SATELLITE TRACKING OF WANDERING ALBATROSS (*Diomedea exulans*) FROM THE AUCKLAND ISLANDS: PRELIMINARY RESULTS

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ABSTRACT

Foraging flights of three female Auckland Island Wandering Albatross (*Diomedea exulans gibsoni*) were tracked from Adams Island in the Aucklands group by satellite radio telemetry. Two of the birds were incubating eggs, while the third was in the early stages of chick raising. All three birds made long flights of 11-13 days and 1000 - 1500 km into the Tasman Sea. The chick-rearing female also made shorter flights of less than 4 days and 900 km. The distances covered were similar to those recorded for other Wandering Albatross subspecies, but foraging strategies differed. Auckland Island birds initially flew fairly directly and at high speed, then seemed to slow down and change direction more frequently for a few days, before flying directly back to the Auckland Islands. Two explanations are suggested: birds may have been "commuting" to favoured foraging areas, or were blown by the winds. Speeds reached during the "commuting" phase were similar to those recorded for *D. e. chionoptera*, but were slower at other times. The Tasman Sea between latitudes 45° S and 40° S is an important foraging area for some female Wandering Albatross breeding on Adams Island.

KEYWORDS: Wandering Albatross, *Diomedea exulans*, satellite tracking, foraging, flight

INTRODUCTION

Long-term studies of the Snowy Wandering Albatross *Diomedea exulans chionoptera* from the Crozet Islands, South Georgia and Macquarie Island have revealed dramatic population declines over the last 20 years, associated principally with an increase in adult mortality (Weimerskirch & Jouventin 1987; Croxall *et al.* 1990; de la Mare & Kerry 1994). Wandering Albatrosses, particularly females, have been a significant bycatch in the tuna long-line fisheries in the southern oceans since the 1960's (Brothers 1991; Murray *et al.* 1993), and this appears to be the main cause of the decline (Gales 1993).

Although the Auckland Island Wandering Albatross (*D. e. gibsoni*) comprises about 25% of the total world population of the species (Gales 1993, Jacinda Amey pers. comm.), little is known of its status, breeding biology or foraging behaviour. Population monitoring of the main breeding colony on Adams Island in the Auckland group began in 1991 (Walker *et al.* 1991).

Recent satellite tracking studies on the Crozet Islands and at South Georgia have accumulated considerable information on the foraging behaviour of breeding birds (Prince *et al.* 1992; Weimerskirch *et al.* 1993); information which is essential if the overlap between albatrosses and longline fishing fleets is to be understood.

In January 1994 our combined Australian-New Zealand team undertook a pilot satellite tracking study at the Auckland Islands. The aims of this study were:

1. to determine the foraging range of breeding females, and this is the aspect reported on here.
2. to test the functioning of sensors designed to examine the oceanic behaviour of albatrosses, and these findings will be described in a later paper.

The Australian group supplied two transmitters and satellite tracking time, while the New Zealanders provided transport to and from the islands and attached the transmitters.

METHODS

Radio transmitters were attached to three female Wandering Albatross breeding on Adams Island (50°52′ S, 166°00′ E) in the Auckland Islands (Figure 1) and their subsequent movements were tracked by satellite. Two Microwave Telemetry transmitters weighing about 100g ($<$2% of the birds weight) were used. The transmitters were glued to the back feathers of the bird with quick-setting epoxy resin (Nicholls 1994) and programmed to transmit every 60 seconds. On the first two birds the transmitters were on continuously whereas on the third, the transmitter was switched to a duty cycle of five hours on and four hours off to extend battery life. Data on the position of tracked birds was obtained from ARGOS satellites, which record location with 4 classes of accuracy: Classes 1 - 3: standard deviation $<$ 1 km; Class 0: $>$ 1 km. We used all classes of location in our analysis, unless the location given was not sensible (i.e. indicated excessive flight speeds; Prince *et al.* 1992).

