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Satellite tracking of wandering albatrosses (*Diomedea exulans*) in the South Atlantic

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Abstract: The movements of two wandering albatrosses, one of each sex, breeding at South Georgia, were tracked using satellite telemetry, particularly to assess whether such birds could be at risk from longline fishing operations in the subtropics. Full details of the performance (number and quality of uplinks) of the Toyocom transmitters are provided, together with data on flight speeds and night and daytime travel by the albatrosses. The female, tracked for seventeen days—covering three foraging trips totalling 13951 km - had a much more northerly distribution than the male, which made two trips to sea during the same period and travelled a minimum distance of 9280 km. On one trip the female frequented the area off Brazil known to be used for longline fisheries. The distributional differences between the sexes support earlier suggestions, based on at-sea observations, that the observed high mortality rates of South Georgian females could be due to a greater likelihood of incidental mortality in longline fishing. These results also show that the presence of females off Brazil can include birds still rearing chicks, rather than simply representing post-breeding dispersal.

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Key words: longline fisheries, satellite telemetry, wandering albatross

Introduction

Wandering albatross *(Diomedea exulans)* populations are declining throughout the Southern Ocean (Croxall 1979, Tomkins 1985, Weimerskirch & Jouventin 1987). Incidental mortality associated with Southern Ocean commercial fishing operations was surmized to be the principal cause (Croxall *et al.* 1984, Jouventin *et al.* 1984). Recently a variety of evidence has clearly indicated that the subtropical longline fisheries for tuna (Croxall & Prince 1990, Croxall *et al.* 1990, Brothers 1991) are a major source of mortality.

Croxall *et al.* (1990) showed that in recent years females have had significantly higher mortality rates than males. The few relevant recovery data for South Georgian birds (off the coasts of southern Brazil and northern Argentina at 34°–36°S) showed a bias towards females and indicated that some birds were killed at or near the end of the breeding season (Croxall & Prince 1990).

These results raised two important questions. First, are fewer males caught on longlines in the subtropics because they are not (or rarely) found in such latitudes, or because they are less susceptible to (or better at avoiding) being caught? Second, do birds, especially females, actually reach these latitudes while still committed to feeding dependent offspring at Bird Island, or do they only occur there as a result of a one-way migration at the end of their reproductive commitments? This question is important because losing a parent before a chick is independent is likely to prejudice survival to or after fledging.

The aim of our pilot study attaching satellite transmitters to wandering albatrosses at South Georgia was to obtain data relevant to these questions. This is only the third study reporting tracking of seabirds at sea by satellite, following the pioneering work on southern giant petrels *(Macronectes giganteus)* on the Antarctic Peninsula (Parmelee *et al.* 1985, Strikwerda *et al.* 1986) and the very successful study on wandering albatrosses in the Indian Ocean by Jouventin & Weimerskirch (1990).

Methods

Toyocom T2028C platform terminal transmitters (PTT) weighing 180g (between 1.3 and 2% of the bird's body weight), were deployed on wandering albatrosses at Bird Island, South Georgia (54°00'S, 38°36'W). Transmitters were attached by first glueing (with quick-set epoxy resin) a strip of plastic 180 by 35 mm to the mid-dorsal feathers of the mantle. Six holes were pre-drilled (three on each side at equal distance apart) so that plastic cable ties could be threaded through to enable attachment of the PTT once the plastic base (Fig. 1) was firmly attached—usually within 15 minutes. On recovery of the PTT, the cable ties were cut and the PTT removed, leaving the plastic in place to be moulted off during the subsequent months. This method offers two advantages over harness arrangements: the bird is not likely to get into physical difficulties, as might occur with a slipped harness, and should the bird either desert or fail to be recaptured it will moult off the entire assembly.

Two birds, one female and one male, from different nests in the same breeding area (Wanderer Ridge), had PTTs attached on 25 and 27 August 1990 respectively. Both birds were captured at the nest while feeding their young which were approximately 36 weeks old (about 12 weeks from fledging).

