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SATELLITE TRACKING OF SOUTHERN BULLER'S ALBATROSSES FROM THE SNARES, NEW ZEALAND[1]

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Pelagic seabirds spend most of their time foraging at sea far from their breeding grounds. Yet most information on their ecology comes from land-based studies, and the need for studies on their foraging ecology has been recognised as of prime importance to an understanding of their extreme life history traits (Ricklefs 1990). Recently, such studies have been made possible for large seabirds such as albatrosses with the development of satellite telemetry (Jouventin and Weimerskirch 1990). However, most studies have concentrated on the largest of the albatross species (e.g., Prince et al. 1992, Weimerskirch et al. 1993, Nicholls et al. 1994), with only one on a smaller species, the Light-mantled Sooty Albatross *Phoebetria palpebrata* (Weimerskirch and Robertson 1994). No studies have been published on mollymawks, the subfamily with the greatest number of species.

Buller's Albatrosses (*Diomedea bulleri*) are endemic to New Zealand, where the Southern subspecies (*D. b. bulleri*) breeds at The Snares and the Solander Islands, and the Northern subspecies (*D. b. platei*) at the Chatham and Three Kings Islands (Turbott 1990). Their distribution at sea is poorly known, although the pelagic range is across the Southern Pacific Ocean, north of the Antarctic Convergence from southeastern Australia to Chile and Peru (Marchant and Higgins 1990). Movements of adults are also poorly known, and Marchant and Higgins (1990) suggested that they may move only locally. An examination of 27 regurgitations from adults and chicks collected on The Snares and the Chatham Islands (West and Imber 1986) indicated that the diet comprised mainly species which occur within the New Zealand region. However, Richdale (1949) showed that incubation spans of birds on The Snares ranged up to 21 days, indicating that these birds could forage long distances form the breeding colonies.

Substantial mortality of Southern Buller's Albatrosses has been reported to occur as a result of commercial fisheries southwest of New Zealand (Bartle 1991, Murray et al. 1993), so knowledge of the foraging zones of the subspecies has important implications for conservation. We used satellite telemetry to determine the foraging movements during late incubation of Southern Buller's Albatrosses breeding at The Snares.

STUDY AREA AND METHODS

The Snares (48°02′S, 166°36′E) consist of North East Island (280 ha), Broughton Island (90 ha) and numerous islets and rock stacks. In 1992, an estimated 8,460 pairs of Southern Buller's Albatrosses bred on these islands (Sagar et al. 1994). Six Southern Buller's Albatrosses breeding within the same colony on North East Island were fitted with four Toyocom 2038C and two Toyocom 2050 Platform Transmitter Terminals (PTTs): four on 25 February 1995, and two on 26 February 1995. The six PTTs deployed were packaged in epoxy resin and weighed 58 g (T2038) and 46 g (T2050), which corresponded to 1.5–2.0% of the body masses of the birds. They were attached directly to the back feathers using adhesive tape. The PTTs were fitted to birds immediately after they had completed incu-

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bation shift changeover and been relieved at the nest by their mates. After a PTT was fitted, birds were returned to their nest sites, where they remained for a few minutes before departing on a foraging trip. The PTTs ran continuously and transmitted a signal every 90 sec. At this rate the two 0.5 AA lithium batteries had an autonomy of about 28 days. One transmitter failed to transmit properly, so subsequent analyses were based on locations from five PTTs. All PTTs were removed when birds started new incubation shifts. Bill measurements were used to determine the sex of each bird fitted with a PTT.

Locations were obtained through the Argos system, and customised software was used to analyse the data. Six classes of location accuracy and quality were provided by the Argos system (Class 3 = to within 150 m), class 2 = 350 m; Class 1 = 1 km; Classes A, B and Z = accuracy of the locations not estimated). Class A and B locations were the most common, and those that appeared improbable because of excessive speed (indicating a mean flight speed > 80 km) or location were excluded. Flight speeds were calculated between locations using only Classes 1–3.

To verify whether birds fitted with PTTs spent more time foraging at sea than other birds, we monitored incubation shift lengths at 31 control nests by checking every second day which banded bird was incubating. This allowed us to determine the average duration of foraging trips.

RESULTS

All six birds fitted with a transmitter returned to the colony, after each had completed a single foraging trip, and started new incubation shifts. The mean duration of foraging trips of the six birds fitted with PTTs, 11.1 ± 2.5 days (range 7.3–13.8 days), was similar to the estimated duration of control birds not fitted with PTTs (12.6 days, range 6–15+ days). As mentioned, one PTT failed to transmit signals, therefore, information was obtained on five complete foraging trips (Table 1).

