so that birds could not become entangled in trees as they crash-landed through the rain-forest canopy and tangled undergrowth on their return to the colony. Consequently, we designed a package which reduced the height of the PTT by placing the battery units alongside the transmitter instead of underneath it (maximum dimensions 65 × 36 × 10 mm, Fig. 1). A model of the new design was measured against Westland Petrel study skins in Canterbury Museum to ensure that the width was not excessive. This new design had essentially the same dimensions as the VHF transmitters deployed successfully in 1993.

In June 1995 the two designs (the standard Microwave Telemetry shaped package and the new low profile package) were tested by ANDF using models on birds during the incubation period. Accurately sized models of correct mass were constructed from balsa wood, lead shot and resin. The models were attached to incubating birds; five low-profile models on 17 June 1995, and five standard-shaped models on 20 June 1995. The models were taped to contour feathers of the back by three strips of Scotch brand 471 plastic tape (12-mm width). This tape was not sufficiently sticky and probably contributed to the loss of three of the models at sea. Four of the models were removed before the birds went to sea; either due to time constraints, or because the attachment was no longer secure.

The Westland Petrel's close relative, the White-chinned Petrel *P. aequinoctialis*, has been found to dive to depths of 13 m (Huin 1994). We anticipated that Westland Petrels would dive to similar depths. Depth gauges were attached to the top of the models to test this. The gauges were lengths of clear plastic tubing with a dusting of icing sugar inside that recorded the maximum depth attained during deployment (Burger & Wilson 1988, Huin 1994).

The results of the PTT model and maximum depth gauge deployments are shown in Table 1. The standard-shaped models proved unsuitable. Because of the height of the models, shortness of the bird's contour feathers, and rubbing against the roof of the burrow, these models soon became loose and pulled out feathers. Three were removed before the birds went to sea, and two birds returned from sea without the model PTTs. The new design was more successful, with only one model lost while the bird was at sea, probably due to failure of the tape. The maximum depth recorded by the three recovered gauges was 7.6 m. However, errors can occur with multiple immersions (as would be the case during foraging trips) and recovered tubes showed signs of moisture accumulation, another source of error (Burger & Wilson 1988). Therefore, these results should be treated as indicative only.

The body masses of the birds returning with model transmitters were close to their masses

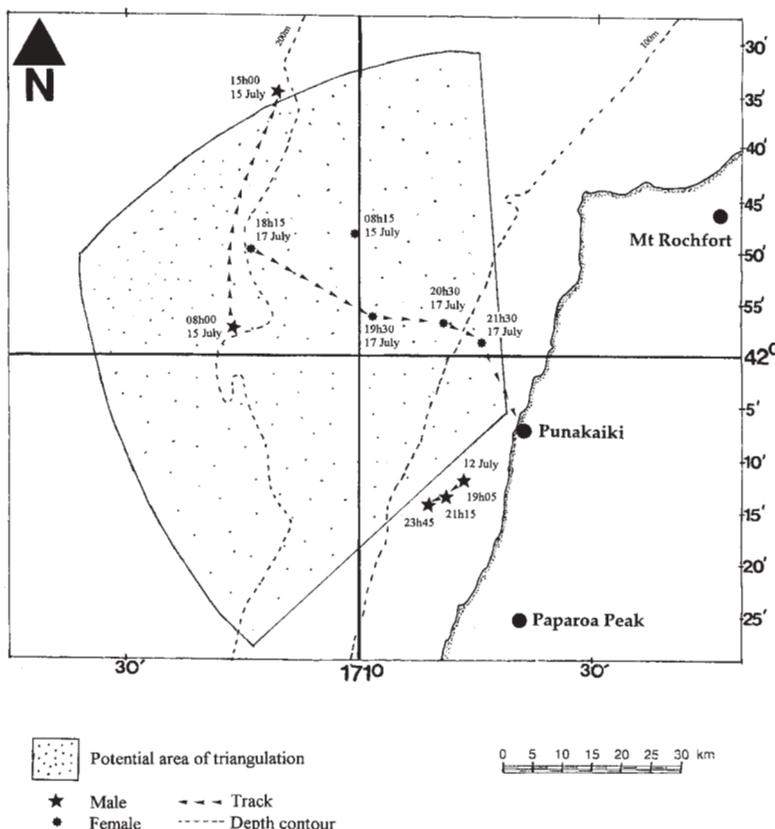


Fig. 2. Locations of one male and one female Westland Petrel radio-tracked in July 1993.

