Antarctic Science Bursary Award 2007 - Initial Report

Identifying foraging behaviour of black-browed albatrosses from satellite-tracking data to improve habitat preference models

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1. Introduction

This report briefly describes field studies undertaken on Bird Island, South Georgia during 2008, which were supported by the Antarctic Science Bursary. This work is part of my doctoral research into the habitat preferences of albatross. Some examples of the data collected during the 2008 field season are presented here but as they have yet to be analysed fully interpretation is kept to a minimum.

The main aim of my fieldwork was to use biologging techniques to measure the behaviour of free ranging black-browed albatrosses to improve habitat preference models for this and other albatross species. The key behaviour types I hoped to distinguish between were commuting versus foraging flight. The former is thought to be typified by fast direct and uninterrupted flight, while the latter, sometimes referred to as Area Restricted Search (Benhamou, 1992), is thought to be slower, more sinus, with frequent takeoffs and landings (Weimerskirch et al., 1997; Pinaud & Weimerskirch, 2005). However, until now this presumed distinction has not been verified in the field and different indices of behaviour can give differing or contradictory indications of where foraging takes place (Austin et al., 2006; Robinson et al., 2007). Hence, to test the hypothesis that greater turning rates, etc. are synonymous with foraging I measured the speed and direction of albatrosses flight using low-resolution GPS loggers (recording positions ever 5 to 30 minutes), the frequency and timing of their takeoffs and landings with wet/dry loggers and the timing and mass of prey ingestion using Stomach Temperature Loggers (STLs).

A subsidiary aim of my work was to find out whether STL data could be used to detect the ingestion of gelatinous prey. Although albatross's and indeed many other procellaifformes have been observed consuming cnidarians and tunicates, the lack of hard body parts in these taxa make them difficult to detect using conventional diet sampling techniques. Hence, I also undertook work in the laboratory and captive feeding trials to calibrate the STLs and to determine whether data from these instruments could be used to distinguish between the different prey types typically consumed by black-browed albatrosses.

I was also interested in examining the effect of wind speed on albatross behaviour and flight performance; firstly, because this could confound attempts to distinguish between commuting and foraging flight (for example, albatross flight paths are more sinus when they fly upwind than downwind) and secondly, because recent modelling work I have carried out suggests that the wind field can have a considerable limiting effect on the foraging areas visited by albatrosses. Hence, I equipped a number of birds with high-resolution (1 Hz sampling rate) GPS loggers and combined GPS and 3D acceleration loggers (which can be used to measure wing beat frequency and other flight parameters). Furthermore, I measured the weight change and morphometrics of foraging birds and videoed the flight of birds at sea, in different wind conditions.

2. Summary of fieldwork and lab work undertaken on Bird Island

I arrived at Bird Island Research Station on the 30th of December 2007 and spent the first week preparing, testing and transporting my equipment to my initial study site, at Colony J, on the western end of the island. At this stage, birds were approaching the end of the incubation period. Once their eggs had hatched, parent birds began alternating between brooding their chicks and making short (~1-3 day <check) trips to provision their young (this is termed the brood/guard stage). Departing adult birds were equipped with various logging devices, which were then recovered on their return to the nest. Between the 5th and the 29th of January 2008 a total of 26 birds were equipped with low resolution GPS or combined GPS/acceleration loggers and wet/dry loggers (table 1). Of these deployments, 23 were successful and 6 birds also carried a high resolution GPS logger. Where possible, adults were weighed just prior to departure and just after their return to the nest in order to determine their weight gain over the course of the trip. The outstretched wing of a subset of these birds was photographed in order to measure morphometrics (wing length, area, etc.). Diet samples were recovered from 10 chicks (by inducing them to vomit) in order to determine the taxa of prey being caught by adult birds.

Table 1. Number of successful deployments of various loggers placed on black-browed albatrosses at Bird Island, January to March 2008 (total number of deployments).