The total distances travelled during these five foraging trips ranged from 1,760 to 3,481 km in 7.3 to 13.8 days (Table 1). Although four of the five foraging trips were similar in terms of the total distance covered and maximum foraging range from The Snares (Table 1), two different patterns of movement were evident (Fig. 1). Either they commuted rapidly to specific areas of ocean, where they foraged for several days before a rapid return to The Snares (Table 2), or they foraged throughout the entire time they were away from the colony. All three birds which commuted to their foraging area travelled NW of The Snares, to the mid Tasman Sea. Two females (F-7332 and F-15966) which left the colony on different days, foraged in the same area of ocean about 1,100 km from The Snares (Fig. 1). A male (M-15965) also foraged about 1,100 km from The Snares, but further south and west of the area used by the females (Fig. 1). When commuting to or returning from their foraging zones these three birds travelled at an average speed of 20.8 ± sd 3.8 km h^{-1} over 1.9–3.5 days; a speed significantly greater than the average of 4.2 ± sd 1.5 km h^{-1} ($t = 11.3$, $P < 0.001$; Table 2) when they travelled in the foraging sector.

The two remaining males (M-7331 and M-15964) tracked foraged mostly along the continental slope of the South Island, New Zealand; one bird feeding close inshore off the west coast and the other off the east coast (Fig. 1). The initial stages of travel for M-7331, which foraged off the west coast, resembled the commuting phase of birds which foraged in mid ocean, but then it looped back to the continental slope. Off the east coast, M-15964 moved along the continental slope on its outward route before returning along a similar route to The Snares. The average flight speed of birds foraging along the continental slope was similar to that of birds feeding in mid ocean (Table 1).

Average flight speeds during the commuting and foraging phases of the trips usually were greater during the day than at night (Table 3), but the differences were not significant.

DISCUSSION

Our study shows that in using the differing foraging strategies of feeding along the continental slope or commuting to specific mid-oceanic sectors, Southern Buller's Albatrosses behave similarly to other species of albatross. Commuting to distant feeding areas in oceanic waters has been shown in Light-mantled Sooty Albatrosses during the incubation period (Weimerskirch and Robertson 1994). Like Southern Buller's, these birds also moved rapidly to and from their foraging zones. During the incubation period, Wandering Albatrosses (*D. exulans*) from the Crozet Islands appear to travel continuously on looping courses during long foraging trips (Weimerskirch et al. 1993), feeding in pelagic waters throughout the trip (Weimerskirch and Wilson 1992). However, commuting to specific zones occurred during short trips associated with chick

TABLE 1. Summary information for foraging patterns of five Southern Buller's Albatrosses. c = continental slope; mo = mid-ocean.

PTT#	Sex	Date of departure	Date of return	Duration (days)	No. locations	Total distance covered (km)	Average flight speed (km h^{-1})	Max. foraging distance (km)	Foraging zone
15966	F	25.02.95	09.03.95	11.7	148	2,796	9.9	1,132	mo
7332	F	26.02.95	10.03.95	12.3	100	2,676	9.0	1,150	mo
15964	M	25.02.95	09.03.95	12.6	164	3,481	11.5	992	c
7331	M	25.02.95	04.03.95	7.3	54	1,760	10.0	559	c
15965	M	25.02.95	10.03.95	13.8	86	3,380	10.2	1,191	mo

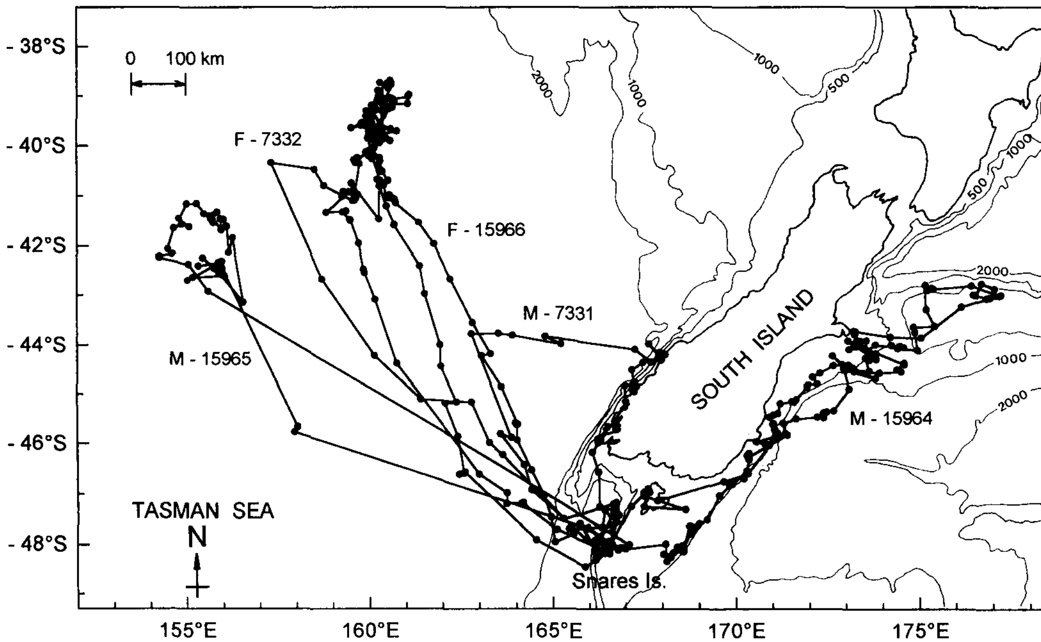

FIGURE 1. Tracks of foraging trips from The Snares taken by five Southern Buller's Albatrosses during the incubation period. M and F male and female respectively, followed by the PTT identification number.