TABLE 1
Deployment and recovery of model PTTs on Westland Petrels

Model type	Bird band no.	Sex	Fate of model PTT	Trip length (d)	Mass (A) (g)	Mass (R) (g)	Max. depth (m)
Standard	L22276	F	L	5	1250		
	L16708	F	L	9–12	1150		
	L22160	F	R	1100			
	L14115	M	R	1270			
	L31715	M	R	1400			
Modified	L18650	M	S	2	1250	1300	0.7
	L14010	M	S	5	1400	1400	1.4
	L15770	M	S	11	1350	1300	7.6
	L13807	M	L	11+	1300		
	L14293	M	R		1450		

L = lost during trip; R = removed before departure; S = secure on return.

Mass (A) = mass at attachment; Mass (R) = mass on return.

when the models were attached (see Table 1). Because birds did not depart immediately, they would have weighed less than shown when they left the colony. A return to their mass at the time of model attachment therefore indicates that they were able to feed successfully.

The foraging trip lengths recorded for the birds returning with model transmitters ranged from two to 11 days. The birds that lost their model transmitters at sea are not included because it is not known when the loss occurred. Six foraging trips of birds without model transmitters, recorded during the same time period, ranged from two to more than 11 days suggesting that the model transmitters did not lengthen trip duration. Of the 10 burrows in which an adult had a model transmitter fitted, nine hatched chicks (compared with overall hatching success in 1995 of 47%) so the models are not thought to have affected hatching success.

Three male Westland Petrels with chicks were tracked by satellite between 11 August and 19 September 1995. Dates and times of attachment and recovery are given in Table 2. Two Microwave Telemetry Nano PTTs were packaged by Sirtrack Ltd to our low-profile design described above (see Fig. 1). The

final masses of the packages were 36.7 g and 37.9 g (2.7 and 3.7% of the birds' masses, respectively). The PTTs were encased in black epoxy polymer, the antennae reinforced with polyurethane sealant and the completed units pressure-tested to 10 metres depth. The time interval between transmissions was 70 seconds, a compromise between location accuracy and battery life. One PTT pulsed continuously for the 14 days it was deployed and the other PTT pulsed continuously for 14 days and was then programmed to a reduced duty cycle of eight hours on, 17 hours off until its batteries ran out soon after recovery – a total of 41 days.

Strips of 10-mm wide "Tesa" tape as recommended by Wilson & Wilson (1989) were used for attaching the PTTs to the bird's back feathers between the wings. Two birds had no significant feather loss or damage resulting from the PTT attachment or recovery. The third had a small area of bare skin, about 1 cm² underneath the PTT when it was removed after 33 days. All PTTs were still firmly attached when recovered.

Locations were obtained from the ARGOS system which records location with seven classes of accuracy: Classes 1–3, less than 1 km error; Class 0, above 1 km error; and Classes

TABLE 2
Deployment and recovery details of PTTs on Westland Petrels

Bird ID/ flight	Bird band no.	PTT attachment/recovery	Flight start/finish	Trip length (d)
Male1/1	L13807	11 Aug 1995 16h15/	12 Aug 1995 predawn/ 16 Aug 1995 18h45	5
Male1/2		24 Aug 1995 18h50	17 Aug 1995 predawn/ 24 Aug 1995 18h50	8
Male2	L18650	11 Aug 1995 16h55/ 16 Aug 1995 03h00	12 Aug 1995 predawn/ 16 Aug 1995 03h00	4
Male3/1	L22370	17 Aug 1995 17h05	18 Aug 1995 predawn/ 31 Aug 1995	14
Male3/2			1 Sep 1995/ 13 Sep 1995	13
Male3/3		19 Sep 1995 19h45	15 Sep 1995/ 19 Sep 1995 19h45	5

