Nr. 16 - Oslo 1984

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Feeding ecology of seabirds in the Svalbard area - a preliminary report .

INTRODUCTION

In the period 6 August to 2 September 1982 Norsk Polarinstitutt conducted a marine ecological programme onboard the research vessel m/s LANCE in the northern part of the Barents Sea. During the cruise seabird censuses were made to map pelagic distribution and abundance of seabirds at sea. The pattern of distribution and abundance is thought to be influenced by the feeding ecology of the different species and different physical environmental factors. Very little is actually known about the distribution of seabirds in the ice -covered waters around Svalbard. To study the feeding ecology a number of seabirds were collected for stomach analysis.

This report is a preliminary work on the feeding ecology of pelagic feeding seabirds in the northern part of the Barents Sea. For comparative reasons food samples from breeding Kittiwakes Rissa tridactyla collected in the Kongsfjord area, Spitsbergen in 1982 and 1983 and one individual from Fram Strait are also included.

MATERIAL AND METHODS

A total of 75 specimens of 9 species were collected during the cruise. Fig. 1 shows the cruise navigation and station grid. The locations where birds were sampled are also indicated. A detailed account of the dates and geographical location is given in Appendix 1. The birds were shot either from the research vessel or from a rubber boat. Actively feeding birds were preferred, but most of the specimens were collected while flying. Samples of zooplankton and under- ice- living organisms were sampled in the same areas, so that the availability of potential food organisms could be compared with the actual feeding preferences of the different bird species.

Immediately after shooting, the birds were stored in a deep freezer (i.e. less than 1/2 hour later). The material was later analyzed at the University of Oslo. The carcasses were dissected and the stomachs and oesophagus preserved in 70% alcohol after removal of endoparasites, which were studied by prof. R. Vik at the Zoological museum in Oslo.

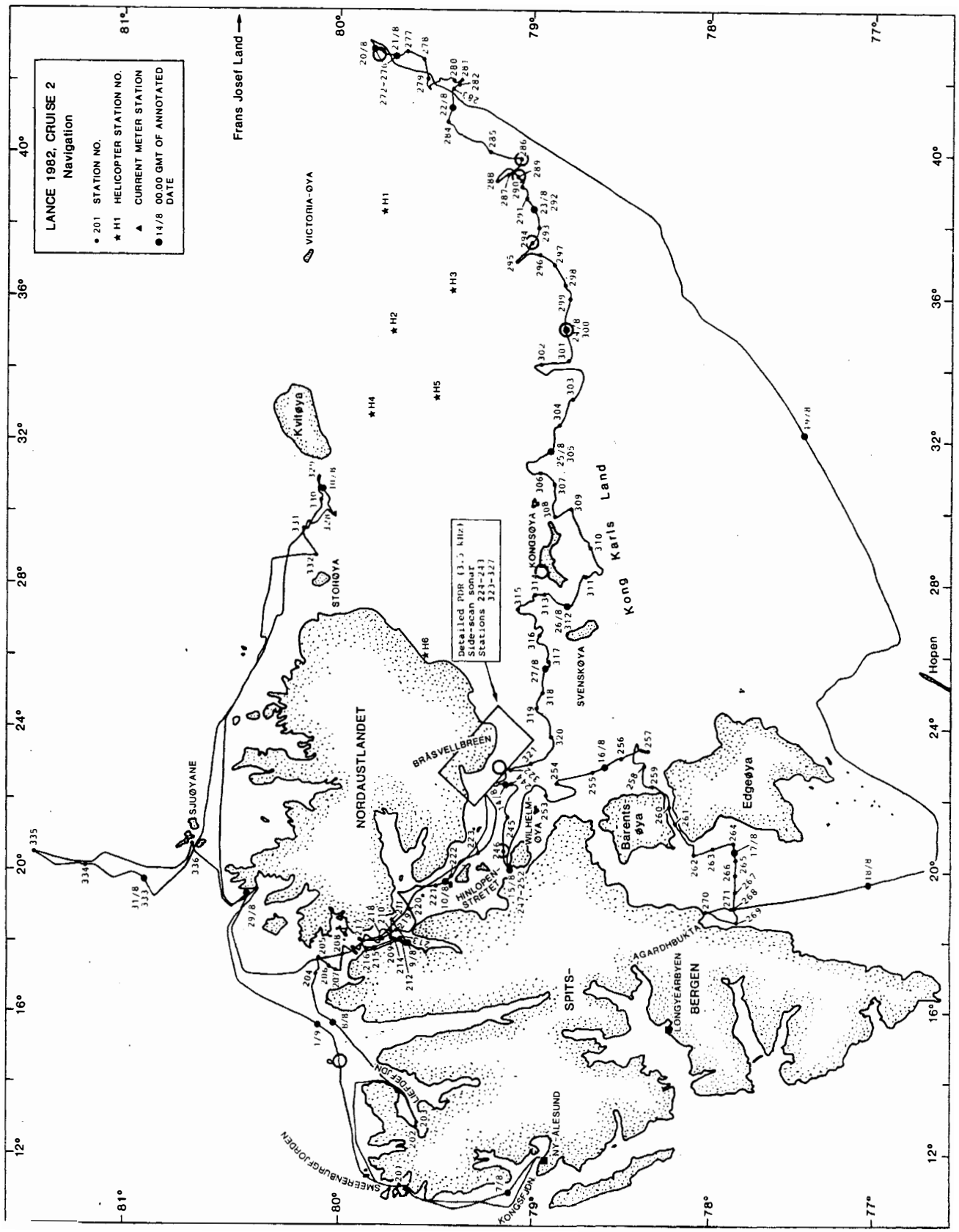

Fig. 1. Lance 1982 cruise navigation and station grid. Seabird samples are indicated by O.