GPS type	Other Instruments	Stage	
		Brood/guard	Post-brood
Low resolution GPS	+ Activity	2 (5)	1 (2)
	+ Activity + STL	-	8 (9)†
Low resolution GPS/Accelerometer	+ Activity	15 (15)	10 (10)
	+ Activity + STL	-	2 (2)
	+ Activity + TDR	-	3 (3)
Low resolution GPS/Accelerometer + High resolution GPS	+ Activity	5 (5)	3 (3)‡
High resolution GPS	+ Activity	1 (1)	-
	Total	23 (26)	26 (29)

† - Two STLs were regurgitated at sea, one failed to download.
‡ - One high resolution GPS failed to download.

At the end of the brood/guard period both parent albatrosses leave their chick unattended and begin making longer (~2-10 day) provisioning trips. During this, the post-brood stage, it became possible to deploy STLs without unduly compromising albatross's breeding attempts. However, because the deployment and recovery of STLs requires at least two people, I moved to a new study colony at Cave Crag, close to the base buildings. Between the 30th of January and the 11th of February I set up a field camp at Cave Crag and modified and tested a number of GPS loggers, which unfortunately had proved defective when deployed at colony J. Between the 12th of February and the 19th of March GPS loggers were deployed on 29 birds. Low resolution GPS data (and in some instances acceleration data) were successfully recorded during 26 of these deployments and high-resolution data was collected simultaneously during two deployments. During this period STLs were deployed on 11 occasions and a further 10 diet samples were recovered from chicks.

During my final three weeks on Bird Island I carried out work in the laboratory to calibrate the STLs and to determine their sensitivity. Firstly, using a flask calorimeter, I measured the specific heat capacity of various species of fish, krill, squid and cnidarians known to occur in the diets of black browed albatrosses, as well as that of the STLs themselves. Then I conducted feeding trials with simulated endodtherm stomachs. These consisted of water filled balloons suspended in a constant temperature water bath (Wilson et al., 1992). Active STLs were placed in the balloons, then samples of fish, krill, squid and cnidarians of known mass and temperature were introduced into the balloons.

I also conducted captive feeding trials with black-browed albatrosses. Three non-breeding birds were captured and housed in a purpose built wooden corral for a period of <40 hours. Each bird was equipped with an STL and at set times fed samples of various prey species of known mass, at the ambient temperature of local seawater. During these three weeks I also made 89 video recordings of albatrosses flying at sea in the vicinity of Bird Island, while wind speed and direction were recorded simultaneously with an anemometer.

Finally, whilst I was on Bird Island I made a number of recordings about my fieldwork for ‘World on the Move’, a BBC Radio 4 program on animal migration. I was on the air several times, including once when I was interviewed while deploying a GPS tag on a bird. These broadcasts have generated a lot of interest in my work and have given a little more exposure to the issue of albatross bycatch, which is threatening to bring many species close to extinction.

3. Initial results and planned analyses

3.1 Low resolution GPS data

The most striking feature of the 2008 breeding season at Bird Island was that black-browed albatrosses made longer foraging trips, both in terms of time and distance flown from the colony, than have been observed in previous years. Mean foraging trip duration is typically around 2 days during the brood/guard period and 3 days during the post-brood period. In 2008 mean durations were 3 and 6 days respectively. In previous years brood/guard stage adult birds have generally foraged in shallow (<200 m) water around South Georgia, especially around Shag Rocks and always south of the polar front. Their furthest forays are typically to an area of deep water in the Scotia Sea, 400 km to the SW of South Georgia. While birds made some similar trips in 2008 they also travelled over 1100 km to the north of the polar front and to the Antarctic Peninsula (figure 1). Such trips are more typical of the incubation and post brood stages, when birds are less time constrained and can thus travel further. During the 2008 post-brood stage black-browed albatrosses also showed an extension of their typical foraging range. While they would ordinarily make trips around 100-1400 km from the colony, to the south of the polar front, in 2008 they also ventured 1500 km to the north and west of South Georgia.

