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Diets of northern fulmar (*Fulmarus glacialis*) chicks in the northwest Atlantic Ocean

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Abstract Northern fulmars (*Fulmarus glacialis*) have recently expanded their breeding range in the northwest Atlantic Ocean. We studied their diet in their largest colony in the northwest Atlantic on Funk Island, eastern Canada, by collecting dietary samples from chicks during 1999 and 2000. Fish, primarily capelin (*Mallotus villosus*), and offal from commercial fisheries were the most common foods in the diets of fulmar chicks. Crustaceans were also common prey fed to the chicks. Squids (*Gonatus fabricii*) were an important food in 2000. Chick diets varied considerably between the 2 years of the study. The diets of northern fulmar chicks on Funk Island were opportunistic and similar to those of chicks at other colonies in the eastern and northern North Atlantic Ocean. Compared to other regions in the North Atlantic Ocean, the diet of birds on Funk Island seems to be most similar to those from Iceland, and least resemble those from Shetland. Long-term studies of the feeding ecology on northern fulmars may be helpful in discerning factors influencing changes in the species' distribution and abundance.

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Introduction

Northern fulmars (*Fulmarus glacialis*) have recently expanded their breeding range in the northwest Atlantic Ocean, with the first successful breeding attempts confirmed at four localities during the 1970s (Stenhouse and Montevecchi 1999a). Since then, fulmars have been observed breeding at ten other localities, and prospecting at six others. The small colonies in this region are (relatively) stable at some sites (e.g. Outer Gannet Island; Gull Island, Witless Bay), decreasing at some sites (Baccalieu Island; Cape St. Mary's) and increasing at others (Funk Island; Great Island, Witless Bay). These new colonies in the northwest Atlantic Ocean are composed almost entirely of light-morph adults (LL: Fisher 1952), suggesting that founding birds originated in European colonies rather than in the Canadian Arctic where most of the fulmars are dark-morph (Hatch and Nettleship 1998).

In order to better understand this range expansion from a warmer European region to a colder low-Arctic oceanographic region in the northwest Atlantic Ocean, it is useful to assess and compare diet composition of fulmars in these regions. There have been a number of recent studies of northern-fulmar chick diets (e.g. Phillips et al. 1999; Cherel et al. 2001; Ojowski et al. 2001), but none from the western Atlantic Ocean.

Here we report on the diets of northern fulmar chicks in 1999 and 2000 on Funk Island, the species' largest colony in the northwest Atlantic Ocean. We compare these diets with those of fulmar chicks elsewhere in the Atlantic Ocean and those of other marine birds in the northwest Atlantic Ocean.

Materials and methods

Dietary samples were collected from northern fulmar chicks on Funk Island (49°45′N, 53°11′W), Newfoundland, Canada, on 5 August 1999 and 7 and 8 August 2000. Chicks were induced to regurgitate by approaching them at their nests, and then inverting

them over a large plastic bucket once they began to spit steady streams of stomach oil. Samples were emptied from the bucket into a plastic bag with a solution of 90% ethanol. Each chick was sampled only once.

Samples were later examined in a laboratory at the University of Kiel using a binocular microscope. All diagnostic structures were stored dry or in 70% alcohol until identification. Prey species were identified to the lowest possible taxonomic level from otoliths and other hard parts, such as vertebrae, premaxillae (fish), exoskeletons (crustacean) or beaks (squid), using the available literature (Lincoln 1979; Clarke 1986; Härkönen 1986; Hayward and Ryland 1995; Watt et al. 1997) and reference collections. Offal could be differentiated from prey fish by visible intestines such as guts, and absence of hard parts, such as bones. It is inherent to this sampling methodology that highly digestible food (possibly including offal) might have been underestimated, while food with hard parts could be found consistently (e.g. Duffy and Jackson 1986). Calculations of fish lengths and fish mass were made by using regression equations for otoliths (Härkönen 1986). Calculations of squid mass and dorsal mantle length were made by using regression equations of beak measurements (Clarke 1986).

