POST-BREEDING MOVEMENTS OF A MALE BLACK-FOOTED ALBATROSS *PHOEBASTRIA NIGRIPES*

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Received 11 July 2000, accepted 20 September 2000

SUMMARY

HYRENBACH, K.D. & DOTSON, R.C. 2001. Post-breeding movements of a male Black-footed Albatross *Phoebastria nigripes. Marine Ornithology* 29: 7–10.

We used satellite telemetry to study the movements of a male Black-footed Albatross *Phoebastria nigripes* during its pelagic travels off California. The tracked albatross covered a minimum distance of 5067 km during 35 days, and moved over of a broad range of water temperature (22–15°C) characteristic of tropical, subtropical and transition zone waters. The rate of movement of the tracked albatross varied significantly during different periods of the day, and was influenced by ambient light levels during the night.

Key words: Black-footed Albatross, *Phoebastria nigripes*, California Current, Transition Zone, satellite telemetry, post-breeding dispersal, water masses,

INTRODUCTION

The advent of satellite telemetry has facilitated the study of the foraging ranges and the movements of pelagic seabirds. To date, most research has focused on the breeding season due to logistical constraints (Jouventin & Weimerskirch 1990). Recently, advances in transmitter design and attachment methods have facilitated the first studies during dispersal from breeding colonies (Nicholls *et al.* 1996, Nicholls *et al.* 1998). Despite this pioneering research, the habits and the habitats of far-ranging seabirds during the post-breeding dispersal remain largely unknown.

The Black-footed Albatross *Phoebastria nigripes* ranges throughout the North Pacific, from the Bering Sea to the tropics and from the west coast of North America to Japan. Black-footed Albatrosses leave their breeding colonies in the central and western North Pacific in July, disperse across subtropical and sub-Arctic latitudes (54°42'N–23°54'N), and return to their colonies by mid-October (Whittow 1993). During their dispersal at sea, Black-footed Albatrosses undergo an energetically demanding partial moult (Langston & Rohwer 1995), and gain extensive fat deposits (Frings & Frings 1961). The general understanding of the post-breeding distribution of this species comes from vessel-based surveys and fisheries bycatch (Wahl *et al.* 1989, Johnson *et al.* 1993). Little is known, however, about the movements and the behaviour of individual birds. Here we describe the use of satellite telemetry to study the movements of a male Black-footed Albatross during its pelagic travels off California.

METHODS

We fitted a male Black-footed Albatross with a Telonics ST-10 (Telonics Inc., Mesa, Arizona, USA) transmitter on 10 July 1997, during a cruise off southern California. The transmitter emitted a signal every 90 s and operated on a discontinuous duty cycle, alternating one week of transmissions with a week of blackout. The expected transmitter life span was 66 days. We followed the recommended instrument specifications and employed the attachment method suggested to minimize transmitter effects during long-term deployments (Fraser & Trivelpiece 1994, Gaunt *et al.* 1997). We attached the 90-g package (approximately 3% of the bird's body mass) with cable ties to a plastic base plate, which had been previously glued directly to the mid-dorsal feathers using quick-set marine epoxy. Even though all transmitters potentially affect a bird's behaviour, certain aspects such as energetics and provisioning rates are likely more heavily impacted than are others. We feel that the effect of the transmitter on the rate of movement and the ranging patterns of the instrumented albatross were likely negligible. DNA extracted from two body feathers was used to determine the bird's gender (Longmire *et al.* 1993).

The Service Argos satellite-tracking system assigns position fixes to one of six possible location quality classes (LQCs) according to their accuracy. We tested the performance of the transmitter by contrasting the quality of the satellite fixes reported by Argos with a known stationary location determined using Global Positioning Systems (GPS). We used satellite fixes from all six quality classes because their spatial resolution, within 10 km (Table 1), was appropriate for the study of large-scale movements.

To obtain a more accurate representation of the bird's trajectory, we excluded satellite fixes less than one hour and more than twelve hours from the previous location. We calculated the bird's net movement rate (speed) between adjacent locations using great-circle distances and rejected satellite fixes which required unrealistic flying speeds in excess of 80 km.h^{-1} (Spear & Ainley 1997). We overlaid the remaining tracks on weekly averages of sea surface temperature (SST) from National Ocean and Atmospheric Association (NOAA) satellites, and calculated the amount of time the bird spent over different water masses.