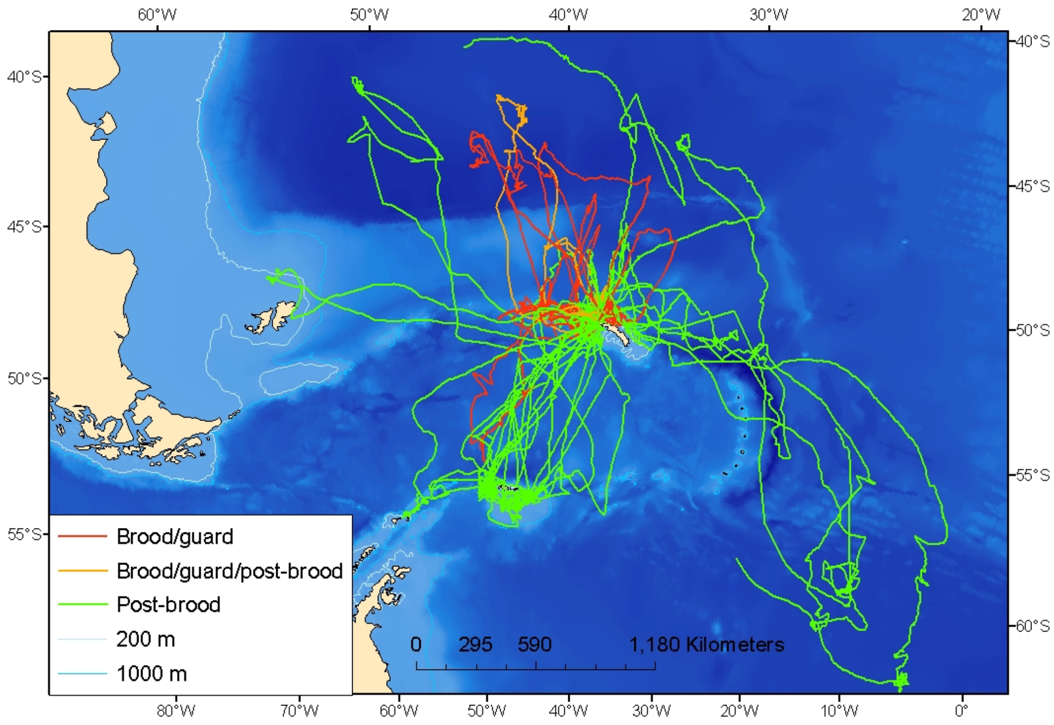

Figure 1. Foraging trips made by 49 black-browed albatrosses provisioning chicks at Bird Island, during the 2008 breeding season. Birds were tracked using low-resolution GPS loggers, recording locations at intervals of 5 to 30 minutes. Colours indicate different stages of the breeding season.

Although the diet sample data has not been fully analysed yet, my initial impression is that black-browed albatrosses were generally catching fish and squid rather than krill during the 2008 season. Taken together with the comparatively long trips being made by the birds, this observation suggest a paucity of krill in the immediate vicinity of South Georgia (see Reid et al., 2005; Reid et al., 1996). However, acoustic surveys undertaken by the James Clarke Ross in early 2008, as well as diet samples from deep diving species such as penguins and fur seals do not support this supposition. It may be the case then that krill were too deep in the water column for black-browed albatrosses to access (this species can only dive to around 5 m).

The physical and biological reasons for the extension in the foraging range of this species during 2008 clearly deserve more investigation. I intend to compare my results to those from previous tracking studies by modelling the inter-annual distribution of black-browed albatrosses in response to remotely sensed oceanographic variables.

3.2 High resolution GPS and accelerometer data

In contrast to the low-resolution GPS loggers, which show where birds went on foraging trips, data from the high-resolution loggers show small-scale detail of the flight patterns of albatrosses (figure 2). Of particular interest is the magnitude of the cross-track deviations made by birds as they undertake dynamic soaring manoeuvres. I am currently quantifying the sinuosity of birds' tracks under different wind conditions (I have obtained wind vectors from the satellite-borne QuickSCAT scatteromter). I am also examining the three-dimensional accelerometer data to see whether different modes of flight can be distinguished. At present it is clear that flapping versus non-flapping flight can be separated using acceleration with time on the heave axis (figure 3). Data from the sway and surge axes may also enable me to quantify how often birds carry out the ‘pull-up’ manoeuvres characteristic of dynamic soaring flight. These data will be validated by analysing the video clips of black-browed albatrosses in flight in different wind conditions.