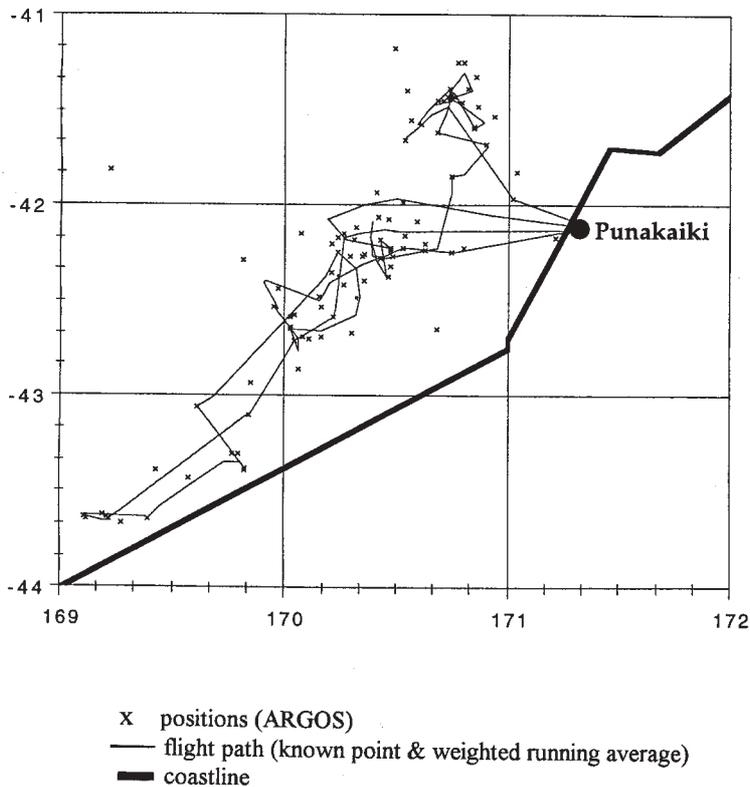


Fig. 3. Male 1 (L13807). Satellite tracks 12–16 August 1995.

A, B and Z, accuracy not determined by ARGOS. The errors inherent in satellite location data for species tracked over relatively short distances presented us with problems of how to process and display these data objectively. After considering several choices, all classes of positions were plotted and a smoothing algorithm fitted. The smoothing algorithm plotted satellite fixes of known accuracy and substituted a weighted running average for the remaining points. The weightings used were 0.2 for classes Z, A and B; 1 for class 0 and 10 for classes 1, 2 and 3. The smoothing algorithm for time t took into account what was known about the accuracy of the previous position (time $t-1$) and next position (time $t+1$) in an attempt to plot objectively points of unknown accuracy. The equation applied to these points was:

$$\frac{\text{position}_{t-1} \times w_{t-1} + 2 \text{position}_t \times w_t + \text{position}_{t+1} \times w_{t+1}}{w_{t-1} + 2w_t + w_{t+1}}$$

where w_{t-1} , w_t and w_{t+1} are the weightings at times $t-1$, t and $t+1$, respectively. The effect of the smoothing algorithm can be seen by comparing the points received from ARGOS with the flight paths derived from the algorithm (Figs 3–5).

A hand-held radio receiver (model AOR 1500) was used in the later stages of tracking to detect when the last bird tracked was close to, or had returned to, the colony. Signals were received from the PTT the night before the bird returned to shore. However, because the PTT was on a reduced duty cycle and was not transmitting when the bird returned, it is not known whether or not the receiver would have detected the bird's return. After the PTT was recovered and was next transmitting it was placed in several different burrows to test whether the receiver could detect PTTs on birds in burrows from the campsite (up to 200 m away). In all cases clear signals were received.