The food samples of breeding Kittiwakes in Kongsfjord were collected by catching the adults on the nests and letting the birds regurgitate their food into plastic bags. The material includes food samples from seven birds from each year 1982 and 1983. The samples were weighed when fresh and frozen for later analysis.

The stomach content was washed into a 0.5 mm sieve. All items were then sorted to the lowest possible taxonomic level by using available keys and, when possible, reference specimens. Identification of prey was primarily based on fish otoliths, squid beaks, polychaete jaws, crustacean exoskeletons and intact specimens.

All otoliths were counted, but only Arctic Cod Boreogadus saida otoliths were measured to the nearest 0.1 mm using a microscope with a measuring ocular and a magnification of 12.5x. Two otoliths differing less than 0.2 mm in length were considered to be from the same fish. Numbers of fish ingested were estimated as half the number of otoliths within mm length categories. By using the relationship between otolith size and body size it was possible to estimate the size of all Arctic Cods ingested. This was done according to Lowry & Frost (1981) where fish length = 2.198 x + 1.588 (x is the length of the otolith).

Crustaceans in each stomach were counted, or when present in large quantities their numbers were estimated from suitable subsamples. When whole crustaceans were encountered their length was measured to the nearest 0.1 mm using a microscope with a measuring ocular and either a 12.5x or 60x magnification. When only fragments were encountered, the length of their posterior parts were measured according to Bradstreet (1980), also by means of the microscope and measuring ocular. The formula given by Bradstreet (Table 1) enables estimates of the total body length based on the measurement of the posterior parts.

Table 1. Relationship between length of posterior parts (x) of crustaceans and total body length (After Bradstreet 1980)

Species	Equation
Apherusa glacialis	3.4393x + 1.4766
Gammarus wilkitzkii	4.4459x + 1.8503
Parathemisto libellula	3.5426x + 0.7690

The number of polychaetes ingested was determined by counting the number of polychaete jaws present in the stomach sample.

The number of squid ingested was determined by counting the squid lower beaks present in a stomach sample.

Dry weights for certain species digested by Little Auks and Kittiwakes were determined by using formulas for dry weight / length relationships according to Bradstreet (1980).

RESULTS

A taxonomic list of all distinguishable stomach contents for each bird species is given i Table 2.

Bird species account

Fulmar Fulmarus glacialis

A total of 10 out of 14 stomachs contained distinguishable contents (Table 3). The polychaete Nereis irrorata was the most numerous and common prey, but also Parathemisto libellula, fish and squid were found. Arctic Cod was the only distinguishable fish present. Squid could only be determined to the family Gonatidae.

In six of the stomachs man - made objects were found. These were rubber, plastic and cotton.

Eider Somateria mollissima

The only specimen collected, a pullus from the Moffen area, contained almost exclusively the amphipod Onisimus edwardsi (Table 11).

Kittiwake Rissa tridactyla

All Kittiwakes had distinguishable stomach contents and vomit(Tables 4,5 and 6). This consisted mainly of Arctic Cod, but also some crustaceans were present,especially in the samples from Kongsfjord. Of these the most numerous were Parathemisto libellula and the euphausiid Thysanoessa inermis.

Fairly intact Arctic Cods found in Kittiwake stomachs had large numbers of Parathemisto libellula in their digestive tracts. P. libellula believed to originate from Arctic Cod were not counted, just noted as being present.

Ivory Gull Pagophila eburnea

All six specimens had distinguishable stomach contents (Table 7). Fish were the most common prey. Arctic Cod was the only species found. Two of the birds had ingested blubber and meat, and one bird had ingested six large specimens (30–42 mm) of the amphipod Gammarus wilkitzkii.

Glaucous Gull Larus hyperboreus

The two investigated gulls both had distinguishable stomach contents

(Table 7). One had ingested only G. wilkitzkii (20-32 mm), while the other had small quantities of blubber, Arctic Cod and P. libellula.

Long-tailed Skua Stercorarius longicaudus

Only one specimen is present in the material (Table 11). The stomach of this bird contained only fish. The otoliths of three Arctic Cod were found together with otoliths of one unidentifiable fish.

Little Auk Alle alle

Of the 29 Little Auks 21 had distinguishable stomach contents (Table 9). These consisted only of crustaceans. The copepod Calanus finmarchicus along with the amphipods P. libellula and Apherusa glacialis were the most numerous and common prey species.

Black Guillemot Cepphus grylle

Of the eight birds seven had distinguishable stomach contents (Table 10). Fish, mainly Arctic Cod, and the amphipod G. wilkitzkii were the main prey.

Brünnich's Guillemot Uria lomvia

Only one bird is included in the material (Table 11). The stomach contents of this specimen were in poor condition and only contained P. libellula.

Table 2. Summary table of prey species in the different species of seabirds.