In late January transmitters were attached to two females (band number R43067, named "Rata" and R42890, named "Hinemoa") in the early stages of their 80 day incubation period. The females, of unknown breeding history, were nesting in a colony of banded study birds on the southern slopes of Adams Island. One transmitter was retrieved when the bird returned to its nest after an 11 day foraging flight. The other was monitored on two consecutive flights, one of 13 days, and for 12 days of the second flight when the batteries were exhausted. This transmitter was not recovered.

On 18 April, the retrieved transmitter was attached to a third female (R42932, named "Gale"), brooding a chick (c.24 days-old) on the northern slopes of Adams Island. Once again the previous breeding history of the bird was unknown. Three days after the transmitter was attached, the brooding stage finished and the bird left the island, subsequently returning

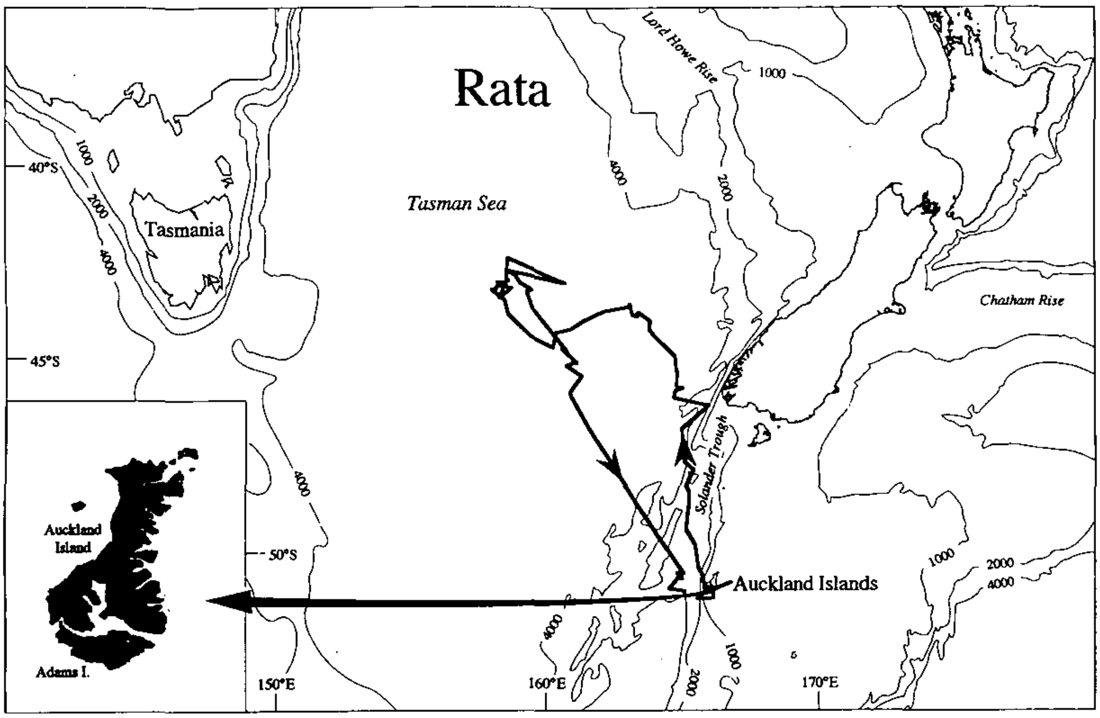

FIGURE 1 – Location diagram of the Auckland Islands with bathymetric contours (in metres) of the surrounding ocean, and flight path taken by female Wandering Albatross, "Rata", between 29 January and 9 February 1994.

briefly every 4-10 days to feed the chick. We monitored four consecutive foraging flights of this female before the transmitter ceased functioning. This transmitter was not recovered.

The series of locations we received from each bird enabled not only the plotting of foraging routes, but the calculation of apparent speed and distance of foraging flights. However, such calculated speeds and distances are affected by the interval between satellite locations. Frequent satellite locations closely map albatross trips, whereas infrequent locations fail to detect many small changes in direction and consequently underestimate distance and speed (see Figure 2). There was considerable variation in the number of locations we received per day for our birds, and in the average number of locations received per day in our and other studies (Prince *et al.* 1992; Nicholls *et al.* 1992; Jouventin & Weimerskirch 1990). To enable comparison both within our study and with other studies we have used the method described below to estimate the apparent flight distances and speeds we would have recorded had we received 17 locations per day. The only study with data suitable for comparison is that of Prince *et al.* (1992) who recorded a maximum of 17 locations per day.