RESULTS

Radio-tracking

Female (Band Nos L30187/30188)

This bird left the colony before dawn on 13 July but no signal was received from it until 08h15 on 15 July when it was 45 km north-west of the colony. By the time of the next tracking session at 15h00, the bird had again flown outside of radio reception range and was not located again until the evening of 17 July. During the evening of 17 July the bird was tracked from a position *c.* 57 km north-west of the colony to a position 24 km north-west of the colony, presumably returning to its burrow. Figure 2 shows the positions recorded for this bird.

Male 1 (Band Nos L 30189/30190)

This bird left the colony before dawn on 12 July and clear signals were received at the Paparoa Peak station that evening. The strong signal at Paparoa Peak and the lack of signal at Mt Rochfort indicate that the bird was close inshore but outside the triangulation area. By 05h45 on 13 July, the bird had flown beyond radio reception range. No signal was received at 22h00 on 14 July but at 08h00 on 15 July, the bird was 52 km north-west of the colony. At 15h00 the bird had flown farther north and the weak and intermittent signal indicated that it was on the edge of reception range about 100 km offshore. No further signals were received from this bird, which returned to the colony after 18 July. Figure 2 shows the positions recorded for this bird.

Male 2 (Band Nos L30183/30184)

This bird left the colony on 13 July and returned on 15 July without being detected by the radio receivers.

Male 3 (Band Nos L23066/30161)

This bird left the colony on 10 July and returned some time after 18 July when tracking had finished. It was not detected by the radio receivers.

When removing the transmitters from the birds we were concerned because the harnesses had tightened as the birds had increased in mass and girth during their foraging trips. As a result, we decided not to use harnesses in further studies of this species.

Satellite-tracking

Male 1 (Band No. L13807)

This experienced breeding male, first banded in 1970, left the colony on his first tracked foraging trip before dawn on 12 August 1995 and returned to the colony on the evening of 16 August 1995. During that time, his locations were concentrated in two areas 90 km north-west and 80 km west of the colony; at 41°30' S, 170°40' E and 42°10' S, 170°20' E on the continental slope. This bird was tracked for a second flight on which he departed before dawn on 17 August 1995 and returned on the evening of 24 August 1995. On this second trip, he travelled south-west and locations were concentrated 150 km

south-west of the colony at 42°30'S, 170°10'E and as far as 300 km south-west at 43°40' S, 169°10' E, also on the continental slope (Fig. 3).

Male 2 (Band No. L18650)

This 17-year old male, that had been recorded breeding only once since 1991, left the colony before dawn on 12 August 1995 and returned at 03h00 on 16 August. During his foraging trip, locations were concentrated at 42°20'S, 170°20'E but also covered areas south-west and west of the colony between approximately 41°40'S and 43°S and 169°20'E and 171°E. Most positions were on the continental slope (Fig. 4).

Male 3 (Band No. L22370)

This male of unknown age left the colony before dawn on 18 August 1995 and was not recaptured until 19 September 1995. However, his burrow was not monitored constantly over that period and there are two occasions when the satellite data suggests he returned to his burrow; 31 August 1995 and 13–15 September 1995. The period 18 August – 19 September is therefore assumed to cover three foraging trips; 18–31 August, 1–13 September and 15–19 September (Fig. 5).

This bird spent the first two days of his first foraging trip north-west of the colony. Locations received were concentrated in the area 41° 30 S, 170° 30 E. He then flew rapidly through Cook Strait on 20 August and spent until 25 August in Cook Strait and on the eastern edge of the Chatham Rise. His homeward flight took him back through Cook Strait on 26 August and by 27 August he was close in-shore in the Karamea Bight. He then returned to the area in which he had spent the first two days of his trip and from there he is presumed to have returned to the colony for no more than two hours on 31 August. Two hours was the maximum time between checks of this bird's burrow on that night.

On his second foraging trip this bird flew in large circles west of the colony on the continental slope. He is presumed to have spent the nights of 13 and 14 September ashore, departing again on 15 September. He visited the same area of the continental slope during his third foraging trip and returned to the colony on the evening of 19 September.