The rate of movement of a tagged albatross can be used to characterize its foraging behaviour during different times of the day (Jouventin & Weimerskirch 1990), and parts of its range (Nicholls *et al.* 1998). Specifically, we were interested in determining if the bird's response to light levels was similar to what had been previously reported for the Wandering Albatross *Diomedea exulans* (Jouventin & Weimerskirch 1990). We classified telemetry tracks as diurnal or nocturnal according to the timing of civil twilight, and defined those displacements that spanned sunset or sunrise as crepuscular. Additionally, we defined the phase of the moon according to the proportion of the lunar disk that was illuminated nightly. Thus, lunar phase ranged from 0% (new moon) to 100% (full moon) illumination.

RESULTS

The Black-footed Albatross was tagged 400 km from the coast of southern California, and travelled a minimum distance of 5067 km during 35 days (3140 km straight-line distance from the deployment site). The albatross ranged over large expanses of the Pacific Ocean, crossed water mass boundaries, and ventured over tropical, subtropical and Transition Zone waters (Fig. 1). It remained within Subtropical Frontal Zone (SFZ) waters along the edge of the California Current (SST: 18–20°C) for the first week of the deployment (11–17 July). During the first blackout period, it travelled a minimum distance of 550 km on a south-west heading. When the transmitter began its second operational period (26 July), the bird was over warm waters beyond the influence of the California Current (Roden 1971). During the second week of tracking (26–31 July), it covered a minimum of 734 km and remained over warm tropical water (SST: 20–22°C). The bird covered a net distance of 675 km north-west during the second blackout period. Finally, it moved rapidly across the Subtropical Frontal Zone (SST: 20–18°C) and subtropical water (SST: 18–16°C) to the north during the last week of the deployment (8–15 August), travelling a minimum of 2338 km. It reached the Transition Zone (SST: <16°C) two days before the third blackout period started. No more transmissions were received after 15 August. It is likely that the transmitter failed or was shed sometime during the third blackout period.

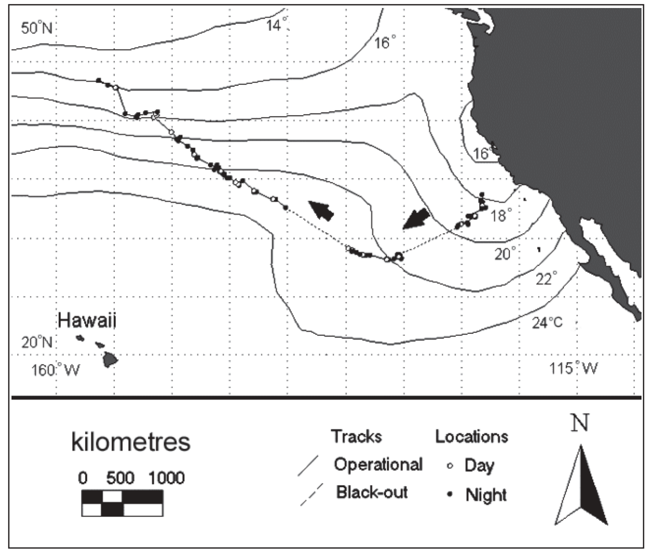

Fig. 1. *Track of a male Black-footed Albatross (11 July–15 August 1997) superimposed on weekly sea surface temperature imagery during the midpoint of the deployment (28 July–2 August 1997). Arrows indicate the bird's direction of movement. Remote sensing data provided by the Pacific Fisheries Environmental Laboratory.*

The rate of movement of the albatross varied significantly during different periods of the day (Kruskal-Wallis, H: 7.04, n: 111, df: 2, $0.05 < P < 0.025$; Table 2). Overall, the bird travelled faster during the day, covering 86% of the total distance travelled during 62% of the time. Furthermore, nocturnal/crepuscular movement rates were positively correlated with the phase of the moon (Spearman Rank Correlation, r_s: 0.394, n: 49, $0.01 < P < 0.005$). These results suggest that ambient light levels influenced the behaviour of the tracked albatross during the night. Similarly, Fernandez &