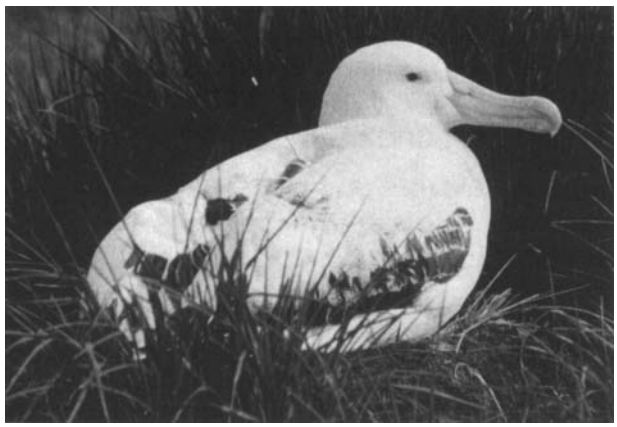

Fig. 1. Wandering albatross (male) with Toyocom PTT attached to its back.

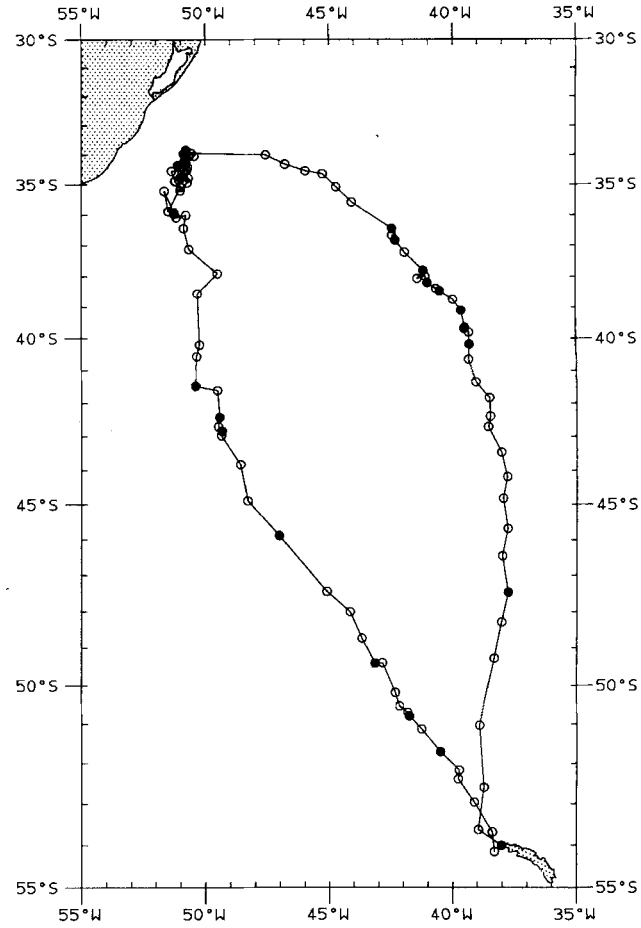

Fig. 2. Track taken by female wandering albatross (third foraging trip) to show relationship between Class 1–3 locations (●, 26% of data), which are accurate at least to within 1 km and Class 0 locations (○, 74% of data), which are of unspecified accuracy. Total distance along track is 6479 km over 8.15 days.

The PTT on the female was deployed for 17 days, covering three foraging trips. The PTT on the male was attached for 19 days covering two foraging trips. Battery life of the PTT is estimated as *c.* 30 days but depends on temperature.

Data on the position of tagged birds were initially obtained via the ARGOS interactive interrogation system, and then in computer readable form. The data were loaded into a database, using the ORACLE relational database management software on a DEC VAX 6410 computer. A specially written program was used to manipulate output.

In this paper references to the accuracy of the locational information are those (for one standard deviation) provided by the ARGOS system: Class 3 = 150 m; Class 2 = 350 m; Class 1 = 1 km; Class 0= at least two messages received during satellite pass, with quality of results to be determined by user. Although most locations were of Class 0 (see Table I), when plotted in relation to Class 1–3 data (see Fig. 2), there were no indications that any Class 0 locations were substantially (say greater than ± 10 km) incorrect or implausible (e.g. on grounds of flight speed etc). Consequently all Class 0 data were used for mapping purposes but only Class 1–3 data were used for estimates of flight speeds.

Day-time is defined as that period from when the rising sun is 9° below the horizon until the setting sun dips to 9° below the horizon. The estimation of this will obviously depend on latitude and longitude. Our distinction between day and night is halfway between civil and nautical twilight. The allocation

Table I. Duration of deployment of PTTs on wandering albatrosses and number and quality of locations data obtained.