Results

Fish, primarily capelin (*Mallotus villosus*), and offal from commercial fisheries were the most common foods in the diets of fulmar chicks (Table 1). Crustaceans were also common prey fed to the chicks. Of these, euphausiids (*Meganyctiphanes norvegicus*), decapods (*Pasiphae multidentata*, *Pandalus borealis*) and amphipods (*Hyperia galba*) were noted. Squids (*Gonatus fabricii*) were an important food in 2000.

Chick diets varied considerably between the 2 years of the study. Three major prey groups (fishes, crustaceans, decapods) were more common in prey samples in 1999 than in 2000, whereas squid were found in more diet samples in 2000.

The mean length and mass of capelin ($n = 3$) was 11.7 ± 1.0 cm and 10.9 ± 2.7 g. Squids (*G. fabricii*; $n = 13$) had a mean mass of 19.5 g (SD = 3.7, min = 12.6, max = 23.8) and a mean dorsal mantle length of 21.0 mm (SD = 1.5, min = 18.0, max = 22.7).

Table 1 Dietary composition of northern fulmar chicks on Funk Island, Newfoundland, 1999 and 2000. The frequency of occurrence (%) of different prey species and groups is shown

Year	1999		2000	
Sample size (chicks)	22		21	
Species	*n*	%	*n*	%
Fishes	20	90.9	16	76.2
Osmeridae				
Mallotus villosus	18	81.8	4	19.0
Isospondylae				
(possibly *Argentina silus*)	6	27.3	0	0.0
Fish offal	2	9.1	9	42.9
Crustacea	14	63.6	10	47.6
Euphausiacea				
Meganyctiphanes norvegicus	0	0.0	2	9.5
Decapoda	2	9.1	3	4.3
Pasiphae multidentata	2	9.1	0	0.0
Pandalus borealis	0	0.0	1	4.8
Decapoda indet.	0	0.0	2	9.5
Amphipoda				
Hyperia galba	0	0.0	1	4.8
Crustacea indet.	12	54.5	9	42.9
Cephalopoda				
Gonatus fabricii	0	0	8	38.1

Discussion

Comparison with northern fulmars at other North Atlantic colonies

The diets of northern fulmar chicks at the largest colony in the northwest Atlantic Ocean were similar to those of chicks at other colonies in the eastern and northern North Atlantic Ocean (e.g. Furness and Todd 1984; Phillips et al. 1999; Cherel et al. 2001). Though sample size in our study might be considered small, it is large relative to the breeding population on Funk Island, and from the results it is obvious that diets varied considerably between 1999 and 2000. Such variation is common at other colonies (reviewed in Phillips et al. 1999), as northern fulmars are opportunistic and generalist predators, more than many other seabirds, which feed on a variety of prey in addition to scavenging for fishery discards and offal (Camphuysen and Garthe 1997; Hatch and Nettleship 1998). The variability exhibited in diet is reflective of the species' opportunistic foraging strategy, and likely a major aspect of the fulmar's ability to show extensive breeding-range expansion throughout the North Atlantic Ocean (Fisher 1952).

How does the dietary spectrum of fulmars from Funk Island fit into the overall pattern? Capelin has been shown to be a primary food of northern fulmars in a recent study in the Barents Sea; Cherel et al. (2001) calculated that capelin made up 87% of the food mass of adult chick-rearing fulmars. Capelin has also been found in 26–37% of diet samples of adult fulmars from northern and eastern Iceland, and in 14–57% of samples of adults from western Greenland (Phillips et al. 1999). High proportions of fisheries' offal are typical for northern fulmars from Shetland (Thompson et al. 1995; Ojowski et al. 2001), and offal is also a regular dietary item in other areas of the British Isles, around Iceland and in the Barents Sea (Phillips et al. 1999). Finally, crustaceans are also an important food delivered to fulmar chicks at colonies throughout the North Atlantic, though apparently less so in Shetland colonies (Phillips et al. 1999). Comparing the overall food habits of northern fulmars studied to date, the diet of birds on Funk Island seems to be most similar to those from Iceland and least resemble those from Shetland. However, the generalized dietary patterns demonstrate the species' catholic and opportunistic diet breadth.