To examine the distances covered by birds during daylight and darkness, we regarded daylight as begining when the rising sun was 9° below the horizon and ending when the setting sun was 9° below the horizon. This is the definition used by Prince *et al.* (1992) and is halfway between civil and nautical twilight. We calculated the sunrise and sunset on each day that each bird was away from Adams Island using the formulas of Walraven (1978) and categorised the movements made by birds between pairs of satellite locations as either daylight or darkness flights. For the purposes of this comparison we ignored bird movements that occurred during sunrise and sunset.

Correction for the number of satellite locations per day

The distances that albatrosses appear to fly when tracked by satellite vary with the frequency of satellite locations (Figure 2) and this confounds comparisons of light distances. Geographers have encountered similar problems when estimating coastline lengths from maps. Such lengths vary

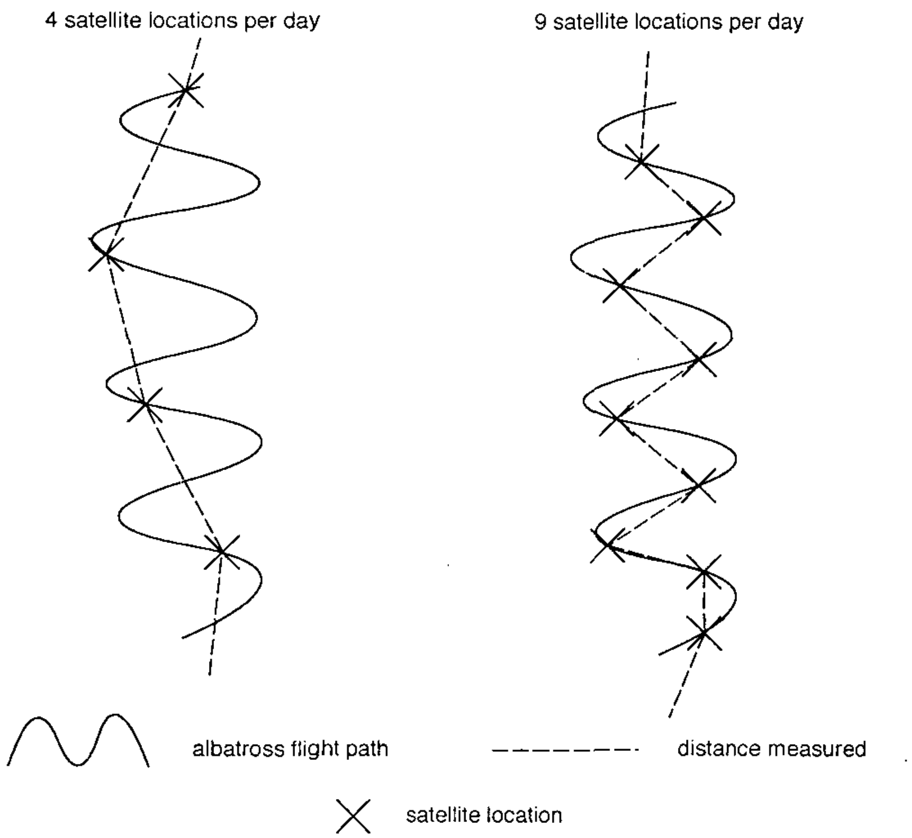

FIGURE 2 – Hypothetical relationship between albatross flight path, number of satellite locations and distance measured.

according to intercept length (the size of dividers used when measuring them). Galloway & Bahr (1979) found coastline length was related to intercept length by the following formula:

$$\textit{coastline length} = a \times \textit{intercept length}^{\,b}$$

where *a* and *b* are constants. It follows that albatross flight distances will be related to the time interval between locations in a similar way:

$$\textit{apparent flight distance} = a \times \textit{interval between satellite locations}^{\,b}$$

where a and b are constants related to the speed of the object, how often it changes direction, and the units of measurement. To use this formula to make "corrections" for the number of satellite locations received each day, we need to know the values of a and b. By deleting some of the satellite locations from our data, we could simulate longer intervals between locations and apparently shorter flights, and by repeatedly deleting more and more locations we simulated a range of longer intervals and even shorter flights. By fitting curves of the above equation to the range of distances and intervals we generated, we were able to estimate a and b for each bird and thus estimate the apparent distances we would have recorded had we received satellite locations more or less frequently.