I have not yet analysed the morphometrics data. However, it is clear that black-browed albatrosses experience an average 9% weight gain during the course of foraging trips. I shall be examining how this weight gain affects the flight performance (airspeed, etc.) and hence behaviour in due course.

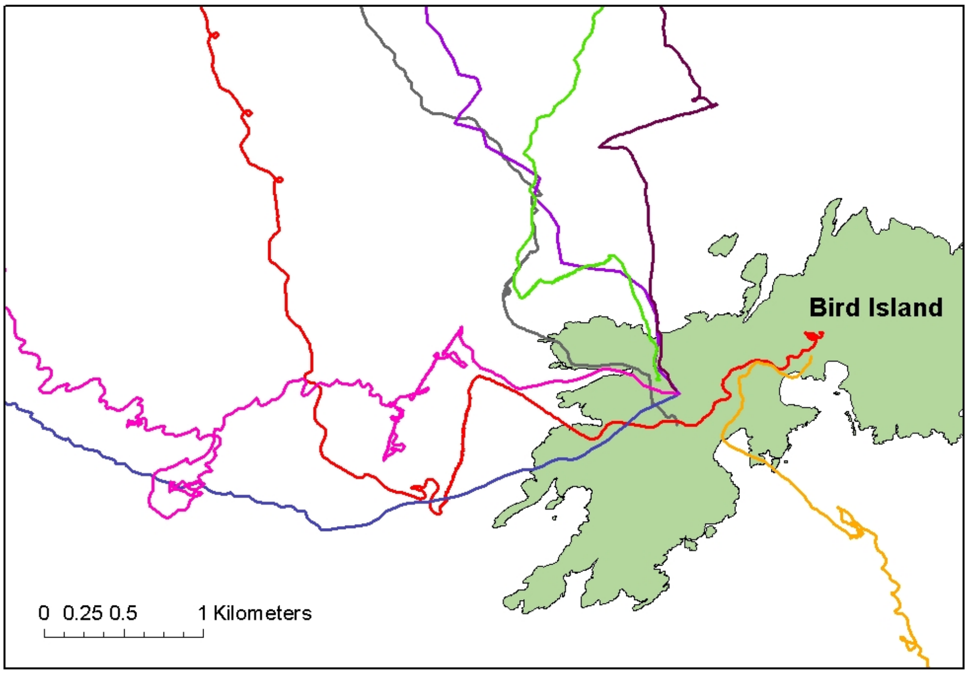

Figure 2. High-resolution (1 Hz) GPS tracks of black-browed albatrosses provisioning chicks at Bird Island during the 2008 breeding season (colours represent different individuals).