Sex	Trip	Period of deployment	Start/end time (GMT)	No. days	No. locations	Total day^{-1}	Quality class of locations (as %) 3	2	1	0
F	1	2508–3008	1629–1117	4.8	81	16.9	1.2	16.0	7.4	75.3
F	2	3008–0309	1200–0801	3.8	62	16.1	0	12.9	8.0	79.0
F	3	0409–1209	0738–1138	8.2	99	12.1	0	9.0	16.1	74.4
M	1	2808–0109	0839–2053	4.5	71	15.7	0	22.5	14.0	63.3
M	2	0309–1609	0622–1020	13.1	205	15.5	2.9	40.0	12.6	44.3
Totals				34.4	518	15.2	1.3	24.7	12.1	61.7

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of time travelled during night and day between two consecutive locations which span sunrise or sunset was determined from linear interpolation of distance against time.

Results

Performance of PTT

The transmitters were deployed between 25 August and 16 September 1990 (Table I). The duration of each foraging trip varied between 3.8 and 13.1 days. A total of 518 locations was obtained, of which 320 (62%) were of Class 0, whereas 38% were accurate at least to within 1 km. The male had significantly fewer Class 0 locations than the female. This is probably a function of the difference in latitude visited by the sexes, because the number of daily satellites passes over a PTT is a function of latitude. At 30°S the mean number of daily passes would be nine, while at 65°S the mean number would be 22 (ARGOS User Manual).

Movements of albatrosses

Table II shows the distance travelled and flight performance of the wandering albatrosses, on each of their five foraging trips. The female travelled a minimum total distance of 13951 km in 16.8 days, during which time she returned to feed her chick on two occasions. She flew 5857 km (42% of total distance) during periods of darkness, at a time when at 54°S (Bird Island), approximately 55% of each day would be in darkness. The male travelled a total of 9280 km in 17.6 days, with one visit to Bird Island, covering 2153 km at night (23%). The minimum average flight speed of the male (20 km h^{-1}) was lower than that of the female (35 km h^{-1}), which probably reflected the male spending more time on the water than the female. However, the fastest flight speeds between successive position fixes were made by the male, who reached 88 km h^{-1}.

Fig. 3 shows the tracks of all three foraging trips made by the female. The direction taken on each trip was to the north and west of Bird Island. On the first and second trips (Figs 3b & c) the bird travelled to the west and returned from the north. The third trip, the longest in duration and farthest in distance, was made in an anti-clockwise direction, taking the bird to an area only 240 km off the coasts of southern Brazil and Uruguay, where it spent at least two days of the eight day trip. Fig. 4 shows the two foraging trips made by the male at the same time as the female was being tracked. The first trip made by the male (Fig. 4a) lasted 4.5 days, the bird remaining to the west and within 220 km of Bird Island. The second trip (Fig. 4b) lasted 13 days, covered 7470 km and started two days after the female had embarked on her longest trip towards the continental shelf of South America. Despite initially heading in a similar direction to the female, the male subsequently turned south towards the Falkland Islands and then headed for the Drake Passage, off Tierra del Fuego, spending three days in this area before returning to Bird Island.

The female travelled almost exclusively at latitudes north of the breeding locality, only three (0.9%) of 322 locations being to the south of Bird Island. By contrast 123 (27.1%) of the male's locations were south of Bird Island. The male travelled no further north than 41°S whereas the female reached 33°S. The male spent over half his time at approximately the same latitude as Bird Island. He travelled twice as far westwards as the female, reaching 69°W, whereas the female only reached 51°S. Overall the female occupied a narrower longitudinal range but wider latitudinal range than the male.

Discussion

Comparable data on satellite-tracked wandering albatrosses come only from the Indian Ocean (Jouventin & Weimerskirch 1990) and involve seven males tracked between mid-January and early March, when the birds would be incubating and later brooding very young chicks. Jouventin & Weimerskirch (1990) reported foraging trips ranging from 3–33 days (mean 16.0 ± 12.7); distances covered ranged from 330 to 15 200 km. Most flying was done during daylight (range= 57.7–95.9%, mean 83.7 ± 12.6%) and maximum flight speed recorded between positions was 81.2 km^{-1}. The average distance travelled per hour was 54.6 ± 3.3 km. Our data are generally in broad agreement with theirs and most differences may well result from birds operating at different stages of the breeding cycle and different times of the year (when night-to-day ratios

Table II. Minimum flight distances and minimum average flight speeds of wandering albatrosses.

