THE DIET OF THICK-BILLED MURRE CHICKS IN THE EASTERN CANADIAN ARCTIC

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ABSTRACT.—I describe the diet of Thick-billed Murre (*Uria lomvia*) chicks at three colonies in the low Arctic of eastern Canada. These are compared with diets described previously for Akpatok Island in the same area and Prince Leopold Island in the high Arctic. Diets varied more among colonies than among years at the same colony. Indices of similarity showed the diet of chicks at Hantzsch Island to be the most distinct. The diets of all low-arctic colonies were more diverse than those reported at Prince Leopold Island. Some factors governing differences among colonies are discussed. *Received 26 November 1984, accepted 9 April 1985.*

THICK-BILLED Murres (*Uria lomvia*) breed over a great range of latitude in eastern Canada, from 47°N at Cape St. Mary's, Newfoundland to 76°N at Coburg Island, Northwest Territories, all within waters classified as either low arctic or high arctic (Salomonsen 1972, Brown et al. 1975). The species is the most numerous seabird in Lancaster Sound, Barrow Strait, and associated channels in the high Arctic and in Hudson Strait and adjacent waters in the low Arctic (Brown et al. 1975, Gaston 1982).

North of 60° latitude Thick-billed Murres breed at only 10 colonies in the eastern Canadian Arctic, all of more than 10,000 pairs (Fig. 1). Five of these are situated between 60° and 64°N, all in low-arctic waters, and 4 between 72° and 76°N in high-arctic waters. The remaining colony is close to the high-arctic/low-arctic boundary. The samples described here include the most westerly and the most easterly of the low-arctic group. Hence, they should provide a good indication of the range of variation in the diet of Thick-billed Murre chicks throughout their range in Canadian low-arctic waters.

The diet of Thick-billed Murre chicks at Prince Leopold Island, in Barrow Strait, was described by Gaston and Nettleship (1981). In this paper I describe their diets at three colonies in or near Hudson Strait [Coats Island (25,000 pairs), Digges Island (with adjacent mainland cliffs, 300,000 pairs), and Hantzsch Island (50,000 pairs)] and compare these with previously published data from the south colony at Akpatok Island (Tuck and Squires 1955) and with data from Prince Leopold Island. I address three principal questions: (1) Is variability among colonies greater than year-to-year variation at individual colonies? (2) Are diets at the low-arctic colonies more similar to one another than to the diet at Prince Leopold Island in the high Arctic? (3) Is the diet more diverse at low-arctic colonies than at Prince Leopold Island?

STUDY AREA AND METHODS

Thick-billed Murres feed their chicks for 15–30 days at the nest site before the young birds depart to sea at about 20% of adult weight (Birkhead and Nettleship 1981, Gaston and Nettleship 1981). Food is carried to the site in the adult's bill; normally, only one item is brought at a time. The meal is delivered to the chick immediately after the incoming adult has landed, and it is therefore difficult to observe the type of food brought. Some meals are dropped, however, and such discarded items can be collected on the breeding ledges during the chick-rearing period to determine the diet of the chicks.

At Prince Leopold Island, Gaston and Nettleship (1981) showed that the proportion of different types and sizes of food identified in the diet of Thick-billed Murre chicks varied with the collecting method. Fish found on ledges may be those brought to eggs not yet hatched, or to chicks that have left the colony. Consequently, the type of food fed either to very young or to very old chicks may be overrepresented. Where comparisons are made among collections made by the same method, however, such biases should not greatly affect the consideration of diversity or overlap.

Collections and observations of food delivered to Thick-billed Murre chicks were made at Digges Island in 1980, 1981, and 1982; at Coats Island in 1981 and 1984; and at Hantzsch Island in 1982. Specimens were collected during visits made to the breeding ledges to weigh and measure chicks or to band them. At Coats Island and Hantzsch Island these collections were augmented by observations made at close range (<10 m), when food items were identified visually.