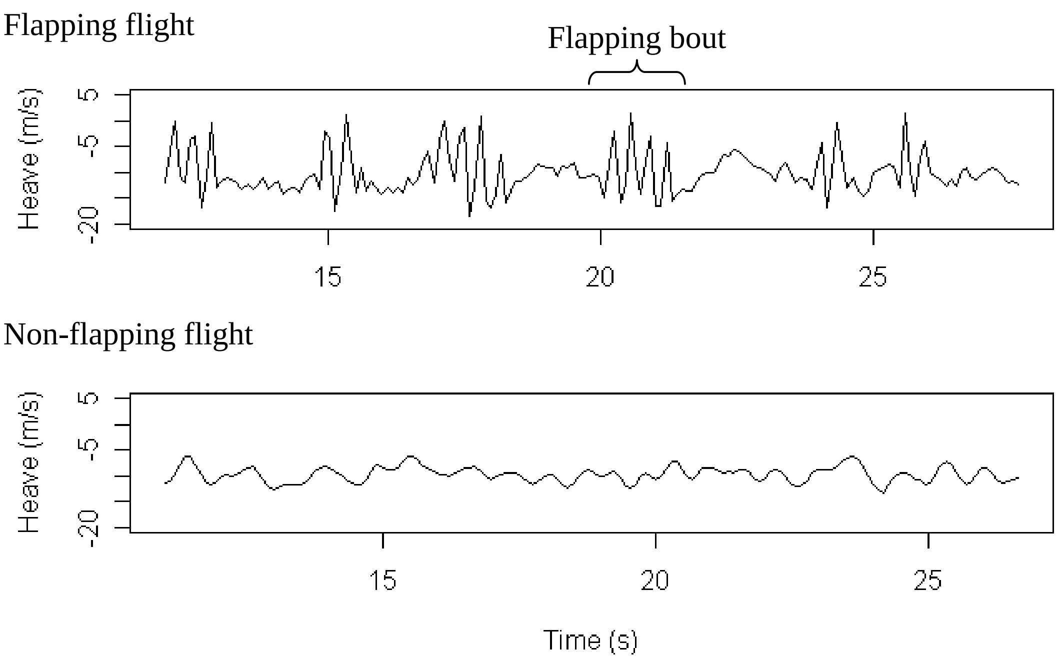

Figure 3. Up and down acceleration of a black-browed albatross in flapping and non-flapping flight.

3.3 Stomach Temperature Logger data

The deployment and recovery of STLs proved far from straightforward. In two instances birds apparently regurgitated STLs while they were at sea and in one instance a bird equipped with an STL lost its GPS logger at sea. However, complete data sets (STL and GPS) were recovered from seven birds. Data from these free-ranging birds show that although prey were ingested throughout foraging trips (figure 4) the majority were consumed during foraging bouts in distinct areas, remote from the colony. However, I have no yet analysed the likelihood of prey ingestion with respect to the birds' movement. Presently, I shall quantify the sinuosity of the birds' movements, their speed and using their rate of takeoff and landing. I shall then use these data to model the likelihood of prey ingestion as a function of behaviour and to determine whether higher turning rates are indeed indicative of foraging behaviour and Area Restricted Search.

Another interesting feature of the STL data is that the rate of prey ingestion of black-browed albatrosses appears to vary diurnally, with the majority of smaller prey items being consumed during darkness. This is a very interesting observation, given that so many of its prey species exhibit deil vertical migration. The analysis of this data will also allow me to quantify the relative importance of aerial versus sit and wait foraging tactics (Croxall & Prince, 1994) in black-browed albatrosses and how foraging tactics differ with prey type (small versus large prey).