Sex	trip	total distance (km)	% of distance flown in daylight	flight speed m s^{-1}		flight speed km h^{-1}	
				max	*x*	max	*x*
F	1	4173	54.5	22.14	9.7	79.7	34.92
F	2	3298	56.8	22.03	10.7	79.3	36.29
F	3	6479	60.9	22.53	9.34	81.11	33.61
M	1	1810	66.5	23.6	5.57	84.96	20.04
M	2	7470	79.3	24.48	5.6	88.13	20.16

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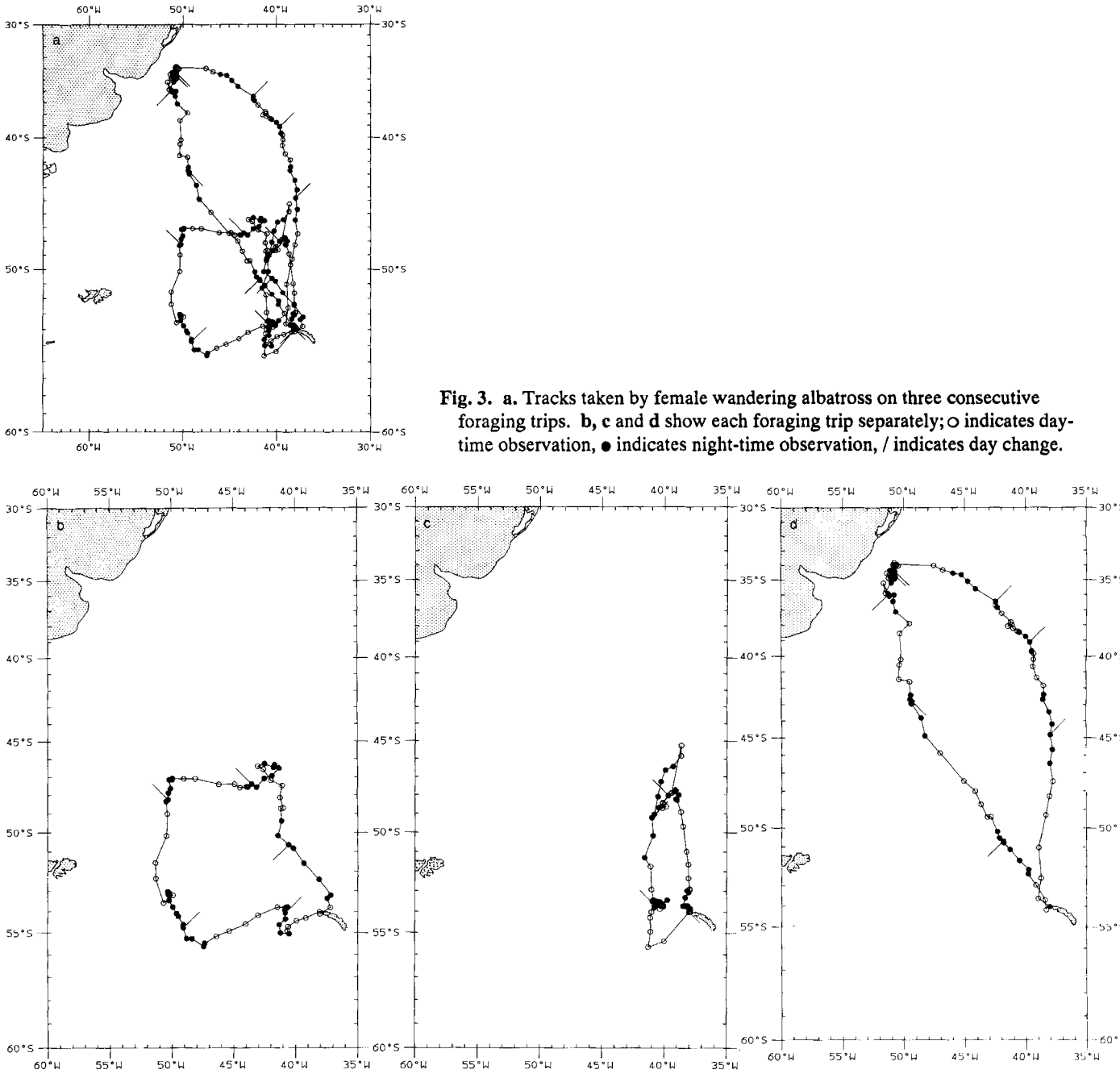