All fresh and complete specimens were weighed to the nearest 1 g and their overall length measured (±1 mm). They then were preserved in 70% ethanol,

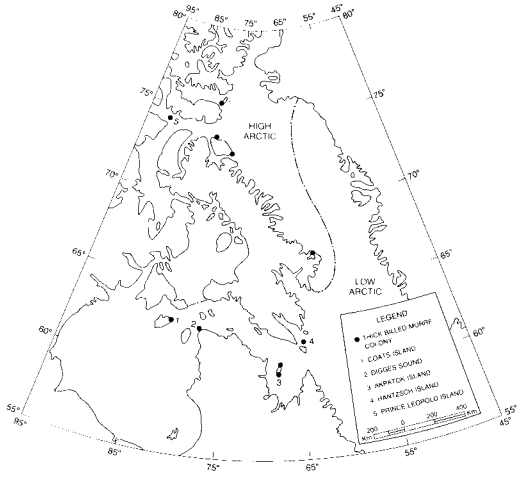

Fig. 1. The eastern Canadian Arctic, showing the position of Thick-billed Murre colonies mentioned in the text.

and representative specimens of all taxa were identified by staff of the National Museums of Canada. For difficult groups, such as blennies (Blennioidei) and sculpins (Cottidae), all identifications were confirmed by museum personnel. Dried specimens were measured, and their weights were determined from the regression of weight on length[3] determined for fresh specimens (Appendix 1). In estimating the contribution of different taxa to chick diets by weight, I used only specimens collected, including those weighed fresh and those estimated from length measurements.

To describe the similarity between diets at different colonies, or at the same colony in different years, I used Morisita's Index (C_λ), as recommended by Wolda (1981):

$$C_\lambda = \frac{2 \sum n_{1i} n_{2i}}{(\lambda_1 + \lambda_2) N_1 N_2},$$

where $\lambda_j = [\sum n_{ji}(n_{ji} - 1)]/[N_j(N_j - 1)]$, N_j = the number of specimens in sample j, and n_{ji} = the number of specimens of species i in sample j. To describe the diversity of the diets, I used the Shannon-Weaver diversity index (H'; Tramer 1969):

$$H' = -\sum_{i=1}^{s} p_i(\ln p_i),$$

where p_i = the proportion of all specimens in the sample that belong to species i and s = total species in the sample.

The magnitude of both these indices is considerably affected by the level of identification employed. The more categories into which the sample is split, the greater the potential diversity and the smaller the likely overlap between samples (Diamond 1983). For present purposes, where I have combined data from sight records and collections, I have had to lump certain taxonomic groups that can be distinguished only in the hand. For comparison of overlap involving this type of data, I have lumped data from all samples into the same categories, namely, capelin (*Mallotus villosus*), lanternfish (Myctophidae), arctic cod (*Boreogadus saida*), blennies (Blennioidei), sand lance (*Ammodytes* spp.), redfish (*Sebastes* spp.), sculpins (Cottidae), lumpfish (*Cyclopteropsis* spp.), lumpsuckers (*Eumicrotremus* spp.), snailfish (*Liparis* spp.), Greenland halibut (*Reinhardtius hippoglossoides*), squid (*Gonatus fabricci*), and Crustacea. Comparisons made with Prince Leopold Island are based on Table 66 of Gaston and Nettleship (1981) and those with Akpatok Island are based on Table 1 of Tuck and Squires (1955). Comparisons of diet diversity are based only on specimen collections, all of which were identified to species level. Names used follow Hunter et al. (1984).

RESULTS

Food items fed to Thick-billed Murre chicks ranged from less than 1 g to 41.5 g in weight. The mean weight of items collected ranged from 5.6 g at Digges Island in 1982 to 11.6 g at Coats Island in 1981 (Table 1). All collections showed a strongly skewed distribution, with the commonest size class being below 5 g. The range and variation among weights was similar among all samples. The size of individual items gives a good indication of the size of meals fed to chicks because practically all meals seen delivered consisted of only a single item, except at Coats Island in 1984, where 6% (n = 125) of deliveries were of two items. Mean weights of individual taxa based on fresh specimens only are given in Appendix 2.

