

NOTES ON THE DIET OF
NORTHERN FULMARS *FULMARS GLACIALIS*
FROM BJØRNØYA (BEAR ISLAND)
HET VOEDSEL VAN NOORDSE STORMVOGELS
OP BERENEILAND

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ABSTRACT

Between 10 June and 14 August 1980, Northern Fulmars were captured and either ringed and released (n= 153) or collected (n= 22) on Bjørnøya (Bear Island, Norway, western Barents Sea). Food remains of the individuals that regurgitated 'considerable' amounts during handling were collected and analysed (13 samples). In addition, the stomach contents of the collected specimens were studied. From regurgitated food (i.e. contents of proventriculus) an entirely different impression of the diet was obtained than from the complete examination of proventriculus and gizzard contents in collected specimens. Only fish flesh and crustaceans were frequently regurgitated, whereas hard parts such as fish eye-lenses, squid eye-lenses and -beaks, jaws of nereid worms, and plastic particles numerically dominated the prey items in stomachs of collected birds. The absence of crustaceans in an earlier study may thus be attributed to the method of study which was entirely based on stomach contents. In total 18 out of 22 gizzards (i.e. 82%) contained plastic particles (range 1-21 items).

Bjørnøya is a remote island in the western end of the Barents Sea, just to the south of Spitsbergen (figure 1). Northern Fulmars *Fulmarus glacialis* breed in large numbers on the island (Norderhaug *et al.* 1977) and an expedition was organised in 1980 to study the morphology of this population (Van Franeker & Luttkik 1981, Van Franeker & Wattel 1982). Northern Fulmars were caught and either ringed and released after measurements were taken, or collected for the collections of the Zoological Museum in Amsterdam. When substantial amounts of food were regurgitated during handling, the food remains were collected opportunistically. From the birds that were collected, the contents of proventriculus and gizzard were preserved. Because the diet of the Northern Fulmar at Bjørnøya had only once been studied earlier (Duffey & Sergeant 1950), it was decided to analyse and describe the food remains in order to contribute to our knowledge of the feeding habits of these birds in this part of the western Barents Sea.

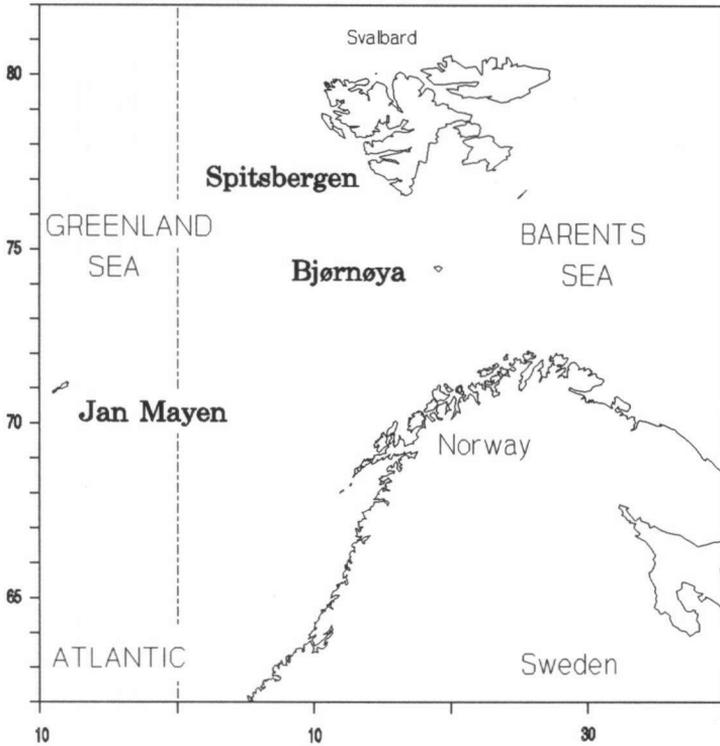


Figure 1. Bjørnøya (Bear Island) as it is located in the western end of the Barents Sea, south of Spitsbergen in the Svalbard archipelago.

Figuur 1. Bjørnøya (Bereneiland), zoals dat in het westelijke deel van de Barentz Zee ligt, juist ten zuiden van Spitsbergen.