Fig. 3. a. Tracks taken by female wandering albatross on three consecutive foraging trips. **b, c** and **d** show each foraging trip separately; ○ indicates day-time observation, ● indicates night-time observation, / indicates day change.

will be very different). Thus our birds may have travelled at slower average rates because they spent more time sitting on the water. Another difference is that the birds that we followed travelled far more extensively at night, a time when they covered 35% of the total distance flown, compared to only 16.2% for the males followed by Jouventin & Weimerskirch (1990). These authors also suggested that birds responded to the phase of the moon by flying greater distances (100–200 km) at night at times of full moon. In contrast our birds flew on average 172 ± 153 km (n=19) on a full moon and 295 ± 171 km (n=9) on a new moon (t_{26} = 1.92; 0.1 <P> 0.05).

Despite the small sample size, the tracks of our wandering albatrosses provide some interesting information in respect of existing knowledge of the at-sea distribution and ecology of the species, particularly since they include the first such data for females.

Records of the plumage characteristics of birds at sea in the Indian Ocean (Weimerskirch & Jouventin 1987) suggested that females and juveniles range more extensively into subtropical waters than do males. Our satellite tracking data support these suggestions showing that, at least in August and September in the South Atlantic, our female tended to frequent more northerly latitudes.

At South Georgia adult female wandering albatrosses show significantly lower annual survival rates than males. Croxall *et al.* (1990) suggested that this might relate to the use of

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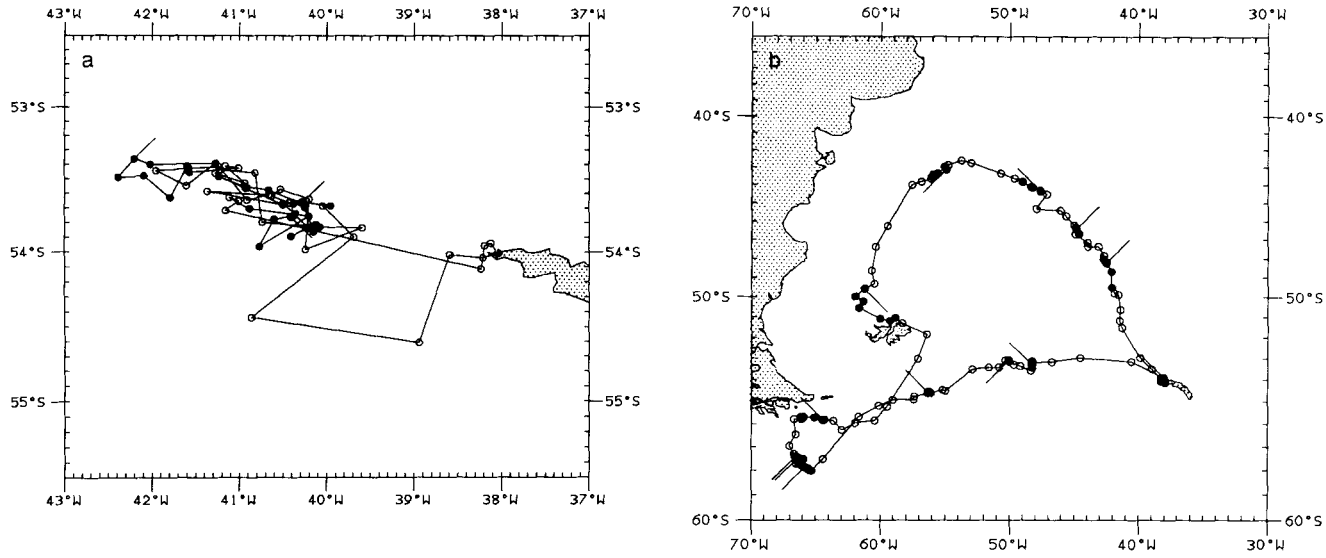

Fig. 4a & b. Two consecutive foraging trips made by male wandering albatross. ○ indicates day-time position, ● indicates night-time position, / indicates day change.

different foraging areas by the sexes, which might in turn be associated with different threats to survival. Croxall & Prince (1990), analysing recoveries in the South Atlantic of wandering albatrosses ringed at Bird Island, showed that 83% of recoveries came from between 30°S and 40°S (southern Brazil to northern Argentina); 75% of these were caught at sea, between 33° and 35°S, by longline fisheries for tuna; of sexed birds, 73% were female. Of 12 birds whose status at Bird Island was known, nine (75%) were females, and six (67%) of these were killed between August and September, at or near the end of a successful breeding season (Croxall & Prince 1990).