Fish comprised more than 90% of items in all samples (Fig. 2). The commonest in all samples except those from Hantzsch Island was arctic cod. Other common constituents were capelin (29% of items at Coats Island in 1984), blennies (14–18% of items at Digges Island), sand lance (up to 20% of items at Digges Island), and sculpins (48% of items at Hantzsch Island). Full details of species identified and numbers recorded in this study are given in Appendix 2. The picture was broadly similar when diets were considered by weight. The predominant fish remained the same in all samples (Fig. 3), but capelin and sand lance were less important and blennies more important.

Although arctic cod was the commonest fish recorded in all but one sample, ranging from

TABLE 1. Mean weights (g) and size range of food items fed to Thick-billed Murre chicks at three colonies.

Colony	Year	Weight				
		Mean	SD	*n*	Median	Range
Coats Island	1981	11.6	8.74	23	11.0	<1–35.0
	1984	10.1	9.01	42	6.0	0.7–41.5
Digges Island	1980	8.9	8.25	59	5.7	0.7–31.8
	1981	8.6	6.66	36	7.2	1.5–30.0
	1982	5.6	4.17	17	4.1	1.4–16.4
Hantzsch Island	1982	10.1	7.23	35	9.0	1.0–29.0

14% (Hantzsch Island) to 62% (Digges Island, 1982) of the diet by number, it never formed as great a proportion as at Prince Leopold Island, where it constituted 78% of items brought over three years. Capelin and sand lance, both frequent at the low-arctic sites, were not recorded at all at Prince Leopold Island. Sculpin were the predominant group of fish at Hantzsch Island, but elsewhere they did not exceed 27% of items (at Akpatok Island).

Similarity indices calculated from frequencies for each combination of years at Digges Island, Prince Leopold Island, and Coats Island were all close to the expected maximum value of C_λ of "about 1" (Wolda 1981; Table 2), indicating that variation among years at the same colony is insignificant. Consequently, I combined samples from different years to increase sample sizes for intercolony comparisons (Table 3). All colony samples differed significantly from every other colony in the frequency of different food types, using a Chi-square test for heterogeneity (Table 4).

Chicks at Hantzsch Island had the most distinct diet, with a mean similarity index of 0.53 (Table 4). The group of colonies within Hudson Strait (Coats, Digges, and Akpatok islands) showed the greatest similarity to one another, all three pairings having indices greater than 0.8.

Diversity of species in the samples was greatest at Coats Island in 1984 ($H' = 1.91$) and Hantzsch Island ($H' = 1.81$). At Digges Island diversity indices ranged from 1.19 in 1982 to 1.41 in 1981 and 1.54 in 1980. It was not possible to calculate a comparable index for Tuck's Akpatok samples because certain families of fishes were not identified by species or genus. At Prince Leopold Island diversity indices were lower than any of those calculated for the low-arctic colonies (1975, 0.47; 1976, 0.91; 1977, 0.62). Only 5 species of fish were identified among 178 specimens collected at Prince Leopold Island, compared with 11 species at Coats Island ($n = 231$), 14 at Digges Island ($n = 194$), and 9 at Hantzsch Island ($n = 73$). At Akpatok Island Tuck and Squires's very much larger sample of 2,530 fish included 20 taxa of species-level or higher.

DISCUSSION

Comparison of similarity indices calculated for samples from the same colony in different years with those calculated for samples from different colonies strongly suggests that differences in diet among colonies are greater than those caused by annual variation at any one colony. Because not all samples were taken in the same years, the differences among colonies could be the result of fluctuations in the populations of certain fish species, which took place over the entire eastern Canadian Arctic. However, this is unlikely to apply to differences between Coats, Digges, and Hantzsch islands, where all sampling was carried out within four years. It seems reasonable to conclude that there are real differences among colonies in chick diets.

Comparisons of the samples from the low Arctic with those from Prince Leopold Island show that the diversity of the diet is considerably greater at the low-arctic colonies, presumably reflecting the greater diversity of prey species available to the Thick-billed Murres. Hunter et al. (1984) record 48 species of marine fishes from Hudson Strait, Ungava Bay, and southeast Baffin Island, compared with only 27 species from Lancaster Sound, Barrow Strait, and adjacent channels, although this may, to a certain extent, reflect differences in sampling intensity.