rearing (Weimerskirch et al. 1993). A female Wandering Albatross from South Georgia commuted to a specific foraging zone, it too used a looping course (Prince et al. 1992) rather than the more direct routes used by Southern Buller's Albatrosses. This difference may be explained by the effects of local winds, as detailed for Wandering Albatrosses from the Crozet Islands (Weimerskirch et al. 1993). The greatest similarity to the foraging strategy of Southern Buller's Albatrosses is found in female Wandering Albatrosses tracked during incubation-period foraging trips from the Auckland Islands, about 150 km south of The Snares. These birds made flights of 11–13 days and 1,000–1,500 km into the Tasman Sea, flying directly and at a higher speed during the commuting than during the foraging phases of their trips (Walker et al. 1995). Interestingly, these Wandering Albatrosses moved into the same oceanic sector as the Southern Buller's Albatrosses from The Snares, perhaps indicating that this was a productive zone providing greater feeding opportunities for these two species of albatross. The track of M-15964, which foraged along the continental slope east of the South Island, showed a pattern similar to that of Northern Royal Albatrosses (*D. epomophora sanfordi*) which nest on the New Zealand mainland (Nicholls et al. 1994).

Foraging strategies vary with sex in Wandering Albatrosses, females tending to feed in more northerly and pelagic waters than males (Prince et al. 1992, Weimerskirch et al. 1993). Despite the small sample size, the five tracks of our Southern Buller's Albatrosses also indicate that foraging strategy or location may differ with the sex of the bird. Of the three birds which foraged in pelagic waters, the two females did so in the same sector, while one male foraged to the south and west. The two remaining males foraged along the continental slope on different coasts. Length of foraging trip affects the foraging strategy of Wandering Albatrosses (Weimerskirch et al. 1993), but this was not a factor in our study.

Our study showed that none of the birds tracked

TABLE 2. Duration and flying speeds of commuting and foraging phases of three complete foraging trips made into the mid Tasman Sea by Southern Buller's Albatrosses from The Snares, February–March 1995.

		Commuting					
		Out		Return		Foraging	
PTT#	Sex	Duration (days)	Av. flight speed (km h^{-1})	Duration (days)	Av. flight speed (km h^{-1})	Duration (days)	Av. flight speed (km h^{-1})
15966	F	1.9	22.1	3.5	14.5	6.9	2.7
7332	F	2.0	20.6	1.9	22.2	7.8	4.3
15965	M	2.4	19.5	1.9	26.0	9.5	5.7

TABLE 3. Average flying speeds of Southern Buller's Albatrosses during five complete foraging trips.

PTT#	Sex	Activity	Av. day speed ($km\ h^{-1}$)	Av. night speed ($km\ h^{-1}$)
15966	F	commuting	18.9	15.6
		foraging	3.3	2.2
7332	F	commuting	27.5	6.4
		foraging	5.3	1.9
15965	M	commuting	23.3	18.5
		foraging	4.4	6.5
7331	M	foraging	12.0	6.0
15964	M	foraging	14.4	8.1

foraged close to their breeding colony at The Snares. The birds spent only a short period close to the breeding grounds, during the outward or return part of their foraging trip. The feeding zones were located far from The Snares, with maximum distances ranging from 559–1,191 km. However, it is likely that during the brooding period, when birds spend short periods at sea, the birds will forage closer to the breeding grounds, as has been shown for Wandering Albatrosses (Weimerskirch et al. 1993). This has important implications for the conservation of Southern Buller's Albatrosses, as many are caught by long-liners fishing west and north of The Snares (Murray et al. 1993). Currently, seabird bycatch mortality has been reported only for foreign vessels fishing inside the New Zealand Exclusive Economic Zone (EEZ) (e.g., Bartle 1991, Murray et al. 1993). No comparable information is available from domestic fisheries operating within the EEZ or any fisheries in the mid Tasman Sea, the latter area now identified as a specific foraging zone for Southern Buller's Albatrosses from The Snares, and Wandering Albatrosses from the Auckland Islands.

These preliminary results suggest that relationships between commercial fisheries and Southern Buller's Albatrosses are likely to change according to the stage of the breeding season and location of the fishing fleets. More extensive studies are now needed of the foraging strategies of Southern Buller's Albatrosses, at different stages of the annual cycle and with birds from the Solander Islands, the other breeding location.

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