

## DIVING DEPTHS OF WHITE-CHINNED PETRELS<sup>1</sup>

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**Key words:** *White-chinned Petrel; diving depth; feeding behavior; Procellaria aequinoctialis.*

For many seabirds, the ability to submerge to capture prey is a key adaptation for their foraging behavior. Studies of diving in seabirds have typically featured species known to be virtually dependent on long, often deep, dives for their livelihood, e.g., penguins (reviewed in Croxall et al. 1993), alcids (reviewed in Burger 1991), cormorants (Wilson and Wilson 1988, Croxall et al. 1991, Wanless et al. 1991). As far as the size of the birds has permitted, these studies have proceeded from collecting data on maximum depth of dive via multiple maximum depths to continuous records of diving depth against time and recently, in the larger penguins, with simultaneous collection of velocity and/or locational data (Kooymann et al. 1992, Ancel et al. 1992).

Although some members of the Procellariiformes and of other families of the Pelecaniformes (e.g., Sulidae) have long been known as proficient divers (Kuroda 1954, Ashmole 1971, Brown et al. 1978), only anecdotal information on the depths they attain has been available until very recently. The use of light-weight capillary gauges (Burger and Wilson 1988) has created opportunities to obtain reliable quantitative data on the maximum depth reached by a wide variety of seabirds, particularly penguins and alcids (Burger 1991), but also Cape Gannets *Sula capensis* (Adams and Walter 1993), South Georgia Diving Petrels *Pelecanoides georgicus* (Prince and Jones 1992), and four species of albatross Diomedidae (Prince et al. 1994). With the exception of the highly specialized Pelecanoididae, the Procellariidae (petrels and shearwaters) are the best adapted of the Procellariiformes for diving. Species in this family may dive as much as 20 m deep (Skira 1979). This paper reports the first systematic quantitative data on diving depths for any species of petrel.

### METHODS

Fieldwork was carried out at Bird Island, South Georgia (54°00'S, 38°02'W) between 7–28 March 1993, approximately half-way through the chick-rearing period. Seventeen capillary gauges were attached to adult birds that had returned to feed their chicks. Most birds were sexed (by comparison of bill measurements between the two partners, males being the larger (N. Huin, unpubl. data)). The gauges were similar to those used by

Burger and Wilson (1988), Prince and Jones (1992) and Prince et al. (1994), that is 10 cm lengths of clear PVC tubing of 1 mm internal diameter, heat-sealed at one end, with soluble indicator powder introduced into the other end. The gauge was attached with adhesive tape to a metal leg band. Breeding burrows were checked twice daily and birds recaptured on subsequent visits to feed their chick. Birds were caught using a box, of dimensions 20 cm × 20 cm (aperture) × 50 cm (length) with a trapdoor at one end, inserted into the mouth of a burrow. (A trapdoor alone was readily circumvented by the bird.) Because White-chinned Petrels typically make lengthy foraging trips, averaging 3–4 days (Hall 1987), gauge deployments ranged from 1–12 days. To minimize disturbance to a species known to be sensitive (Hall 1987), only one gauge deployment was made per individual.

Gauges were recovered from 11 birds and the length of the tube still covered with indicator powder was measured to the nearest 0.5 mm. Maximum depth attained was calculated by the equation:

$$d_{\max} = 10.08 \left( \frac{L_s}{L_d} - 1 \right)$$

where  $d_{\max}$  is maximum depth (m),  $L_s$  is the initial length (mm) of undissolved indicator and  $L_d$  the length (mm) on recovery (Burger and Wilson 1988).

### RESULTS

The durations of gauge deployment and depths attained by each bird are given in Table 1. There was no significant difference in mean maximum depth between the sexes ( $t = 1.46$ ,  $P = 0.28$ ) nor in relation to the size of the bird (whether expressed as mass, or as mass corrected for body size using bill or wing measurements). However, the maximum depth recorded was positively related to gauge deployment duration (depth =  $2.58 + 0.624$  duration,  $r^2 = 0.47$ ,  $P < 0.05$ ), although this relationship was no longer significant if the deepest dive was excluded.

### DISCUSSION

The results indicate that White-chinned Petrels reach depths of 13 m. Such depths are not dissimilar to those reported for *Puffinus* shearwaters of 40–60% the mass of White-chinned Petrels. Thus Skira (1979) recorded Short-tailed Shearwaters *P. tenuirostris* reaching 10–12 m and possibly 20 m, Brown et al. (1981) reported Sooty Shearwaters *P. griseus* attaining 10 m and Wood (1993) recorded Flesh-footed and Fluttering shearwaters *P. carneipes* and *P. gavia* reaching 5 m and 2–3 m, respectively.

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TABLE 1. Maximum diving depths and gauge deployment durations of White-chinned Petrels at South Georgia.

