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Short note
Diving depths of albatrosses

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Introduction

Studies of diving in seabirds have mainly been confined to penguins, alcids and cormorants. There are few data on the depths to which other seabirds dive although some species are known to have considerable abilities for diving and swimming underwater e.g. shearwaters (Kuroda 1954, Brown *et al.* 1978), diving petrels (Prince & Jones 1992) and gannets (Adams & Walter 1993).

Albatrosses, with their long wings and light bodies are supremely adapted for wide-ranging flight (Pennycuick 1987) but are generally regarded as structurally unsuited for diving. Most recorded feeding methods involve surface-seizing (review in Harper *et al.* 1985), supplemented by shallow plunges and dives from the surface, usually in association with fishing trawlers discarding offal (Milledge 1977, Oatley 1979, Prince 1980, Harper 1987, Harrison *et al.* 1991, Thompson 1992). There are also three records of pursuit diving, two for black-browed albatrosses (Nicholls 1979, Harper 1987) and one for wandering albatross (Voisin 1981). To see if albatrosses routinely submerge (and what depths they attain) while on foraging trips to sea, we used light-weight capillary gauges (Burger & Wilson 1988) to record maximum dive depths for four species of albatross.

Methods

Fieldwork on black-browed and grey-headed albatrosses *Diomedea melanophris* and *D. chrysostoma* was carried out on Bird Island, South Georgia (54°00'S, 36°08'W) between 9–22 February 1993 and in August 1993 (wandering albatross *D. exulans* only), during the chick-rearing period. Data for light-mantled sooty albatrosses *Phoebetria palpebrata* were collected at Macquarie Island (54°40'S, 158°55'E) in November–December 1992, during the incubation period and at Iles Kerguelen (49°00'S, 65°00'E) in January 1993 during the brooding period. Capillary gauges were attached to 12 grey-headed, 22 black-browed and five wandering albatrosses that had returned to feed chicks and to 14 light-mantled sooty albatrosses before they departed to sea at the end of incubation or brooding shifts. The gauges were identical to those described by Prince & Jones (1992). At South Georgia the gauge was attached to feathers on the bird's tail using small cable ties; at Macquarie and Kerguelen gauges were attached to metal leg bands with adhesive tape. Deployment durations are summarized in Table I. For grey-headed albatrosses, although the average deployment duration was 3.3 days, 9 (75%) gauges were recovered within 48h. For black-browed albatrosses 9 (48%) gauges were recovered within 48h and 17 (80%) within 120h. The longer deployments on wandering and light-mantled sooty albatrosses reflect the much longer foraging trips of the former and with the latter, the use of some birds during incubation, when lengthy fasts are followed by long trips at sea. On recovery of the gauges, the length of tube still covered with indicator powder was measured to the nearest 0.5mm. Maximum depth attained was calculated by the formula given in Burger & Wilson (1988) and Prince & Jones (1992).

Results

All but one (from a black-browed albatross) of the 53 capillary gauges were recovered successfully. The mean maximum dive depths recorded are summarized in Table I. No wandering albatross reached 1m depth and for one bird no submersion was detectable. This was significantly different from the other species, in which every bird submerged and only five individuals (10%) failed to exceed 1m. For black-browed and grey-headed albatrosses, there were no significant differences between species in dive depths attained (with both having mean maximum depths at 2–3m and absolute maxima of 5–6m). Light-mantled sooty albatrosses reached significantly greater depths (mean and absolute maxima of 5m and 12m) than the two mollymawk species combined ($t = 2.52, P = 0.03$). For no species was there any significant relationship between dive depth and deployment interval, suggesting that overestimation of depth, due to the potential effects of repeated plunge-diving (see Burger & Wilson 1988), was not a problem.

Discussion

Previously, the only reports of albatrosses submerging, other than on shallow plunge and surface dives, were of a 20s submersion by a black-browed albatross (Harper 1987), of black-browed and shy albatrosses *Diomedea cauta* diving to about 2m for offal (Nicholls 1979) and of one wandering albatross plunging from 2m and then swimming underwater

Table I. Duration of deployment of depth gauges and mean maximum depths attained by albatrosses.

Species		Deployment (d)			Max depth (m)		
	n	mean	s.d.	range	mean	s.d.	range
Wandering albatross	5	10.8	7.1	4–19	0.3	0.2	0–0.06
Black-browed albatross	21	3.6	2.1	1–9	2.5	1.3	1.4–4.5
Grey-headed albatross	12	3.3	2.0	1–11	3.0	1.8	0.8–6.0
Light-mantled sooty albatross	14	8.5	7.1	3–18	4.7	3.4	0.7–12.4

(Voisin 1981). Our results reveal that some albatross species have hitherto unsuspected diving capabilities. Wandering albatrosses, however, appear to be distinct in not, or rarely, diving. Although we tested only 5 birds, this represented 54 days at sea including 19 days for the bird which made no detectable submersion. Given the mass (8–10kg) of wandering albatrosses, any plunge-diving would certainly result in detectable submersion. Thus the depths we recorded may simply reflect preening activity, in which birds, after submerging their head and back, immerse the rear of their body before commencing thorough preening (P.A. Prince personal observation).

The other species of albatross must be using some form of active diving to reach average depths of 2–5m, let alone maximum depths of 5–12m, even after allowing for the fact that gauges subjected to simulated plunge-diving overestimated depths by 39% and 9% on submergence to 5m and 10m respectively (Burger & Wilson 1988). Thus our data for albatrosses compare favourably with the information currently available for other Procellariiformes, some of which are known to utilise wing and foot-propelled pursuit diving as a principal feeding behaviour (Brown *et al.* 1978, Skira 1979, Ogi *et al.* 1980, Morgan 1982, Wood 1993). Recorded depths reached by short-tailed shearwaters *Puffinus tenuirostris* are 10–12m and possibly 20m (Skira 1979), by sooty shearwaters *P. griseus* 10m (Brown *et al.* 1981), by flesh-footed shearwaters *P. carneipes* 5m (Wood 1993) and by fluttering shearwaters *P. gavia* 2–3m (Wood 1993).

Because the gauges on every mollymawk and sooty albatross had recorded submersion, diving behaviour may even be a typical part of foraging activity for such species. The greater depths attained by light-mantled sooty albatrosses compared to the mollymawks might result from the former having a superior hydrodynamic design (slimmer bodies, long wings and pointed tails) and smaller size, combining to permit more efficient underwater travel. Indeed observations of many species of albatross taking baits off hooks on sinking long-lines behind fishing vessels indicate that the two species of sooty albatross are easily the most proficient divers (N. Brothers, personal communication, 1993).

How the albatrosses in our study were diving and whether it was associated with capture of live prey or with scavenging of dead, sinking prey (see Croxall & Prince 1994) is unknown. Useful insights come from a study, using identical techniques, of diving in cape gannets (Adams & Walter 1993), which recorded mean maximum depths of 5–9m (range 1.2–12.6m). Adams & Walter (1993) concluded that, using aerial plunging, the gannets could reach 2–4m but that to go deeper they would need to use active swimming. Albatrosses are less well-adapted than gannets for plunge-diving so it is unlikely that they could penetrate deeper than 2–3m. This suggests that light-mantled sooty albatrosses, whose mean and absolute maximum depths of 4.7m and 12.4m are very similar to the gannets, must regularly swim underwater. The two mollymawks could be more reliant on plunging but are likely to swim actively to reach maximum depths and to sustain submersions longer than 4–5s (the average duration of a gannet dive).

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