	Little Auk	Kittiwake	Ivory Gull	Fulmar	Black Guillemot	Brünnich's Guillemot	Glaucous Gull	Long-tailed Skua	Common Eider
CEPHALOPODA									
Decapoda	-	-	-	X	-	-	-	-	-
Gonatidae	-	-	-	X	-	-	-	-	-
POLYCHAETA									
Nereis irrorata	-	X	-	X	-	-	-	-	-
CRUSTACEA									
Calanus sp.	-	X	-	-	-	-	-	-	-
Calanus finmarchicus	X	-	-	-	-	-	-	-	-
Calanus hyperboreus	-	-	-	-	X	-	-	-	-
Parathemisto libellula	X	X	-	X	-	X	X	-	-
Lysianassidae	-	X	-	-	-	-	-	-	-
Onisimus edwardsi	-	-	-	-	-	-	-	-	X
Anonyx nugax	X	-	-	-	-	-	-	-	-
Gammarus wilkitzkii	X	X	X	-	X	-	X	-	-
Apherusa glacialis	X	-	-	-	-	-	-	-	-
Thysanoessa inermis	-	X	-	-	-	-	-	-	-
Pandalus borealis	-	X	-	-	-	-	-	-	-
Eualus pusiolus	-	X	-	-	-	-	-	-	-
PISCES									
Boreogadus saida	-	X	X	X	X	-	X	X	-
Lycodes sp.	-	X	-	-	X	-	-	-	-
Cottidae	-	X	-	-	-	-	-	-	-
MAMMALIA (blubber)	-	-	X	-	-	-	X	-	-

Table 3. Stomach contents of Fulmars.

(n = 14) Specimen no.	Indet.	Nereis irrorata	Amphipoda indet.	Parathemisto libellula	Pisces, indet.	Boreogadus saida	Cephalopoda Decapoda	Cephalopoda Gonatidae	Comments
1	-	-	-	1	-	2	-	-	Plastic threads
2	x	-	-	-	-	-	-	-	
3	-	1	-	-	-	1	-	3	
4	-	1	-	-	-	-	-	-	Plastic threads
5	x	1	x	-	-	-	-	-	
6	-	-	-	-	x	-	-	-	
12	-	25	-	-	-	2	4	-	Plastic threads
16	x	-	-	-	-	-	-	-	Cotton
17	-	3	-	-	x	-	-	-	
18	-	1	-	2	x	-	-	-	Plastic threads
22	x	-	-	-	-	-	-	-	
27	x	-	-	-	-	-	-	-	
40	-	1	-	1	x	-	-	-	
68	-	10	-	3	-	-	1	-	Rubber - plastic threads and wood
Tot. no. of items	-	43	-	7		5	5	3	
Frequency (%)	-	68.3	-	11.1	-	7.9	7.9	4.8	
No. of birds with taxon present	5	8	1	4	4	3	2	1	
%	35.7	57.1	7.1	28.6	28.6	21.4	14.3	7.1	

Table 4. Stomach contents of Kittiwakes - total material.

(n = 27)	Nereis irrorata	Crustacea, indet.	Calanus	Amphipoda, indet.	Parathemisto libellula	Lysianassidae	Gammarus wilkitzkii	Thysanoessa inermis	Eualus pusiolus	Pandalus borealis	Pisces, indet.	Boreogadus saida	Cottidae	Lycodes
Tot. no. of items (n = 393)	1	-	100	2	103	1	2	125	1	1	-	54	2	1
Frequency (%)	0.3	-	25.5	0.5	26.2	0.3	0.5	31.8	0.3	0.3	-	13.7	0.5	0.3
No. of birds with taxon present	1	1	1	2	7	1	1	3	1	1	2	25	2	1
Occurence (%)	3.7	3.7	3.7	7.4	25.9	3.7	3.7	11.1	3.7	3.7	7.4	92.6	7.4	3.7
Estimated dry weight per bird (in mg)	-	-	6	-	53	-	147	-	-	-	-	6983	438	-
%	-	-	0.1	-	0.7	-	1.9	-	-	-	-	91.6	5.7	-

Table 5. Stomach contents of breeding Kittiwakes from Kongsfjord.

(n = 14) Date of sample collection	Nereis irrorata	Calanus	Amphipoda indet.	Parathemisto libellula	Pandalus borealis	Thysanoessa inermis	Lysianassidae	Pisces indet.	Boreogadus saida
25.7. 1982	-	100	-	80	-	2	-	-	1
25.7. 1982	-	-	1	-	-	-	-	-	2
25.7. 1982	-	-	-	-	-	-	-	-	2
27.7. 1982	-	-	-	-	-	-	-	-	1
28.7. 1982	-	-	-	-	-	13	-	-	1
29.7. 1982	-	-	-	-	-	110	-	x	-
29.7. 1982	-	-	-	-	-	-	-	-	2
15.7. 1983	1	-	1	12	1	-	-	-	3
15.7. 1983	-	-	-	9	-	-	-	-	2
15.7. 1983	-	-	-	1	-	-	1	x	-
15.7. 1983	-	-	-	1	-	-	-	-	1
15.7. 1983	-	-	-	x	-	-	-	-	1
15.7. 1983	-	-	-	x	-	-	-	-	1
15.7. 1983	-	-	-	-	-	-	-	-	3
Tot. no. of items	1	100	2	103	1	125	1	-	21
Frequency (%)	0.3	28.3	0.6	29.1	0.3	35.3	0.3	-	5.9
No. of birds with taxon present	1	1	2	7	1	3	1	2	12
Estimated dry weight per bird (in mg)	-	6	-	53	-	-	-	-	2235
%	-	0.3	-	2.3	-	-	-	-	97.4