Males tend to do more of the provisioning duties than females towards the end of the chick rearing period (BAS unpublished data). We were therefore uncertain whether females could commute to southern Brazil from Bird Island or whether their presence there simply represented post-breeding dispersal. The satellite tracking data indicate that, as early as August, females can make such a round trip from Bird Island. Furthermore, the course flown by the female on her trip took her directly to the area where our recoveries came from (Fig. 5). Indeed she spent almost 2.5 days in this area before returning to Bird Island.

The implications from this are substantial. It demonstrates that females rearing chicks can travel to what is currently a major operational area for the South Atlantic tuna longline fishery, which is most active between August and October (Croxall & Prince 1990). So far mortality of adult wandering albatrosses has not been associated with a decrease in breeding success (Croxall *et al.* 1990). However, should the fishery start any earlier in the year, it is likely that albatrosses would be caught at a time when the survival of their offspring would be prejudiced by being reared by only one parent.

Finally, the foraging by the male wandering albatross also raises some interesting possibilities concerning association

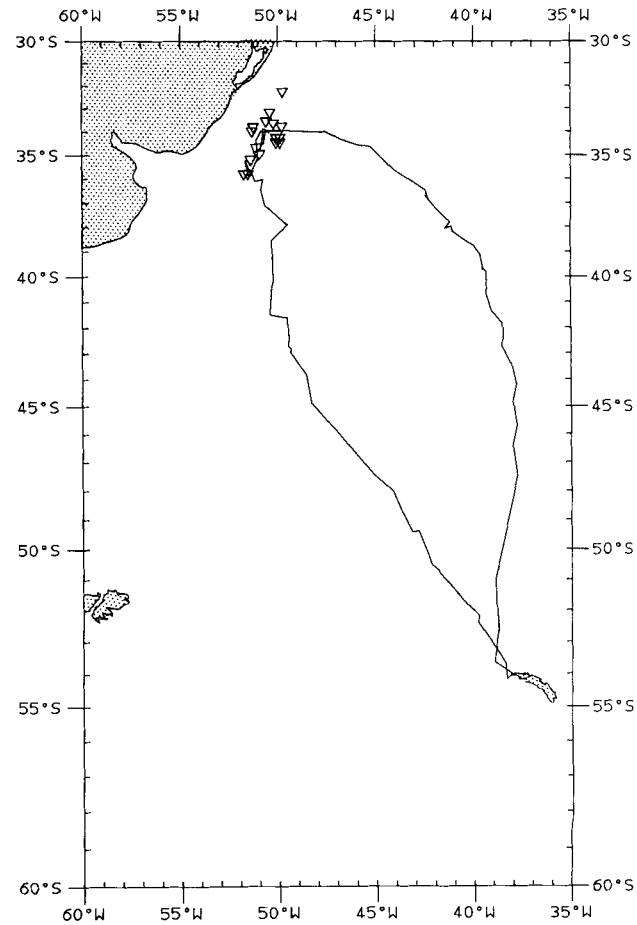

Fig. 5. Track taken by female wandering albatross between South Georgia and the Brazilian coast. Symbols indicate position of recoveries of birds caught on longlines set for tuna (from Croxall & Prince 1990).

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and interaction with fishing vessels. The whole of the first foraging trip (Fig. 4a) took place within 220 km of Bird Island and was confined to the area of continental shelf lying to the east of Shag Rocks (55°30'S, 42°10'W). This is coextensive with the area of operation of USSR fishing vessels long-lining for Antarctic cod *(Dissostichus eleginoides)*, which fishery was active at South Georgia from July to at least October 1990. It is unknown whether there is incidental mortality of albatrosses associated with this fishery (which only started in 1988–89), but there are clear grounds for serious concern and detailed investigation.

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Note added in proof

Mortality of albatrosses and petrels in this (*Dissostichus*) fishery has now been confirmed. Fisheries inspector O. Senetsky reported that four to eight seabirds are caught per ship per day (J. Dalziell personal communication 1991) and S. Kaplun forwarded to us rings from two birds caught in February 1990; they were from wandering albatrosses (aged 5 and 8 years) ringed as chicks on Bird Island. Furthermore, during two days of monitoring of one longline vessel by Greenpeace in March 1991, at least six birds (two albatrosses and four petrels) were killed (J. Dalziell, unpublished data).

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