All three birds increased in mass between PTT attachment and recovery, indicating that they fed successfully during their foraging trips. Their foraging trips ranged

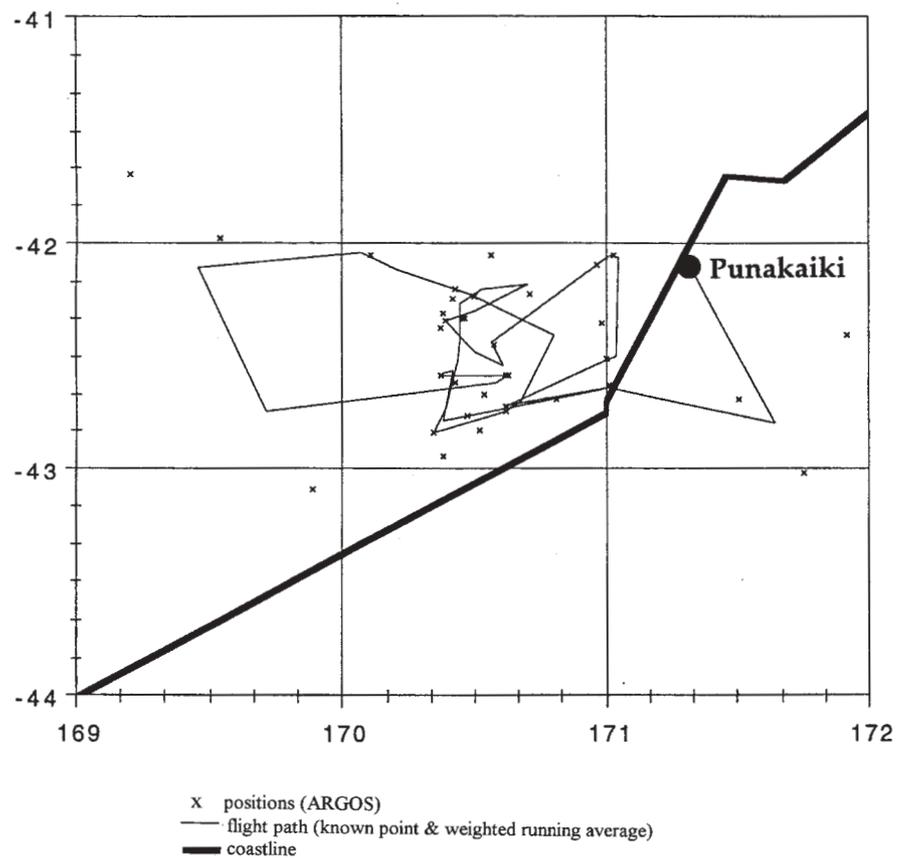


Fig. 4. Male 2 (L18650). Satellite track 12–16 August 1995.