RESULTS

Figures 1,3,4 and 5 and Tables 1 and 2 show the seven foraging trips which were tracked. Foraging flights appeared different during the two parts of the breeding cycle that we monitored. The three flights made by "Rata" and "Hinemoa" while incubating were all of long duration (> 10 days), covered large distances (>4000km) and headed north-west and then westwards into the Tasman Sea between 40° and 45° S. One of the four flights that "Gale" made after she finished brooding had a similar pattern, but the three other flights were much shorter (<4 days) and two of them went west or south-west of the Auckland Islands rather than north west. On all but one flight the birds took off to the north, followed an anticlockwise circuit, and all returned from the west (Figures 1, 3-5).

TABLE 1 – Dates, duration, number, and quality of satellite locations received from seven foraging trips made by three female Wandering Albatrosses breeding on Adams Island in 1994.

Bird's name	Trip	Start/end date	Duration (days)	Number of locations per day	% of locations in quality classes	
					0	1 - 3
"Rata"	1	29 Jan-9 Feb	11.0	9.63	65	35
"Hinemoa"	1	2-15 Feb	13.2	10.08	76	24
	2	1-13 March	12.0	8.51	74	26
"Gale"	1	21-24 Apr	3.9	7.11	79	21
	2	25-29 Apr	4.0	8.31	79	21
	3	30 Apr-2 May	2.1	7.26	71	29
	4*	2-10 May	>8	4.33	79	21

*Incomplete trip. The transmitter failed before the bird's return to Adams Island.

TABLE 2 – Flying speeds and distances covered on seven foraging trips made by three female Wandering Albatrosses breeding on Adams Island.

Bird's name	Trip	Distance travelled (km)	Max. distance from Adams I. (km)	Apparent flight speed (km/h)	
				Average	Corrected*
"Rata"	1	3959	1098	14.98	17.03
"Hinemoa"	1	5601	1508	17.69	20.28
	2	4053	1220	14.08	16.84
"Gale"	1	2040	879	21.59	23.45
	2	1403	349	14.71	17.15
	3	673	209	13.57	15.30
	4**	2941	1472	15.14	19.40

*Flight speed adjusted for 17 satellite locations per day (see Appendix I).
**Incomplete trip. The transmitter failed before the bird's return to Adams Island.