Table 6. Stomach contents of Kittiwakes collected in Barents Sea. (* from Fram Strait)

(n = 13) Specimen no.	Crustacea, indet.	Gammarus wilkitzkii	Eualus pusiolus	Boreogadus saida	Cottidae	Lycodes
7	-	-	-	1	-	-
8	x	-	1	3	-	-
9	-	-	-	1	-	-
10	-	-	-	2	-	-
11	-	2	-	1	-	-
23	-	-	-	3	-	-
26	-	-	-	6	-	-
29	-	-	-	3	-	-
32	-	-	-	3	1	-
34	-	-	-	2	-	1
41	-	-	-	3	1	-
42	-	-	-	1	-	-
85*	-	-	-	4	-	-
Tot no. of items	-	2	-	33	2	1
Frequency (%)	-	5.3	-	86.8	5.3	2.6
No. of birds with taxon present	1	2	-	13	2	1
Occurrence (%)	7.7	15.4	-	100.0	15.4	7.7
Estimated dry weight per bird (in mg)	-	147	-	9100	438	-
%	-	1.5	-	94.0	4.5	-

Table 7. Stomach contents of Ivory Gulls.

(n = 6) Specimen no.	Crustacea, indet.	Gammarus wilkitskii	Pisces, indet.	Boreogadus saida	(blubber) Mammalia
19	-	-	x	-	-
21	-	6	-	5	-
24	-	-	-	-	x
33	-	-	1	2	-
36	-	-	-	1	x
39	x	-	x	-	-
Tot. no. of items	-	6	1	8	-
Frequency (%)	-	40.0	6.7	53.3	-
No. of birds with taxon present	1	1	3	3	2
Occurrence (%)	16.7	16.7	50.0	50.0	33.3

Table 8. Stomach contents of Glaucous Gulls.

(n = 2) Specimen no.	Parathemisto libellula	Gammarus wilkitzkii	Boreogadus saida	(blubber) Mammalia
82	1	-	1	x
83	-	46	-	-
Tot. no. of items	1	46	1	x
Frequency (%)	2.1	95.8	2.1	-
No. of birds with taxon present	1	1	1	1
Occurrence (%)	50	50	50	50

Table 9. Stomach contents of Little Auks. (Eight stomachs empty).

(n = 21) Specimen no.	Crustacea, indet.	Copepoda, indet.	Calanus	Amphipoda, indet.	Parathemisto libellula	Anonyx nugax	Gammarus wilkitzkii	Apherusa glacialis
13	-	-	-	-	-	-	6	100
14	-	-	-	-	-	1	-	116
44	-	-	233	-	39	-	-	-
45	-	-	100	-	7	-	-	-
46	-	x	-	-	-	-	-	-
47	-	-	212	-	4	-	1	-
48	-	x	-	-	-	-	-	-
49	-	x	-	x	-	-	-	-
50	-	-	165	-	2	-	-	-
52	-	-	168	-	4	-	-	-
53	-	-	160	-	32	-	-	-
54	-	-	250	-	2	-	-	-
55	x	-	-	-	-	-	-	-
56	x	-	-	-	-	-	-	-
57	-	-	10	-	2	-	-	30
58	-	-	230	-	20	-	-	-
72	-	x	-	-	-	-	-	-
75	x	-	-	-	-	-	-	-
76	-	10	-	-	-	-	14	-
78	-	-	-	-	-	-	-	29
80	-	15	-	-	4	-	-	-
Tot. no. of items	-	25	1528	-	120	1	21	275
Frequency (%)	-	1.3	77.6	-	6.1	0.1	1.1	14.0
No. of birds with taxon present	3	6	9	1	10	1	3	4
Occurrence (%)	14.3	28.6	42.9	4.8	47.6	4.8	14.3	19.1
Estimated dry weight per bird (in mg)	-	1.2	22.4	-	51.4	-	27.9	251.7
%	-	0.3	6.3	-	14.5	-	7.9	71.0

Table 10. Stomach contents of Black Guillemots. (One stomach empty).

(n = 7) Specimen no.	Crustacea, indet.	Calanus hyperboreus	Gammarus wilkitzkii	Pisces, indet.	Boreogadus saida	Lycodes
43	-	-	13	-	-	-
61	x	1	-	-	-	-
62	-	-	-	-	5	-
64	-	-	-	-	1	1
65	-	-	-	-	2	-
66	-	-	-	x	-	-
81	x	-	-	-	-	-
Tot. no. of items	-	1	13	-	8	1
Frequency (%)	-	4.4	56.5	-	34.8	4.4
No. of birds with taxon present	2	1	1	1	3	1
Occurrence (%)	28.6	14.3	14.3	14.3	42.9	14.3

Table 11. Stomach contents of Eider, Brünnich's Guillemot and Long-tailed Skua.