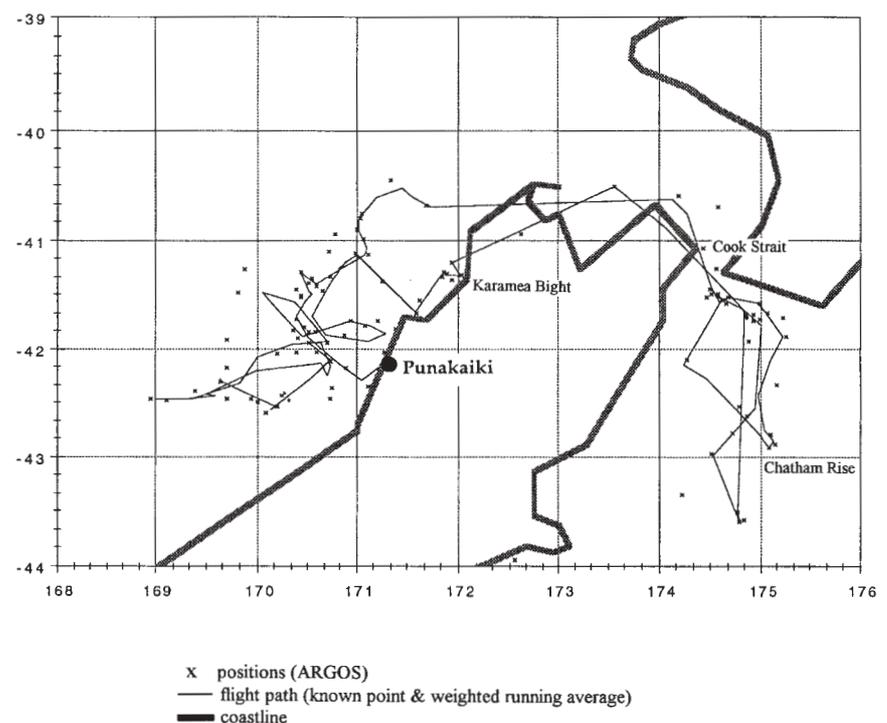


Fig. 5. Male 3 (L22370). Satellite track 18 August–19 September 1995.

in length from five to 14 days (Table 2) and were comparable with the highly variable trip lengths recorded for untracked birds in other burrows. Fourteen foraging trips by other male and female Westland Petrels monitored during September 1995 ranged in length from one day to at least nine days (two birds had been absent for nine days when monitoring stopped). All three satellite-tracked birds had chicks approaching fledging when their burrows were inspected on 15 November 1995.

DISCUSSION

Both of the birds tracked by VHF radio telemetry were recorded around the 200-m depth contour on a few days during their foraging trips but were beyond reception range most of the time. The birds were always out of range at night except when leaving or returning to the colony. From what is known of Westland Petrel distribution at sea, and has now been shown by satellite-tracking, we suggest that birds were probably feeding on the continental slope, outside of radio reception range, during the times that signals were not received.

Although the theoretical range of the radio-tracking equipment was about 100 km, it is possible that factors such as weather conditions and interference reduced signal quality and the distance over which signals could be received (Sinclair 1994). At short distances, however, signals were strong (A.B. Freeman pers. comm.), and because all transmitters were still functioning when recovered, we are confident that signals could be received whenever the birds were within range. The distances over which Westland Petrels forage during incubation made VHF radio telemetry unsatisfactory for tracking them. Interestingly, Scofield (1989) found that radio-tracking the Black Petrel *Procellaria parkinsoni* produced more useful results because most foraging trips were entirely within the radio horizon.

The satellite-tracked flights reported here are the first recorded for a procellariiform seabird smaller than an albatross or mollymawk. The results confirm the impression, gained during radio-tracking, of the importance of the continental slope to breeding Westland Petrels. They also show that a breeding bird can complete a long-distance flight ranging as much as 800 km from the colony.

Experiments with model PTTs showed that a flat PTT package is necessary for burrowing birds to prevent damage from the burrow roof and to provide an adequate attachment for birds with short contour feathers. Attaching the PTTs with tape provided a secure attachment that was quick and easy to apply and remove. Tape is considered preferable to the harnesses which became tight at the end of foraging trips and had the risk of snagging in vegetation.

The majority of positions received from ARGOS for birds in this study were of unknown accuracy. Over the relatively short distances breeding Westland Petrels fly, location errors are likely to be significant and will limit our ability to relate locations to fishing activity. These inaccuracies also mean that estimates of distance and direction between successive points are dubious; and the number of known-accuracy points were too few to calculate flight speed. Applying an algorithm that uses what is known about the accuracy of previous and next positions to plot points of unknown accuracy provides an objective way to smooth and interpret the flight paths.

Delays of several hours often occur between satellite fixes and the data becoming available. For our Westland Petrel tracking this meant that we had to maintain a watch over the birds' burrows each night in order to be sure of recapturing birds as the satellite data was not current enough to give early warning of a bird's return. Maintaining a constant watch was not feasible due to weather conditions and time constraints and so we appear to have missed two of Male 3's returns to the colony. Use of a hand-held receiver on the colony can alleviate this problem by making detection possible from a campsite.

Neither current VHF nor satellite telemetry can map in detail the foraging of the Westland Petrel. However, our study has shown that satellite-tracking provides useful data on general foraging areas and patterns of this species which were not achievable using VHF radio-tracking.

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