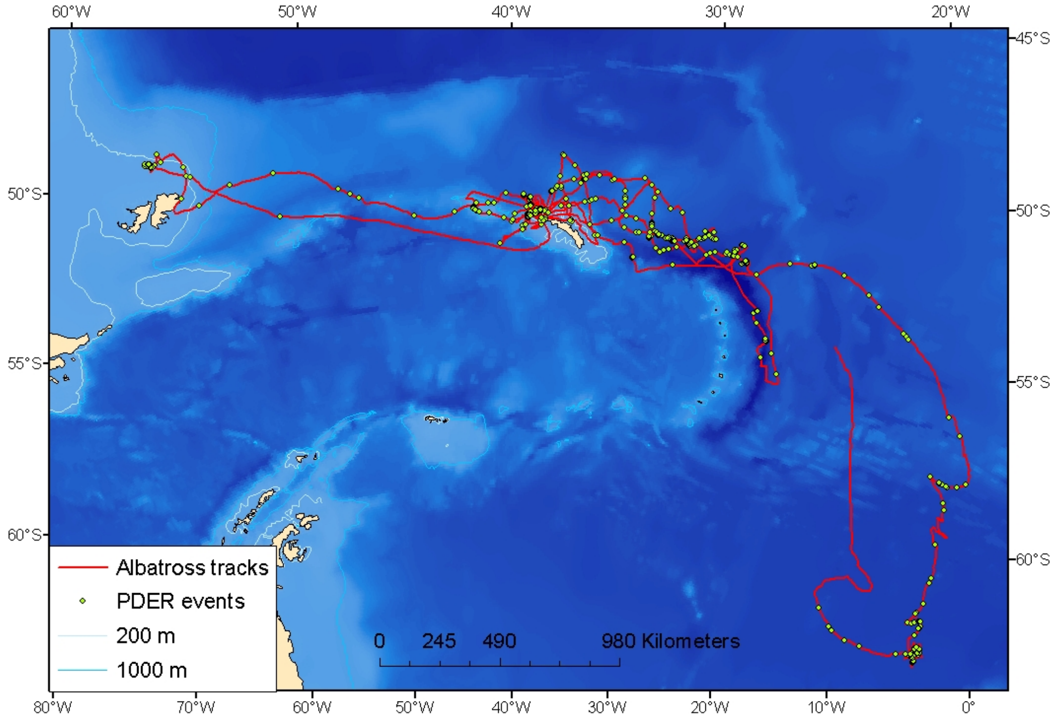

Figure 4. Foraging trips made by 7 black-browed albatrosses provisioning chicks at Bird Island during the 2008 breeding season. Birds were tracked using low-resolution GPS loggers and Stomach Temperature Loggers. Yellow dots mark Precipitous Drop Exponential Rise (PEDR) temperature events, which are indicative of the ingestion of prey items.

The results of my laboratory work and the captive feeding trials will help to validate data from the free-ranging birds. For instance, although it is clear that the STLs can be used to detect the ingestion of majority of prey items consumed by black-browed albatrosses they are not sensitive enough to register the ingestion of single zooplankton, such as krill (figure 5). However, the ingestion of several such small items in quick succession is detectable.

Finally, at this stage it looks unlikely that the time/temperature signature of gelatinous prey is distinct enough to separate it from the signatures of solid prey, such as squid and fish. However, these data have not yet been the subject of a detailed analysis.

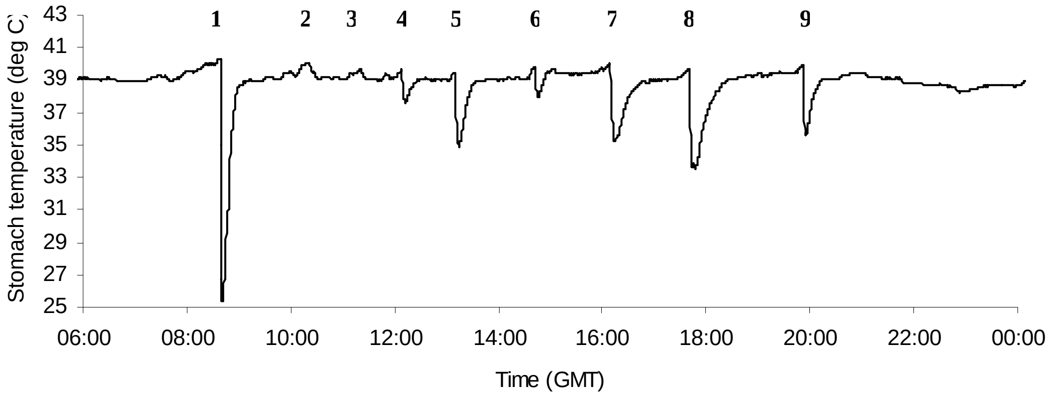

Figure 5. Stomach temperature of a captive black-browed albatross fed different prey items. Numbers indicate time of ingestion of prey item (1. 100 ml of seawater; 2. 1 x krill; 3. 5 x krill; 4. 30 x krill; 5. 51g of fish; 6. 23g of squid; 7. 80g of fish; 8. 95g of squid; 9. 33g of jellyfish).

4. Conclusion

The funding provided by the Antarctic Science Bursary was key to my undertaking this piece of fieldwork. It enabled me to collect highly accurate GPS tracking, STL and accelerometer data from over 50 birds. This will allow me to refine the albatross habitat preference models I have been developing during the course of my PhD, by incorporating behavioural information inferred from tracking data into the models. These data will also allow me to well as to address several ancillary questions related to the foraging ecology and flight of albatrosses.

By planning, organising and implementing this field project, as well as setting up and deploying GPS tags, stomach temperature loggers, activity loggers, I have gained experience that will be invaluable in my future career. I intend that the results of this work will be presented in a number of papers, one of which at least I shall submit to Antarctic Science for consideration.

5. References

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