MATERIAL AND METHODS

A total of 153 Northern Fulmars were caught, ringed and released, by using a long-handled net while sitting at the cliff edge, mainly at the SE and S side of the island in July and August 1980. Most birds regurgitated at least some oil, but this was not always recorded. In the chick rearing period, some individuals produced a considerable amount of food and after 23 July, such samples were collected ($n=13$). None of the birds were forced to regurgitate during handling by means of 'Water Off Loading', and, hence, the amount of food produced by the birds was probably seldom the full contents

Table 1. Components of food regurgitated by 13 Northern Fulmars handled on Bjørnøya, July-August 1980. Presence is indicated by '+' for small fish, fish offal, plants, and unidentified remains ('unknown'). Otherwise, where possible, the number of items is indicated.

Tabel 1. Belangrijkste componenten van het voedsel van 13 in juli en augustus 1980 op Bjørnøya gevangen Noordse Stormvogels. De aanwezigheid van vis, plantaardig materiaal en onbekende prooiresten is aangegeven door middel van een '+' overigens is zo mogelijk het aantal getelde exemplaren gegeven.

sample	1	2	3	4	5	6	7	8	9	10	11	12	13	n=	%
small fish	+	+		+	+	+	+		+	+	+			9	69
fish offal												+		1	8
Crustacea	2		+			6		9			6		210	6	46
plastic								1						1	8

of their proventriculus. In addition to the ringed birds, 22 individuals collected. Their stomach contents were collected and kept for later identification. Samples were kept in 70% alcohol and identified to the lowest possible taxonomic level. Unfortunately, the contents of gizzard and proventriculus from the collected birds were not kept apart, but placed in the same container.

RESULTS

The composition of regurgitated matter and stomach contents was strikingly different. The regurgitated samples, probably food loads brought home for the chick, comprised whole fish or large pieces of fish and virtually undigested crustaceans, but very few hard particles (table 1). Few fleshy remains of fish, crustaceans or nereid worms were encountered in the stomach contents, in which hard, slowly digesting objects such as eye-lenses, squid-beaks, nereid jaws, plastic particles and grit predominated (table 2). The identifiable prey items are described below.

FISH (PISCES) Fish were important prey items, considering their occurrence in 10 out of 13 samples of regurgitated prey (77%) and in 20 of 22 stomach contents (91%). Fish remains in the stomach were, with few exceptions, only eye-lenses (mean 7.5 ± 6.9 lenses per stomach, $n=22$, presence 91%), none of which could be identified to species. In two stomachs (presence 9%), some small fish bones were encountered which also did not contribute to the identification of these prey. Among the regurgitated fish, more useful remains were found. At least four (#1, 2, 4, and 6), and perhaps another two

Table 2. Stomach contents of 22 Northern Fulmars collected on Bjørnøya, July (#1-14) and August 1980 (#15-22). Presence is indicated by '+', otherwise, where possible, the number of individuals or items is indicated (see legend).

Tabel 2. Maaginhouden van 22 in juli (#1-14) en augustus 1980 (#15-22) op Bjørnøya verzamelde Noordse Stormvogels. De aanwezigheid is aangegeven door middel van een '+', overigens is zo mogelijk het aantal getelde exemplaren of het aantal individuele resten gegeven (zie legenda).

sample	1	2	3	4	5	6	7	8	9	10	11		
fish*		1	1	22	6	4	3	3		24	11		
Crustacea				+									
Cephalopoda**	1	1	2	4						5			
Nereid worms***		100	27	14	390	2	2			10	42		
plastic	3	1	3	15		3	1		1	1	21		
grit	1	3		1	1	1					2	4	
feathers									1				
others										+			
unknown		+	+	+				+			+	+	
sample	12	13	14	15	16	17	18	19	20	21	22	n=	%
fish	15	10	5	17	3	5	3	11	2	11	7	20	91
Crustacea												1	5
Cephalopoda			2	1				1		1		9	41
Nereid worms	3	7	5	6	1		4	9	3	7	2	18	82
plastic	1	5	9	7			4	3	4	5	7	18	82
grit	1	1				1	1			2	1	13	59
feathers												1	5
others			+	+			+					4	18
unknown		+					+	+	+	+		11	50

* aantal ooglenzen number of eye lenses, ** bekhelften lower or upper beak halves, *** linker- of rechterkaken left or right jaws

samples (#9, 11) contained the remains of Capelin *Mallotus villosus* (table 3). One sample (#5) contained Polar Cod *Boreogadus saida*, another (#7) held Norway Haddock *Sebastes viviparus* and Saithe or Pollack *Pollachius* spp. Unidentified small gadoids were found in sample #10 and remains of some large fish, which either had been floating dead when taken by the Fulmar or which were discarded by a fishing vessel, were found in another two samples (#4, #12). Polar Cod, Norway Haddock and Saithe or Pollack were all in a size range of 90-135 mm. Reconstructing the remains of some partly digested Capelin, these fish were on average slightly longer (estimated total length 120-180 mm). The bones of unidentified fish found in #4 and #12 were of large fish of which it is doubtful that the birds could have swallowed them whole. These were probably the remains of (discarded?) fish which were ripped to pieces by the Fulmars, just as is seen often near commercial fishing vessels (Hudson & Furness 1989, Camphuysen *et al.* 1995).