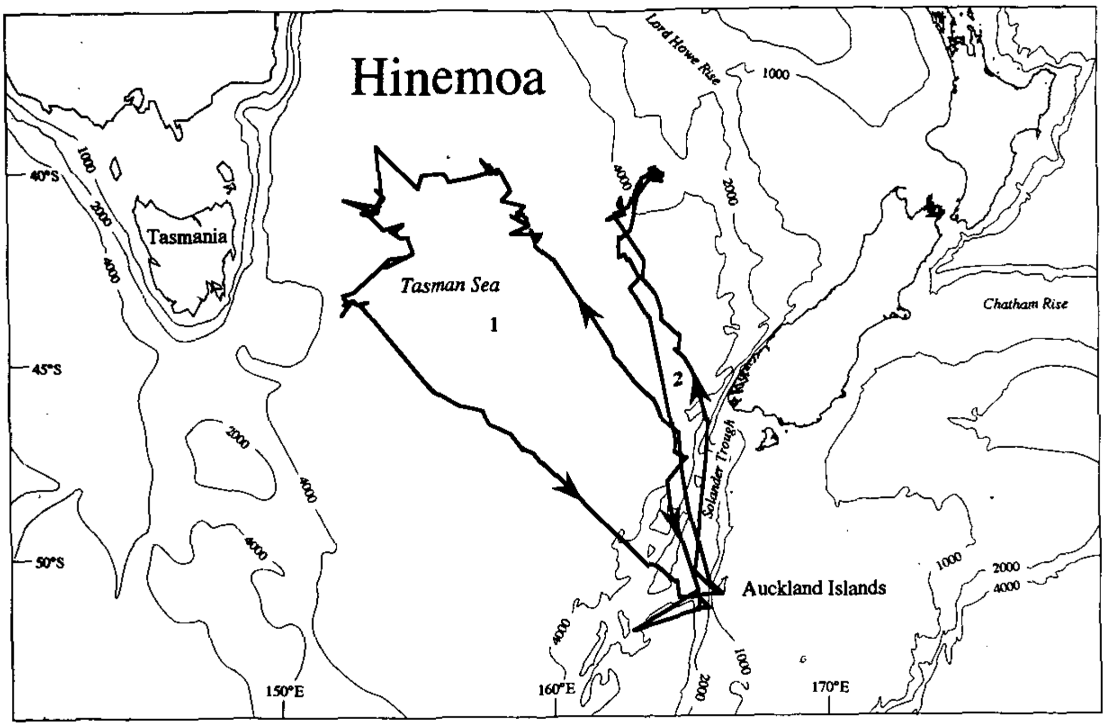

FIGURE 3 – Flight paths taken by female Wandering Albatross, "Hinemoa", between (1) 2-15 February 1994 and (2) 1-13 March 1994.

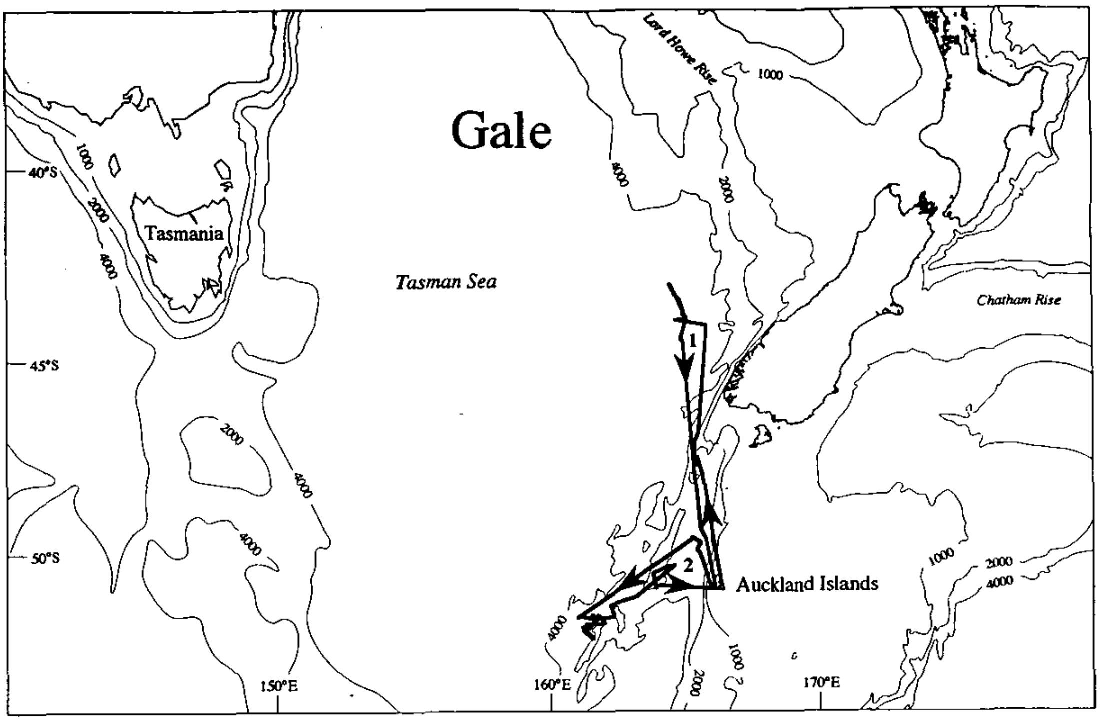

FIGURE 4 – Flight paths taken by female Wandering Albatross, "Gale", between (1) 21-25 April 1994 and (2) 25-29 April 1994.