Specimen no.	Parathemisto libellula	Onisimus edwardsi	Amphipoda indet.	Boreogadus saida	Pisces, indet.
(Eider) 84	-	74	1	-	-
(Brünnich's Guillemot) 38	x	-	-	-	-
(Long-tailed Skua) 15	-	-	-	3	1

Prey size

Arctic Cod

The length of otholithes found in different bird species is given in Table 12. Only in the Kittiwakes were enough otoliths found to enable a frequency distribution of otolith sizes to be made. Such a frequency distribution indirectly reveals the size range of Arctic Cod ingested by Kittiwakes (Fig. 2). The average otolith size (5.2 mm, s.d. 1.2) of Arctic Cod ingested by Kittiwakes corresponds to a fish size of 13 cm (Lowry & Frost 1981).The range between the smallest and largest individuals was 9 to 19 cm. The four cods in the Kongsfjord sample had smaller otoliths than the average value, but the sample size is too small to make any conclusions of differences between the two groups of birds.

The sizes of otoliths found in Black Guillemots (average otolith size 5.3 mm, s.d. 0.7) were compared with those found in Ivory Gulls (average otoliths size 6.0 mm, s.d. 1.4). The corresponding total fish lengths according to Lowry & Frost (1981) were 13 and 15 cm respectively. No significant difference in otholith size was found ($p > 0.05$, Wilcoxon matched pair test). The same test was used to compare sizes of otoliths found in Kittiwakes with those found in Black Guillemots and Ivory Gulls. In neither case was any significant difference in otolith sizes found.

Crustaceans

Crustaceans found were often in poor condition, and relatively few were whole, thus preventing measurement of their length. Tables of all crustaceans measured are given in Appendix 2. Bradstreet's (1980) methods for estimating the lengths of different crustaceans were used. The body length of Parathemisto libellula could be estimated quite accurately from the length of their posterior parts. This could also be done for smaller Gammarus wilkitzkii (<25 mm). As for Apherusa glacialis the actual length and estimated length differed in that estimated lengths were too short.

Parathemisto libellula was the most frequently occurring amphipod in this study and was found in 47.6% of the Little Auks, and a size frequency distribution (Fig.3) for this prey species could be made. To avoid error only estimated P. libellula lengths were used. In samples where only a small part of the P. libellula could be measured, these

were treated as a subsample, and the lengths of the whole sample estimated accordingly. This resulted in an average total length of 12.9 mm (s.d. 3.0), which corresponds to the size of juveniles (Dunbar 1957).

Total lengths of Gammarus wilkitzkii found in Black Guillemots and Glaucous Gulls were measured. The average lengths of G. wilkitzkii found in Black Guillemots was 31.4 mm (s.d. 11.5) compared with an average length of 32.4 mm (s.d. 2.1) for those found in the Glaucous Gulls. There was no significant difference between the length of the G. wilkitzkii taken by the Black Guillemot and the Glaucous Gull ($p>0.05$, Wilcoxon matched pair test).

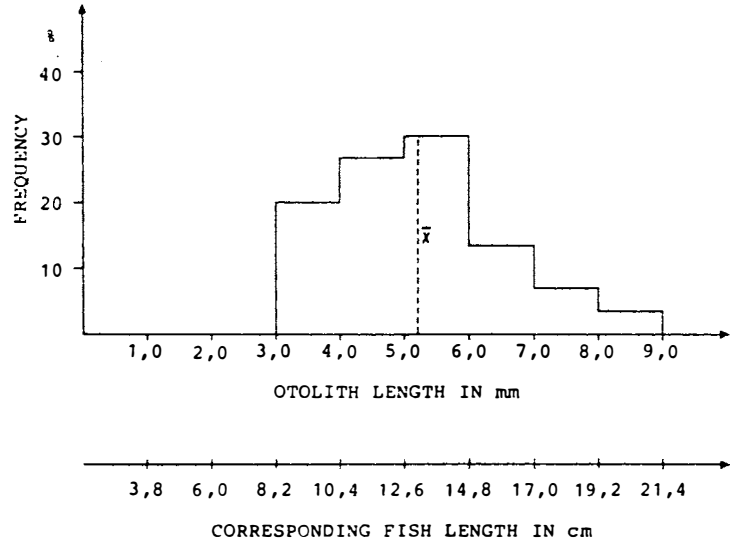

Fig. 2. Frequency distribution of sizes of otoliths from Arctic Cod Boreogadus saida found in Kittiwakes. Mean value (x) indicated. N=30.

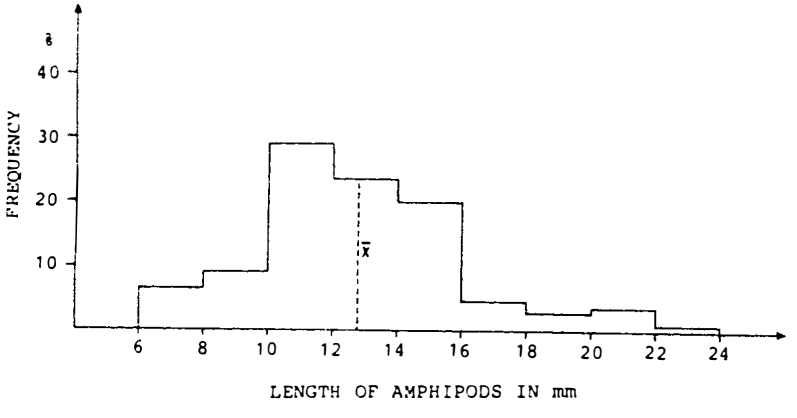

Fig. 3. Frequency distribution of lengths of Parathemisto libellula found in Little Auks. Mean value (x) indicated. N=110.