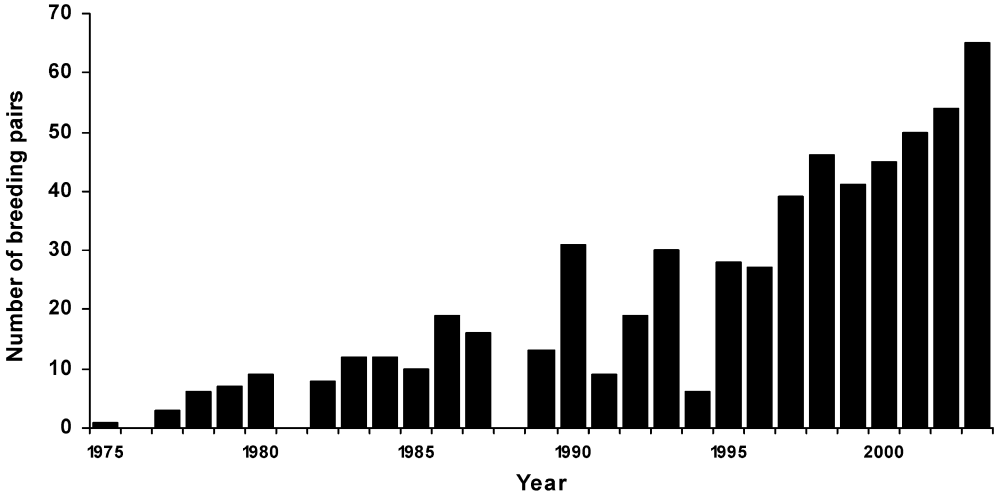

Fig. 1 Population growth of breeding northern fulmars on Funk Island, the species' largest colony in the western Atlantic, from 1975 to 2003. No counts were carried out in 1976 and 1981. In 1988, no nests were established due to the presence of an Arctic fox (*Alopex lagopus*) on the island

Comparison with other marine birds of the northwest Atlantic

Most marine birds and mammals in the northwest Atlantic Ocean, as well as fish such as cod (*Gadus morhua*), rely heavily on capelin as a dietary staple (Lavigne 1996; Bundy et al. 2000; Montevecchi 2001). Among birds, capelin consumption is most pronounced in common murres (*Uria aalge*; Davoren and Montevecchi 2003), but is also important in Atlantic puffins (*Fratercula arctica*; Rodway and Montevecchi 1996) and in northern gannets (*Morus bassanus*; e.g. Montevecchi and Myers 1997). Capelin fed to fulmar chicks are somewhat smaller than those that common murres (*U. aalge*) feed to their chicks, and within the range of capelin sizes that Atlantic puffins feed to their chicks (Rodway and Montevecchi 1996; Russell 1998).

Similar to many species of gulls, fulmars opportunistically take advantage of fishery discards and offal. Circumstances changed radically in 1992 when the eastern Canadian ground-fishery was closed and massive tonnages of fishery discards and offal were no longer available. These circumstances created major problems for scavenging gulls, which directed considerable predatory attention to smaller seabirds, such as black-legged kittiwakes (*Rissa tridactyla*), Atlantic puffins, and Leach's storm-petrels (*Oceanodroma leucorhoa*; Regehr and Montevecchi 1997; Stenhouse and Montevecchi 1999b). The fishery closure would also have been expected to have a negative influence on northern fulmars, although the longevity and the late age of first breeding may have hidden such effects so far. Interestingly, however, the breeding population of fulmars on Funk Island has continued to increase to 65 pairs in 2003 (Fig. 1). This observation is consistent with the conclusion drawn from the North Sea and the northwest Atlantic that, although fishery waste is an important food for northern fulmars, at-sea distribution and abundance can be much better explained by hydrographic regimes and associated natural prey, such as small pelagic fish and zooplankton (Brown 1970; Camphuysen and Garthe 1997).

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