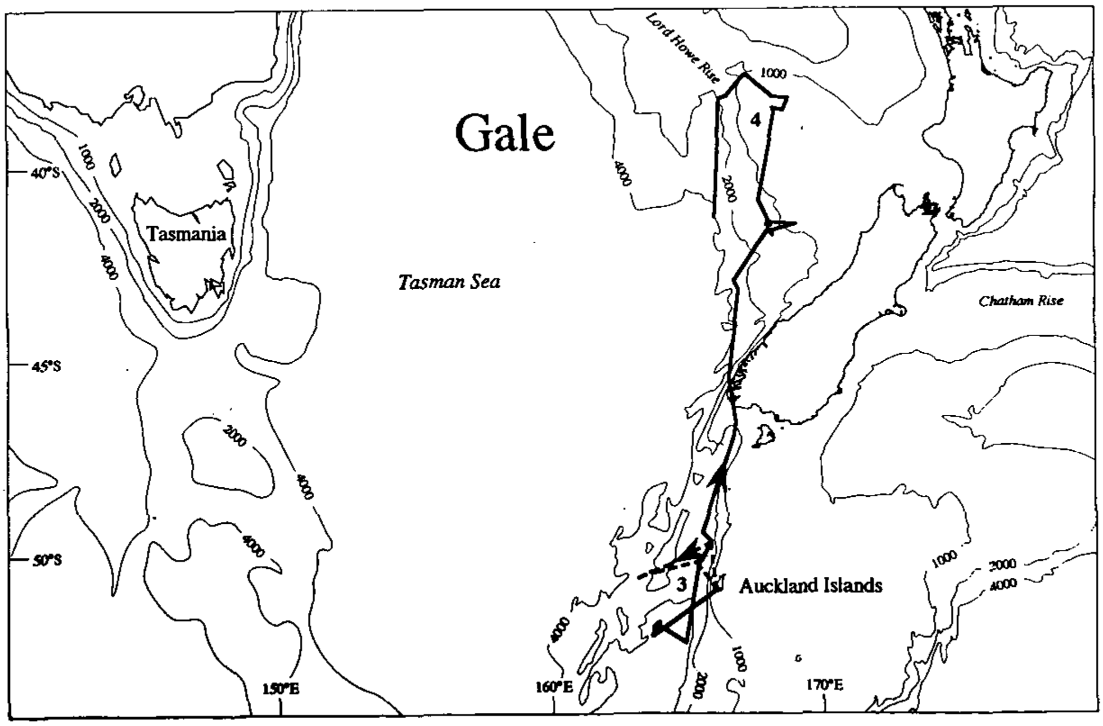

FIGURE 5 – Flight paths taken by female Wandering Albatross, "Gale", between (3) 30 April - 2 May 1994 and (4) 2-10 May 1994.

Close examination of the four long flights reveals a consistent pattern. The birds flew quickly north, then westwards in the first few days into latitudes of between 40° and 45° S in the Tasman Sea. For the next few days, they flew much more slowly, the flew quickly back to Adams Island (Table 3).

Apparent speeds of Wandering Albatross were much higher during the day than the night (Table 4).

TABLE 3 – Stages in four long flights by Wandering Albatross from Adams Island. The middle part of the flights began when birds suddenly slowed down, and ended when they speeded up again.

Bird's name	Trip	Beginning		Middle		End	
		Duration (days)	Speed (km/h)	Duration (days)	Speed (km/h)	Duration (days)	Speed (km/h)
"Rata"	1	3.85	17.80	3.32	5.09	3.84	20.72
"Hinemoa"	1	1.36	35.51	9.54	12.97	2.28	26.76
	2	1.81	27.96	7.23	5.68	2.96	26.12
"Gale"	1	1.55	26.26	1.46	9.55	0.92	32.81

TABLE 4 – Apparent flying speeds at day and night during seven Wandering Albatross flights from Adams Island. Distances flown between pairs of locations received at dawn and dusk are excluded.