Table 12. Size of otoliths (in mm) found in different bird species. Each measurement represents one fish. Two otoliths differing less than 0.2 mm in length were considered to be from the same fish and their mean size was noted.

Kittiwake	Kittiwake (Kongsfjord)	Black Guillemot	Ivory Gull	Fulmar	Long-tailed Skua
8.0	3.9	5.8	6.7	2.5	2.5
4.9	3.8	5.5	5.8	2.8	2.5
5.7	3.8	6.1	7.8	5.3	3.2
6.4	3.8	4.9	5.6	3.8	
5.8		3.9	3.7	3.5	
7.1		5.5	7.7	5.1	
5.5		5.6	6.5		
5.7			4.4		
5.9					
4.8					
5.2					
3.6					
4.3					
4.0					
5.9					
4.8					
5.3					
5.1					
6.0					
6.3					
4.0					
4.6					
7.2					
6.0					
4.4					
3.5					

DISCUSSION

The present material is too small to give a complete account of the feeding ecology of the different seabird species in the Svalbard - Barents Sea area. In addition the investigation only comprises a very short period of the year - the late summer situation. However the material gives an indication of segregation in feeding ecology between the bird species in the area.

The seabirds in the area can be divided into two main groups according to their feeding methods. The Kittiwake, Ivory Gull, Glaucous Gull and Fulmar are surface feeders, while the Little Auk, Brünnich's Guillemot and Black Guillemot are divers.

The surface feeders depended on planktonic crustaceans, i.e. the amphipod Parathemisto, but also on epibentic amphipods which are known to be associated with sea ice, like Gammarus wilkitzkii. Arctic Cod was also an important food item, which must have been close to the surface, probably associated with the sea ice. In the nesting Kittiwakes from Kongsfjord krill was an important prey, as also reported from the Billefjord area, Spitsbergen (Hartley & Fisher 1936). Krill was not common in the plankton samples collected during the LANCE - cruise (Norden Andersen 1983). In the Ivory Gull mammalian blubber was found in two specimens. This is probably seal blubber, which is an often recorded food item in this species (Løvenskiold 1964).

The seabirds feeding by diving mainly depended on the same type of prey organisms as the surface feeders, planktonic and epibentic crustaceans and Arctic Cod. The smallest species, the Little Auk, had the most different diet with the copepod Calanus and small individuals of the amphipods Apherusa, Gammarus wilkitzkii and Parathemisto as dominating prey. The largest food items in the Little Auk were G. wilkitzkii measuring up to 16 mm. In general the prey species recorded is in concordance with the results obtained in the elaborate work done in the Lancaster Sound area in Arctic Canada (Bradstreet 1982) and studies from Northwest Greenland (Roby, Brink & Nettleship 1981), except that in these studies small Arctic Cods were also present in the food samples. Bradstreet (1982) claims that the diet varies geographically and with year. Previous studies in coastal waters of Svalbard (Hartley & Fisher 1936, Løvenskiold 1964,

Norderhaug 1980) also mentioned Calanus, and amphipods, Mysis, Thysanoessa and Arctic Cod as important food items.

In the Black Guillemot the G. wilkitzkii present in the digestive tract belonged to an older cohort, and had a mean length of 31 mm. But Arctic Cod (and other fish species) seems to be the most important prey for the Black Guillemot in the ice-edge zone in the Barents Sea. Bradstreet (1980) in his extensive study of guillemots in the Barrow Strait area in Arctic Canada found that the species caught mainly Arctic Cod, Onisimus glacialis and Apherusa glacialis along offshore ice- edges. In coastal waters of Svalbard the species seems to have a varied diet, comprising krill, mysids, amphipods, molluscs and fishes (Hartley & Fisher 1936).

The present collection only contains one food sample from Brunnich's Guillemot. The only prey found was Parathemisto, but we believe that this auk, as in other parts of its distribution area, mainly depend both on Arctic Cod and crustaceans (Hartley & Fisher 1936, Gaston & Nettleship 1981)

The Arctic Cod seems to be a key prey species for several of the seabird species.The growth pattern of this fish can be very variable between different geographical localities (Lowry & Frost 1981). The spawning period is during winter and the transition from larva to juvenile is reported to occur in August. At that time the individuals are 3-5 cm (Rass 1968). The otoliths of the Arctic Cods in the samples indicate that most of the fish were one year old or older, but some of the smallest individuals were first-year fishes.

One possible source of error in the description of the diet of the fish eating seabirds is that some of the small crustaceans recorded may not be the prey of the bird but stomach content of the fishes. However this is thought to be of minor importance.

The polychaete Nereis irrorata was a common food item in Fulmars. It was also recorded in one Kittiwake from Kongsfjord. Very little is known about the biology of this polychaete, but Nereis-species are known to spawn in pelagic swarms.

In the Fulmars five of the 14 stomachs contained man- made debris, most probably remnants from fishing nets or ropes. We have no data on potential negative effects on the birds' digestive tracts by these items. Plastics are becoming common contents of seabird stomachs (see review by Franeker (1983), but little attention has been given to

this problem. Plastics have been found very frequently in procellariiform birds. For example, about 80% of the Fulmars found dead on Dutch beaches contained plastics (Franeker 1983). The plastic may have adverse effects on the seabirds both directly by gastro-intestinal blockage and by long-term sublethal effects, the decrease in food uptake and increased assimilation of toxic plastic chemicals like PCB and others.