TABLE 1

Summary of telemetry information used in this study

Location of quality class	Sample size of transmitter test	Median error (km)	No. of satellite fixes obtained
3	32	0.3	2 (1.7%)
2	36	0.5	5 (4.3%)
1	32	0.8	22 (19.1%)
0	32	1.5	45 (39.1%)
A	31	1.8	23 (20%)
B	31	7.3	18 (15.7%)
Total	**194**		**115 (100%)**

TABLE 2

Variation in rate of travel (km.h^{-1}) with light conditions

Period of day	Mean	Median	Max.	Sample size
Diurnal	14.64	8.04	53.24	62
Crepuscular	13.07	5.15	64.73	33
Nocturnal	7.86	1.53	37.65	16

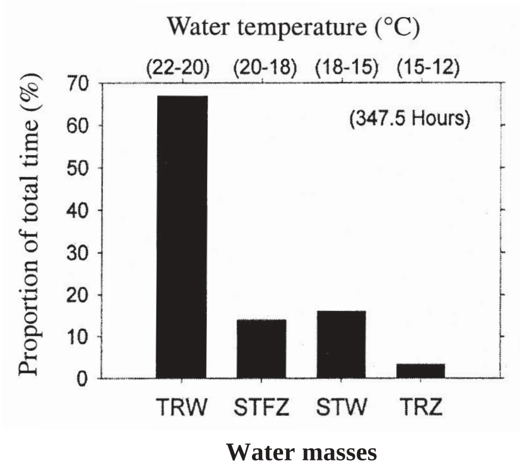

Fig. 2. *Water masses used by a male Black-footed Albatross (11 July–15 August 1997). TRW: Tropical Water, STFZ: Subtropical Frontal Zone, STW: Subtropical Water and TRZ: Transition Zone.*

Anderson (2000) reported that breeding Black-footed Albatross males equipped with immersion recorders landed on the water more frequently during daytime than at night. These findings suggest that daytime foraging is prevalent in Black-footed Albatrosses. It is likely that foraging behaviour is linked to the ability to see food, since they typically seize non-bioluminescent prey available at the surface (e.g. flying fish eggs), scavenge offal, and are known to ingest large amounts of floating debris (Whittow 1993).

DISCUSSION

The results of our study were not consistent with the idea that, off southern California, Black-footed Albatrosses remain within the highly productive, cool waters of the California Current, and restrict their movements to foraging ranges in the order of 80–120 km (Miller 1940, 1942). The tracked albatross covered a broad range of water temperature (22–15°C) characteristic of tropical, subtropical and transition zone waters (Roden 1971, Lynn 1986). It is particularly interesting that this albatross travelled from the Subtropical Frontal Zone, where the California Current mixes with subtropical waters to the south (Roden 1971), to the North Pacific Transition Zone separating subtropical and sub-Arctic waters (Lynn 1986). These findings are in agreement with evidence that Black-footed Albatrosses aggregate over water mass boundaries during summer and fall (Wahl *et al.* 1989, Johnson *et al.* 1993).

Technological advances and the development of improved transmitter attachment methods will facilitate further studies of far-ranging seabirds during their post-breeding dispersal at sea (e.g. Weimerskirch & Wilson 2000). This study illustrates some of the valuable information such research can provide marine ornithologists and underscores the exciting possibilities that lie ahead.

ACKNOWLEDGEMENTS

We thank Tom Hayward, the California Cooperative Fisheries Investigations (CalCOFI) organization, and the captain and crew of the NOAA research vessel *David Starr Jordan* for accommodating our research. David Anderson, Darrel Crow, Will Harrison, George Hunt, Gerald Kooyman, David Nicholls and Peter Prince answered a myriad of telemetry questions. Leona Chemwick and Lori Eggert sexed the bird. Tony Gaston and an anonymous reviewer provided suggestions that greatly improved an earlier version of this manuscript. This research was conducted under the auspices of United States Fish and Wildlife Service banding permit 22795-A to Dick Veit and University of California San Diego animal use permit 7-014-01 to Paul Dayton.

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