Table 3. Fish remains in regurgitated food of 10 Northern Fulmars ringed and released in 1980 (cf. table 1). OL= otolith length (mm), FL= fish length (mm).

Tabel 3. Visresten in braaksels van 10 Noordse Stormvogels die werden geringd in 1980 (vgl. tabel 1). OL= lengte otoliet (mm), FL= vislengte (mm)

sample ringno.	fish remains
1	456458 2 partly digested Capelin <i>Mallotus villosus</i> , 6 eye-lenses.
2	456465 3 partly digested <i>Mallotus villosus</i> , 1 eye-lens.
4	456531 1 <i>Mallotus villosus</i> and skull remains of large, unidentified (discarded?) fish.
5	456538 9 otoliths of Polar Cod <i>Boreogadus saida</i> (OL [5.6, 5.6], [4.2, 4.2], 4.1, [3.6, 3.6], 3.5, and unmeasurable), 10 eye-lenses, partly digested fish flesh. From the otoliths the presence of at least 5 fish can be deduced, varying in size from FL 90-134 mm (Härkönen 1986).
6	456542 otolith and 2 partly digested <i>Mallotus villosus</i> .
7	456543 5 otoliths, 21 eyelenses and over 100g fish flesh (weighed during sampling). Three otoliths were of Pollack or Saithe <i>Pollachius</i> spp. (OL 4.5-5.2), 2 otoliths were of Norway Haddock <i>Sebastes viviparus</i> (OL both 3.7). The size of the otoliths indicates a FL of c. 90-120 mm in <i>Pollachius</i> spp. and 129 mm in <i>S. viviparus</i> (Härkönen 1986).
9	456556 1 worn otolith probably of gadoid fish, 13 eyelenses and a large amount of pieces of spinal columns similar to those of <i>Mallotus villosus</i> (but not identified with certainty). This sample weighed ca. 60g when collected.
10	456557 10 eyelenses in great quantity of fish flesh (ca. 50g when collected), without any further identifiable remains.
11	456584 at least 10 small fish, probably <i>Mallotus villosus</i> . This sample, which included some tiny remains of Euphausiacea, weighed ca. 100g when collected.
12	456587 big lump of fish liver, large bones of heavy skull (i.e. apparently discards).

CRUSTACEANS (CRUSTACEA) Only one of the 22 collected Fulmar stomachs contained crustaceans: the tiny and nearly fully digested remains of a small, unidentified species. Six of the birds which regurgitated produced crustaceans, including Euphausiids (5x) and Amphipods (2x; table 2). Sample #6 was lost before the identification sessions could take place. Euphausiids were usually digested too far to enable identification, but one sample held 209 eye pairs and a substantial number of complete individuals which could be identified as *Thysanoessa inermis*. Euphausiacea are krill-like creatures which are probably mainly caught at night when they rise to the sea surface. One unnumbered sample contained remains of a large, unidentified Decapod.

SQUID (CEPHALOPODA) Contrary to the previous two prey types, fish and crustaceans, squid remains were *only* encountered in the stomach contents of collected birds (table 2ab) in the form of moderately worn squid beaks. Squid beaks were found in 9 samples (41%, n= 22), ranging in numbers from 1 to 5 beak halves (i.e. a maximum of three individual squid per bird). None of

Table 4. Remains of crustaceans in regurgitated food of 6 Northern Fulmars ringed and released in 1980 (cf. table 1) and an extra sample of food regurgitated by a collected bird.

Tabel 4. Resten van crustacea (garnaalachtigen) in braaksels van 6 Noordse Stormvogels die werden geringd in 1980 (vgl. tabel 1) en een extra monster van voedsel dat werd opgebraakt door een verzamelde Noordse Stormvogel.

sample ringno.	fish remains
1	456458 digested remains and eye pairs of 2 Euphausiacea.
3	456468 "crustaceans regurgitated", but the sample is lost.
6	456542 digested remains and eye pairs of 6 Euphausiacea.
8	456550 digested remains of 7 <i>Parathemisto</i> spp. and 2 Euphausiacea.
11	456584 digested remains and eye pairs of 6 Euphausiacea.
13	456634 remains and eye pairs of 209 <i>Thysanoessa inermis</i> and the head of an amphipod (Hyperiididae). Sample weighed ca. 30g when collected.
-	- Decapoda spp., remains of large shrimp

the squid could be identified to species, but the size of the beaks suggests that the squid were very small and that the Fulmars must have been capable of swallowing these prey whole.