ACKNOWLEDGEMENTS

We thank Thor Larsen, Viggo Ree, Bjørnar Seim, Anders Solheim and Ragnar Syvertsen for help in collecting the material. We also thank the Zoological Museum in Oslo for their valuable assistance in the dissection of the birds,and Egil Soglo for technical assistance during the analysis. The analysis of the material was supported by the Norwegian Ministery of the Environment.

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APPENDIX 1

Species list and geographical localities for the seabirds collected in Svalbard/Barents Sea 1982.

Appendix 1. Species list and localities of seabirds collected in Svalbard/Barents Sea 1982. The skins are deposited at the Zoological museum in Oslo.

No.	Date	Time	Species	Sex	Locality		Position (N,E)	
1-82	11.8	1800	Fulmar	F	W. part of Bråsvell-		7909	2255
2-82	-	-	-	M	breen		-	-
3-82	-	-	-	M	-		-	-
4-82	-	-	-	F	-		-	-
5-82	-	-	-		-		-	-
6-82	-	-	-	F	-		-	-
7-82	-	-	Kittiwake	M	-		-	-
8-82	13.8	1900	-	M	Bråsvellbreen	St.243	7911	2316
9-82	-	-	-		-	-	-	-
10-82	-	-	-	M	-	-	-	-
11-82	-	-	-	F	-	-	-	-
12-82	-	-	Fulmar	M	-	-	-	-
13-82	14.8	1100	Little Auk	F	Sørporten	St.246	7909	2032
14-82	-	-	-	M	-	-	-	-
15-82	-	-	Long-tailed Skua		-	-	-	-
16-82	-	-	Fulmar	F	-	-	-	-
17-82	-	-	-	F	-	-	-	-
18-82	-	-	-	F	-	-	-	-
19-82	-	-	Ivory Gull	M	-	-	-	-
21-82	20.8	1100	-	F		St.273	7947	4248
22-82	-	-	Fulmar	M		-	-	-
23-82	-	-	Kittiwake			-	-	-
24-82	-	-	Ivory Gull	M		-	-	-
26-82	-	1300	Kittiwake	M		-	-	-
27-82	-	-	Fulmar	F		-	-	-
29-82	-	1400	Kittiwake			-	-	-
32-82	-	-	-	F		-	-	-
33-82	-	-	Ivory Gull	M		-	-	-
34-82	-	-	Kittiwake	M		-	-	-
36-82	-	-	Ivory Gull	F		-	-	-
38-82	-	1600	Brunnich´s Guillem.	F		-	-	-
39-82	-	-	Ivory Gull	F		-	-	-
40-82	-	-	Fulmar			-	-	-
41-82	-	-	Kittiwake	F		-	-	-
42-82	-	-	-	F		-	-	-
43-82	22.8	0900	Black Guillemot	M		St.286	7904	3951
44-82	-	-	Little Auk	F		-	-	-
45-82	-	-	-	M		-	-	-
46-82	-	-	-	M		-	-	-
47-82	-	-	-	F		-	-	-
48-82	-	-	-	M		-	-	-
49-82	-	-	-	F		-	-	-
50-82	-	-	-			-	-	-
51-82	-	-	-	M		-	-	-
52-82	-	-	-	M		-	-	-
53-82	-	-	-	M		-	-	-
54-82	-	-	-			-	-	-
55-82	-	-	-	F		-	-	-
56-82	-	-	-			-	-	-
57-82	-	-	-	M		-	-	-
58-82	-	-	-	F		-	-	-
61-82	22.8	2300	Black Guillemot	M		St.289	7904	3923

62-82	-	-	-	F		-	-	-
63-82	-	-	-	M		-	-	-
64-82	-	-	-	F		-	-	-
65-82	-	-	-	M		-	-	-
66-82	-	-	-	F		-	-	-
67-82	-	-	Little Auk	M		-	-	-
68-82	-	-	Fulmar	F		-	-	-
69-82	23.8	0400	Little Auk	M	St.294	7900	3731	
70-82	-	-	-	M		-	-	-
71-82	-	-	-	M		-	-	-
72-82	-	-	-			-	-	-
73-82	-	-	-	M		-	-	-
75-82	-	2400	-	M	St.300	7848	3558	
76-82	-	-	-			-	-	-
77-82	-	-	-	F		-	-	-
78-82	-	-	-	M		-	-	-
79-82	-	-	-	F		-	-	-
80-82	-	-	-	F		-	-	-
81-82	-	-	Black Guillemot	F		-	-	-
82-82	-	-	Glaucous Gull	F		-	-	-
83-82	26.8	0900	-	M	Kapp Koburg, Kongsøya			
84-82	1.9		Eider (pull)		Moffen			
85-82	29.7		Kittiwake	F	7857 N	0751 W		

APPENDIX 2

Measurements of food items found in each bird species.

Measurements of food items in Fulmars (in mm).

Species/	Items in sample	No. of measurable items	Total length, incl.(tail length)	Tail length	Estimated total length
Parathemisto libelulla	3	2		6.0 6.0	22.0 22.0
	3	2		2.0 3.6	7.9 13.5

Measurements of Parathemisto libellula from Little Auks (in mm).

