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## Diving Depths of Atlantic Puffins and Common Murres

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The diving ability of an aquatic bird is an obvious, important determinant of its foraging niche. Piatt and Nettleship (1985), for example, showed that the depths attained by four species of alcids in Newfoundland were correlated positively with body mass, which suggests that these similar, sympatric species might exploit different parts of the water column. The development of miniature gauges to measure depth (Kooyman et al. 1971, 1982, 1983; Wilson and Bain 1984a), speed (Wilson and Bain 1984b), and distance traveled (Wilson and Achleitner 1985) has greatly facilitated studies of diving in birds.

We report maximum diving depths, measured with gauges attached to free-living birds, attained by Atlantic Puffins (*Fratercula arctica*) and Common Murres (*Uria aalge*) off Gull Island (47°16'N, 52°47'W) in Witless Bay, Newfoundland. Piatt and Nettleship's (1985) study, on the depths at which alcids were trapped in fishing nets, was made in the same area.

We used depth gauges similar to those used by Kooyman et al. (1971) and Adams and Brown (1983), comprising lengths of flexible plastic tubing sealed at one end and coated internally with water-soluble powder (icing sugar). As water was forced down the tube when submerged, the powder dissolved, recording the maximum depth attained (Adams and Brown 1983). The tubing used was Intramedic® polyethylene (PE 160, i.d. 1.14 mm, Clay-Adams, Inc., New York) and Tygon® (R-3603, i.d. 1.6 mm, Norton Specialty Plastics Div., Akron, Ohio). The latter type was found to be less likely to leak or to be damaged.

Sample gauges were calibrated by being lowered

from a boat to depths up to 150 m in the study area. The coefficient of variation of the readings on 10 gauges was within 4% at any depth. The gauges were not affected significantly by the rate of descent (5 gauges lowered at 1.38 and 5 at 0.40 m/s to depths of 50 and 70 m;  $P > 0.10$  in each case, Mann-Whitney *U*-test), the duration of immersion (6 gauges immersed at 50 m for intervals of 0.5, 1.0, 2.0, 4.0, and 8.0 min;  $P > 0.10$ , two-tailed Kruskal-Wallis test with tied ranks), or repeated immersions (6 gauges immersed 5 times to 5 m and 5 times to 50 m;  $P > 0.10$  in each case, two-tailed Kruskal-Wallis test).

Gauges were 145 mm long for puffins and 200 mm long for murres. They were attached to metal leg bands with short (10 mm) lengths of string. The tubing caused no discernible impediment to the birds during flight or on land, and was not long or flexible enough to entangle their legs. The string would wear through, releasing the gauge, should it not be recovered. These small, trailing gauges were unlikely to have had the same negative effects on the streamlining and swimming of birds as found with harness-mounted devices (Wilson et al. 1986).

All birds studied were breeding adults tending chicks. Puffins were caught in nooses set in their nesting burrows, and murres were caught with a noose pole. Fifteen gauges, of which 10 were undamaged, were recovered from puffins, out of 46 deployed. Two gauges, both undamaged, were recovered from murres out of 29 deployed. The greatest limitation of this technique is the ability to recapture birds without undue disturbance.

The Atlantic Puffins in our sample, totaling 75 bird-days, usually foraged at depths less than 60 m (Table 1). Only one puffin exceeded this depth, diving to 68 m during 17 days of foraging. Piatt and Nettleship

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TABLE 1. Maximum diving depths (m) attained by Atlantic Puffins and Common Murres breeding at Witless Bay, Newfoundland.

Species	Type of gauge <sup>a</sup>	Dates gauges deployed	No. days deployed	Maximum depth $\pm$ 95% confidence intervals
Puffin	P	9-14 July 1984	5	41 $\pm$ 1
Puffin	P	9-20 July 1984	11	47 $\pm$ 3
Puffin	P	12-21 July 1984	9	43 $\pm$ 2
Puffin	P	14-21 July 1984	7	41 $\pm$ 1
Puffin	T	23-25 July 1984	2	52 $\pm$ 4
Puffin	T	21-26 July 1984	5	52 $\pm$ 4
Puffin	P	12-29 July 1984	17	68 $\pm$ 7
Puffin	P	16 July-2 Aug 1984	17	40 $\pm$ 1
Puffin	T	24-25 July 1985	1	22 $\pm$ 1
Puffin	T	22-23 July 1985	1	37 $\pm$ 3
Murre	P	15-18 July 1985	3	67 $\pm$ 7
Murre	T	11-13 July 1985	2	138 $\pm$ 10

<sup>a</sup> P = Intramedic® polyethylenene, T = Tygon® tubing (see text).

(1985) found that Atlantic Puffins were caught regularly in nets at 0-40 m but never in nets set deeper than 60 m.

Our small sample from Common Murres (5 bird-days) shows that these birds dived to at least 138 m (Table 1). Piatt and Nettleship (1985) found that most (80%) Common Murres were caught in nets at 0-50 m but some were caught at 180 m, the deepest that nets were set in the Witless Bay area. Clearly, these birds can dive considerably deeper than the apparent limits for Atlantic Puffins. The proportions of time spent foraging at various depths by these two species remain unknown.

The birds' diving abilities would determine their capacity to exploit deep schools of fish (Brown and Nettleship 1984) and might play a role in ecological segregation of these and other alcids (Piatt and Nettleship 1985). Common Murres and Atlantic Puffins off Newfoundland prey primarily on capelin (*Mallotus villosus*) and occasionally on sand lance (*Ammodytes* spp.) (Brown and Nettleship 1984). These fish are, at times, most common at or near the ocean floor (Winters 1983, Brown and Nettleship 1984), where they might be accessible to murres but not puffins. For example, puffins restricted to the upper 60 m would have access to only 13% of the sea floor, within a 20-km radius of Gull Island, whereas a murre diving to 180 m would have access to 97% of the sea floor (data from Canadian Hydrographic Survey map).

The maximum depths (180 m and 60 m, respectively) usually attained by Common Murres (average body mass 930 g) and Atlantic Puffins (510 g) were comparable to those usually reached by penguins of

much larger mass. Chinstrap Penguins (*Pygoscelis antarctica*; 3.5 kg) had a maximum diving depth of 70 m, and 90% of their dives were less than 40 m (Lishman and Croxall 1983). Maximum depths of 19 Gentoo Penguins (*P. papua*; 5-6 kg) did not exceed 40 m except for one bird that exceeded 70 m (Adams and Brown 1983). Wilson (1985) reported a maximum depth of 130 m for Jackass Penguins (*Spheniscus demersus*; 3.2 kg), although most birds foraged at depths of less than 30 m. Only the very large penguins have been recorded to dive far deeper than Common Murres. King Penguins (*Aptenodytes patagonica*; 12-14 kg) frequently dived beyond 100 m and one was recorded below 240 m (Kooyman et al. 1982), while Emperor Penguins (*A. forsteri*; 20-24 kg) have been recorded deeper than 265 m (Kooyman et al. 1971). Our impression is that the underwater swimming abilities of alcids are comparable to those of the penguins.

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