Bird's name	Trip	Day speed (km/h)	Night speed (km/h)
"Rata"	1	19.10	5.7
"Hinemoa"	1	19.26	10.71
	2	20.62	7.65
"Gale"	1	48.24	10.71
	2	15.49	9.39
	3	19.78	8.80
	4	46.37	21.73

DISCUSSION

The distances flown and maximum ranges that we recorded for *D. e. gibsoni* are within the ranges reported in other studies (Prince *et al.* 1992; Weimerskirch *et al.* 1993). However, although the apparent speeds of our females during the "commuting" parts of their long trips are similar to those reported by Prince *et al.* (1992), their speeds during the middle part of the flights are much slower. Weimerskirch *et al.* (1993) thought that Wandering Albatross from Crozet Island mostly foraged continuously during their long flights, only occasionally stopping when becalmed or near a fishing boat. In contrast, Auckland Island birds commuted at speed to 40° to 45° S to the Tasman Sea, where they flew slowly for a few days, then flew quickly and directly back to the Auckland Islands. They were presumably flying to a favoured feeding area, though they could perhaps have slowed down because of a lack of wind. However, we tracked only three female birds which constitutes a small and possibly non-representative sample.

Wandering Albatross from both the Auckland Islands and Crozet Island appear to make long foraging trips during the incubating stage, and intersperse long trips with short ones during the chick rearing stage. Weimerskirch *et al.* (1994) argued that long trips give the best return of food for effort and are favoured when there are no other constraints. When rearing a chick, repeated long trips would not allow the chick to be fed frequently enough. At this stage adults make short trips to gather food for the chick, but lose weight in doing so. To make up this weight loss they occasionally make long trips in which they not only gather food for the chick but also increase their own weight.

Both populations are apparently more active during the day than the night as both had higher apparent flight speeds during the day. They may spend more time sitting on the water during the night.

The low number of satellite locations per day in our study largely results from the lower latitude of Adams Island (50° S) compared to Bird Island (54° S) where Prince *et al.* (1992) undertook their study: there are more satellite passes at higher latitudes (Anon. 1988). It also results from the duty cycle of one of our transmitters, and intermittent transmitting by "Gale"'s transmitter just before it failed. The low number of locations that we received from our birds compared with those received by Prince *et al.* (1992) has little effect on comparisons between our two studies. We calculated that apparent flight distances would have been 14% higher had we received the 17 locations a day sometimes achieved by Prince *et al.* (1992). This was of little consequence because of the great variation in flight distances and the small sample sizes in our study. However, our correction technique shows that the sampling regime potentially has a significant impact on apparent distance and speed, and future attempts to compare speed and distance will also need to apply a correction algorithm similar to ours.

The apparent speed calculated in this and other studies is not flying speed, but rather a combination of flying speed, proportion of time spent flying, and the directness of the path taken by the birds. The high apparent speed achieved by our birds during the "commuting" stages of their flights might result from either high flying speeds, little time spent resting on the water, a very direct route, or a combination of all three. A high apparent speed implies an albatross is heading somewhere without stopping or deviating and/or has a tail wind; a low apparent speed suggests many stops and deviations and/or a head wind. A better understanding of albatross behaviour on foraging trips may soon be provided by more sophisticated satellite transmitters that can measure and store instantaneous speed, time on the water and in the air.

All flights initially followed the deep trench on the edge of the Auckland Island shelf, but most areas covered beyond that were over very deep water. The only exception to this was the last flight monitored during which one albatross spent some time over the Lord Howe Rise. The Solander Trough and mid Tasman Sea seem to be important to female Wandering Albatross from Adams Island, at least in the early to middle stages of the breeding cycle (January-May). Much of this area is outside the Exclusive Economic Zones (EEZs) of either Australia or New Zealand and data on the location of tuna fishing boats outside EEZs is extremely difficult to obtain. However, the Solander Trough and seas off south west Fiordland and South Westland are areas which have been intensively fished for at least a decade (Murray *et al.* 1994). It seems likely that the further satellite tracking study planned for 1995 will confirm that these areas are also important foraging areas for Wandering Albatross breeding at the Auckland Islands.

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