No. of items in sample	No. of measurable items	Total length, incl.(tail length)	Tail length	Estimated total length	Subsample multiplication factor
4	2	19 (4.9)	- 5.4	18.0 19.9	
2	2		1.8 2.4	7.2 9.3	
4	2		5.1 6.5	18.8 23.8	
2	1		2.8	10.7	
4	4		4.0 2.0 3.0 4.2	14.9 7.9 11.4 15.7	
7	5	12(3.1) 14(4.9)	- - 3.8 3.9 3.6	11.8 18.0 14.2 14.6 13.5	
20	5	13(3.5) 11(3.0)	- - 5.5 2.8 2.5	13.2 11.4 20.0 10.7 9.6	4
36	7	10(2.5) 15.5(4.2) 13.5(3.7)	- - - 3.0 4.5 1.8 4.0	9.6 15.6 13.9 11.4 16.7 7.2 14.9	5
39	5	16.5(3.5) 13.3(3.0)	- - 3.8 3.0 3.2	13.2 11.4 14.2 11.4 12.1	7

Length measurements of *Calanus finmarchicus* in Little Auks

No. of items in sample	No. of items measured	Length (in mm)
233	5	4.8 4.8 4.4 4.6 4.5
230	3	5.0 4.5 4.7
10	2	3.1 3.3
250	10	4.0 - 4.8
160	10	4.7 - 5.0
168	10	4.3 - 4.8
165	5	5.0 4.3 4.5 5.0 4.5
212	5	4.8 4.8 4.6 4.4 4.2
100	10	4.0 - 5.0

Measurements of food items from Little Auks (in mm).

Species/	Items in sample	No. of measurable items	Total length, incl.(tail length)	Tail length	Estimated total length
Apherusa glacialis					
	29	5	11(1.5)	-	6.6
			11(1.5)	-	6.6
			12(1.6)	-	7.0
				1.3	5.9
				2.0	8.4
	30	2	6.8	1.1	5.3
	116		12(2.0)	-	8.3
			10(1.5)	-	6.6
			10.5(1.8)	-	7.7
				0.8-2.0	4.2-8.4
	100	7		1.0	4.9
				1.8	7.7
				1.3	5.9
				1.4	6.3
				2.0	8.4
				2.0	8.4
				1.1	5.3

Species/	Items in sample	No. of measurable items	Total length, incl.(tail length)	Tail length	Estimated total length
Gammarus wilkitzkii					
	6	1	13(3.0)	-	13.3
	1	1	14.5(3.5)	-	15.6
	6	1	16.5(3.6)	-	16.0
	8	3	10(2.3)	-	10.2
				2.5	11.1
				1.2	5.3

Measurements of food items in Black Guillemots (in mm).

Species/	Items in sample	No. of measurable items	Total length, incl.(tail length)	Tail length	Estimated total length
Gammarus wilkitzkii	13	9	28(6.8)	-	28.4
			24(4.5)	-	18.2
			40(8.9)	-	37.7
			45(9.1)	-	38.6
			30(6.0)	-	24.8
			38(8.2)	-	34.6
				10.5	44.8
				5.3	21.7
				2.9	11.0

Measurements of Parathemisto libellula from Kittiwakes (in mm).

No. of items in sample	No. of measurable items	Total length, incl.(tail length)	Tail length	Estimated total length
80	1		1.5	6.1
9	4	8.3(1.8) 13.7(3.9)	- - 3.5 3.9	7.2 14.6 13.2 14.6
1	1		4.6	17.1
12	-			
1	-			

Measurements of food items in Kittiwakes (in mm).

Species/ Items in sample	No. of measurable items	Total length, incl.(tail length)	Tail length	Estimated total length
Gammarus wilkitzkii				
2	2	32(7.0)	-	29.3
		41(8.0)	-	33.7
Calanus finmarchicus				
100		3.5		
Thysanoessa inermis				
2	-			
13	-			
110	9	28		
		26		
		25		
		24		
		22		
		21		
		28		
		20		
		20		

Measurements of food items in Ivory Gulls (in mm).

Species/	Items in sample	No. of measurable items	Total length, incl.(tail length)	Tail length	Estimated total length
Gammarus wilkitzkii	6	4	42(10.0)	-	42.6
			40(7.5)	-	31.5
			35(7.0)	-	29.3
			30(6.0)	-	24.8

Measurements of food items in Glaucous Gulls (in mm).

Species/ Items in sample	No. of measurable items	Total length, incl.(tail length)	Tail length	Estimated total length
Gammarus wilkitzkii				
46	10	32		
		32		
		32		
		35		
		31		
		33		
		32		
		28		
		35		
		34		

Measurements of food items in a juvenile Eider (in mm).

Species/	Items in sample	No. of measurable items	Total length, incl.(tail length)	Tail length	Estimated total length
Onisimus edwardsii	74		7.5		

APPENDIX 3

Estimates of dry weight - length relationship of food taxa.

Estimates of dry weight - length of different food taxa. After Bradstreet (1980). Dry weight (in g) = Y (length in mm)^Z

Taxon	Y	Z	Mean length in Kittiwake	Little Auk
Parathemisto libellula	0.0035	2.78	12.1	12.9
Gammarus wilkitzkii	0.0031	2.80	-	12.9
Apherusa glacialis	0.0045	2.85	-	10.5
Calanus finmarchicus	0.0016	2.89	3.5	4.6
Calanoid copepods	0.0016	2.89	-	4.1
Cottidae	0.0006	3.36	55.6	-
Boreogadus saida	0.0002	3.41	5.4	-