POLYCHAETE WORMS (NEREIDAE) Jaws of polychaete worms, or fleshy and hairy remains of these animals, were found exclusively in the stomach contents (table 2). The frequency of occurrence was very high (82%, n=22) and sometimes very large number of jaws were found (27, 42, 100, and 390 respectively in the samples #3, 11, 2, and 5, indicating a maximum of nearly 200 individual prey). This suggested that polychaete worms are an important food source Northern Fulmars of Bjørnøya. Nereids were not seen in the regurgitated food samples, so that their significance for the growing chick at the nest is possibly rather small. All jaws were of the same type and probably of *Nereis irrorata*, a common species in these waters (cf. Mehlum & Giertz 1984, Lydersen *et al.* 1989). It is probably the pelagic, reproductive variety of these animals (known as the *epitoke*; Campbell 1976) which is taken by the surface feeding Northern Fulmars.

PLASTIC PARTICLES Plastic particles were only found once in the regurgitated food (#8, a single 6x5x2 mm triangular fragment; table 1), but plastics occurred frequently in the stomach of collected birds (82%, n= 22; table 2). The maximum number of plastic particles observed was 21 (#11), the mean number was 4.3 ± 5.2 objects (n= 22). Particularly numerous were pieces of nylon thread and small, broken fragments (table 5). Cells of polystyrene

Table 5. Occurrence of plastic particles in stomach contents of 22 Northern Fulmars collected in 1980 at Bjørnøya. Shown are the maximum number in one stomach, mean \pm S.D. ($n = 22$), and the frequency (n and % of all samples examined).

Tabel 5. Voorkomen van plastic in de maaginhoud van 22 Noordse Stormvogels die in 1980 op Bjørnøya werden verzameld. Gegeven wordt het maximum in één maag, gemiddelde \pm S.D. ($n = 22$) en het aantal gevallen (n en % van alle magen).

Type of plastic	max	mean	S.D.	freq. n	%
Industrial pellet	7	0.9	± 1.8	8	36
broken fragment	6	1.5	± 1.8	14	64
nylon thread	12	1.2	± 2.7	7	32
other form	5	0.6	± 1.1	8	36
Totals	21	4.3	± 5.2	18	82

foam, commonly encountered in Northern Fulmar stomachs collected elsewhere in the North Atlantic, were not found.

PARASITIC WORMS (NEMATODA) The examination of gizzard and proventriculus in a healthy seabird often results in considerable numbers of nematodes. These nematodes may have originated from consumed fish rather than from the bird. Small nematodes were only frequently found in the stomach contents of the collected birds (73%, $n = 22$). On two occasions tens of worms were present, otherwise only small numbers were found (1-10 worms).

OTHER ITEMS Other objects, most of which were hard objects of which digestion will have been fairly slow or even impossible, were found in the stomach contents of some of the collected birds (table 2). In four birds (#9, 14, 15, 18; presence 18% of the stomachs), objects were found of the size and shape of rabbit droppings, which were made of very strong, hairy fibres. The fibres burnt like hair and it is possible that these hairs originated from marine mammals such as seals (Pinnipedia). Grit was found in 59% of the stomachs, with a maximum of 4 small stones.

DISCUSSION

Diet studies such as the present one are small, but significant contributions to the jigsaw of Northern Fulmar diet. Samples are difficult to obtain, particularly if the killing of birds is to be prevented, and isolated breeding stations such as Bjørnøya are not frequently visited. Many studies are needed to fully

Table 6. Frequency of occurrence (n and % of all samples examined) of prey items in regurgitates of Northern Fulmars handled in 1980 (table 1), in stomach contents of Fulmars collected on Bjørnøya in 1980 (table 2), in stomach contents of individuals collected in 1948 (Duffey & Sergeant 1950), and in stomach contents of Fulmars collected during the Lance 1982 expedition in the Barents Sea around Svalbard (Mehlum & Giertz 1984).