Bird	Sex	Mass (g)	Deployment duration (days)	Maximum depth (m)
088		1,170	1	2.8
089	F	1,080	5	5.4
090	F	1,400	12	12.8
091	M	1,150	5	8.3
092	M	1,200	2	3.3
096	M	1,300	7	3.0
097	F	1,330	6	9.1
098		1,330	8	4.9
099		1,400	10	7.2
100		1,380	3	4.9
103	F	1,230	5	6.6

It is not easy to assess the accuracy of the results in the present study. Burger and Wilson (1988) found that gauges subjected to simulated plunge-diving overestimated depths by 39% and 9% on submergence to 5 m and 10 m, respectively. However, most observations on feeding by White-chinned Petrels indicate that they rarely plunge-dive (and then from heights of only 0.3–0.5 m (M. J. Whitehouse, pers. comm.), mainly making surface dives (Harper et al. 1985), so overestimation of dive depth is unlikely from this source. Wanless et al. (1991) suggested that gauges on European Shags *Phalacrocorax aristotelis* not recovered within 24 hr gave less plausible (overestimated) results. In White-chinned Petrels, there was an increase in maximum recorded dive depth with deployment duration, but this was small and could well simply reflect the greater likelihood of recording deeper dives the longer the gauge is in operation. Overall, even if overestimating dive depth by 10%, my data indicate that diving White-chinned Petrels regularly attain 5 m and can reach 12 m.

White-chinned Petrels observed making wing-propelled surface dives had dive durations that averaged 2.4 sec (SD 2.0, range 0.4–6.3 sec,  $n = 14$ ) (M. J. Whitehouse, pers. comm.). Another observer reported similar dives lasting at least 5 sec (J. R. Ashford, pers. comm.). These records probably substantially underestimate the breath-hold capacity of White-chinned Petrels but if they can travel at 2 m sec<sup>-1</sup> (as typically recorded for wing-propelled penguins (Kooyman et al. 1992) and alcids (Swennen and Duiven 1991) underwater), then on a 6 sec dive they could reach 6 m, which is the average depth recorded by the birds in the study.

Thus, there is little reason to believe that the data reported here are not representative of the diving abilities of White-chinned Petrels. The distribution of maximum depths of White-chinned Petrels is very similar to the range of dive depths measured for the Light-mantled Sooty Albatross *Phoebastria palpebrata* (Prince et al. 1994), the species most similar in body proportions to White-chinned Petrels (Pennycuik 1982, Pennycuik et al. 1984). That all birds in the sample reached about a depth of 3 m or more suggests that such diving may be a regular part of foraging behavior in White-

chinned Petrels. The only study of the species' diet, at South Georgia in 1985/1986 (Croxall et al., in press), showed that Antarctic krill *Euphausia superba*, lanternfishes Myctophidae and oceanic squid (mainly the ommastrephid *Martialia hyadesi*) were the main prey. All these frequently occur in large swarms or shoals at or near the sea surface (Croxall et al., in press) and would probably be very suitable targets for pursuit and capture on relatively short and shallow dives.

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## MULTIPLE CASES OF POLYGYN Y IN THE BLACK-CAPPED CHICKADEE: A POSSIBLE ADVANTAGE TO THE PRIMARY FEMALE<sup>1</sup>

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*Key words:* Polygamy; polygyny; Black-capped Chickadee; *Parus atricapillus*; female choice.

The Black-capped Chickadee, *Parus atricapillus*, is almost strictly monogamous with only one reported case of polygyny (Smith 1967, Smith 1991) and two reported cases of polyandry (Waterman et al. 1989, Howitz 1991). Here I report several cases of bigyny occurring during one breeding season within a small study area. The primary female was identified as the first female to nest on the territory.

In 1992, there were three cases in which female chickadees constructed nests on territories of mated pairs in the Picnic Point area of the University of Wisconsin–Madison. Two cases occurred in an area with about ten nesting pairs. The males assisted primary females with excavation of the nesting cavities, whereas secondary females excavated alone. Copulation with the secondary female while the primary female incubated was observed in one case. In the second case, although copulation with the secondary female was not observed, the male defended her nesting area, as demonstrated when he sang “*fee-bee*” in response to playbacks of *fee-bee* song within 20 m of her nesting cavity.

In both cases, the nests of the primary females were depredated, and the primary females subsequently usurped the nests of the secondary females. Secondary females were not seen in the nesting area after usurpation. The third case was discovered in a nearby woods after the eggs of the secondary female were laid. This nest resided within the defended area of the male, as indicated by his response to playbacks of *fee-bee* song. The nest of the primary female fledged, and the nest of the secondary female was depredated after hatching.

The degree to which secondary females were tolerated on the territories was unclear, but they were probably excluded from the nest vicinity of the primary female. In one case the primary female was once observed to chase the secondary female a short distance from the nest but not completely off the territory. In another case, the two females and the male foraged together without aggression on the territory but away from the nest site of the primary female prior to egg laying. The primary female was once observed to supplant the secondary female who was peering into the primary female’s nesting cavity. Aggression is also known to occur between resident females in polygynous species (Searcy 1988, Yasukawa et al. 1992).

Why polygyny was common in the Madison study area during the breeding season of 1992 is unclear. There were no other reported cases of polygyny in the previous three years of the study. In the related Blue

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