Tabel 6. Voorkomen (n en % van alle geanalyseerde monsters) van prooisorten in braaksels van Noordse Stormvogels in 1980 (tabel 1), in de magen van exemplaren die in 1980 op Bereneiland werden verzameld (tabel 2), in de maag van exemplaren die in 1948 werden verzameld (Duffey & Sergeant 1950) en in de maag van vogels die tijdens de Lance 1982 expeditie in de Barentz Zee rondom Spitsbergen werden verzameld (Mehlum & Giertz 1984).

	regurg. 1980 (see table 1)		stomachs 1980 (see table 2)		stomachs 1948 (Duffey & Sergeant 1950)		stomachs 1982 (Mehlum & Giertz 1984)	
	n = 13		n = 22		n = 23		n = 14	
	n	%	n	%	n	%	n	%
fish	10	77	20	91	9	39	7	50
Crustacea	6	46	1	5	0		5	36
Cephalopods	0		9	41	12	52	3	21
Nereid worms	0		18	82	11	48	8	57
plastic	1	8	18	82	0		5	36
grit	0		13	59	1	4	0	
feathers	0		1	5	0		0	
others	0		4	18	0		2	14
unknown	0		11	50	0		5	36

appreciate the range (species composition, size) and relative abundance of prey items taken by Northern Fulmars. Single-season studies should be treated with caution, because Northern Fulmars are capable of considerable shifts in their diet in response to altering prey availability (Harvey *et al.* 1990, Camphuysen & Van Franeker 1996).

From the samples collected on Bjørnøya in 1980, it can be deduced that several species of small (young) fish and pelagic zooplankton, such as surface swarming Euphausiacea and epitokous polychaete worms, are of significance. Most of the bulk loads of food regurgitated by Fulmars ringed in 1980 were probably meals meant for the chick. This study suggests that fish and crustaceans are the main prey items delivered to the offspring, whereas evidence that nereid worms or squid were fed to the chick is not found. The remarkably large spectrum of fish species found in only 10 samples is indicative of the wide feeding range and opportunistic feeding strategy of the species.

Notable differences existed between regurgitated food and stomach contents, demonstrating the limitations of using small samples and the bias cau-

sed by choosing either one method. Duffey & Sergeant (1950) described the diet of Northern Fulmars on the basis of 23 stomach contents and did not trace crustaceans as food (table 6). They concluded, just as we would on the basis of stomach contents alone, that fish, squid and nereid worms were the dominant prey items of these birds. Not surprisingly, plastics were absent in the 1948 samples. More remarkable is the scarcity of grit in 1948 (4% of all stomachs, compared to 59% in 1980). Mehlum & Giertz (1984) collected Fulmars at sea around Svalbard in August 1982 and, hence, obtained relatively much those freshly caught prey. The prey items of these birds were similarly varied as of the Northern Fulmars collected at Bjørnøya in 1980.

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SAMENVATTING

Van 10 juni tot 14 augustus 1980 werden 153 Noordse Stormvogels gevangen op Bereneiland om de morfologie van deze vogels te bestuderen. De voedselkeuze van Noordse Stormvogels werd onderzocht aan de hand van uitgebraakte voedselresten (tabel 1) en aan de hand van de maaginhoud van 22 verzamelde vogels (tabel 2). Er bestond een groot verschil in de samenstelling van de beide soorten monsters. Gedeeltelijk verteerde vis en kleine garnaalachtigen (Crustacea) kwamen vooral voor in de braaksels, terwijl de maaginhoud vooral bestond uit de langzaam verderende onderdelen van vis, inktvis en borstelwormen. In de braaksels werden tenminste vier vissoorten aangetroffen: Lodde *Mallotus villosus*, Poolkabeljauw *Boreogadus saida*, Koolvis *Pollachius* sp., en Noorse Schelvis *Sebastes viviparus*. Aan garnaalachtigen werden de resten van krill (Euphausiacea, waaronder tenminste eenmaal *Thysanoëssa inermis*), een vlokreeftje (*Parathemisto* spp.) en een grotere garnaal (Decapoda) aangetroffen. Kaken van borstelwormen, vermoedelijk *Nereis irrorata* waren talrijk in de magen van de verzamelde stormvogels. Het grootste aantal dat werd aangetroffen was 390 kaakjes (de resten van bijna 200 wormen). Het is vermoedelijk de reproducerende, pelagische vorm van deze borstelworm die voor de aan de oppervlakte fouragerende Noordse Stormvogels ter beschikking komt. In de magen werden gemiddeld 4.3 ± 5.2 plastic partikels aangetroffen (maximaal 21 stukjes, presentie 82%, n = 22).

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