Differences among colonies within the low-arctic zone suggest that there is considerable

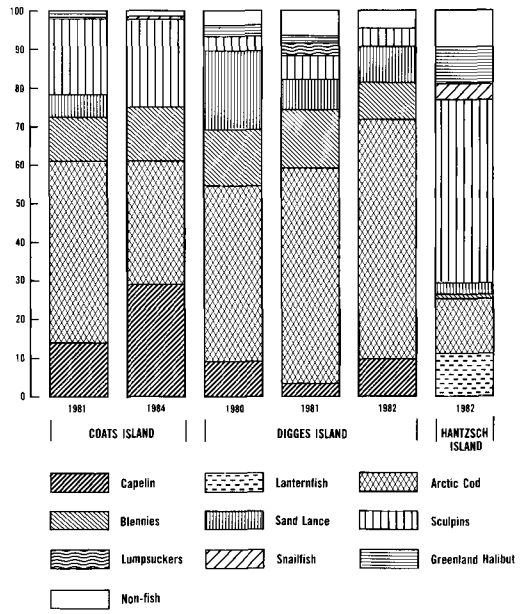

Fig. 2. Proportions of different food types by number in the diets of Thick-billed Murre chicks at three colonies.

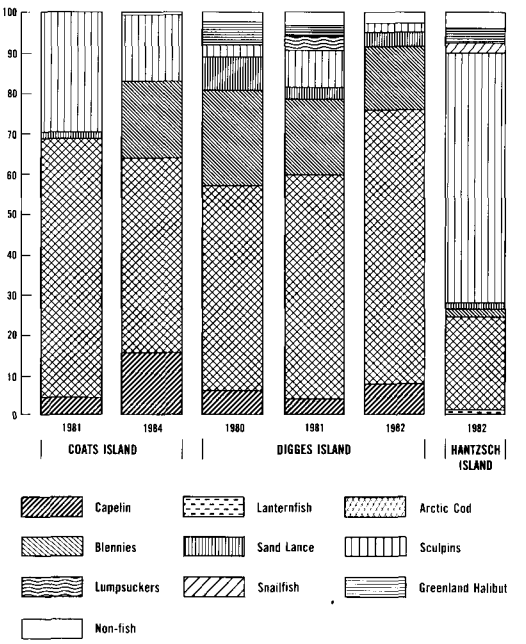

Fig. 3. Proportions of different food types in the diets of Thick-billed Murre chicks by weight.

regional variation in the availability of different fish species. Capelin and sand lance, both midwater schooling species, were commonest at Coats and Digges islands. These fish are typical of low-arctic waters off eastern Canada (Dunbar and Hildebrand 1952). Stocks fluctuate considerably over periods of several years (Carscadden 1984), and this may have accounted for their rarity at Hantzsch and Akpatok islands.

Blennies and sculpins are bottom-living fish (Leim and Scott 1968). If their presence indicates that the murres involved were feeding in shallow water, then we might have expected parallel variation in the samples. This was not the case. Only one blenny was found at Hantzsch Island, where sculpins were common. Where either group was numerous, it usually was represented by more than one species; hence, variation in year-class strengths seems unlikely to account for the intercolony variation observed. Probably, the two groups favor different water-depths or bottom-types, but little information is available on the ecology of noncommercial arctic marine fishes.

Lanternfish, recorded only at Hantzsch Island in 1983, generally are considered to be bathypelagic fish. However, Orr and Parsons (1982) found them to be an important component in the diet of surface-feeding Ivory Gulls (*Pagophila eburnea*) in Davis Strait, not far from Hantzsch Island. Dunbar and Hildebrand (1952) mentioned that Ungava natives were familiar with lanternfish, which sometimes occurred at the surface, "often dead or dying." Clearly, they occur at the surface on occasion, and hence their appearance in the diet of the murres tells us nothing about the murres' foraging.

At Digges Island adult murres were collected from nearby feeding areas during the chick-rearing period in all three years. Analysis of stomach contents yielded many fish otoliths, the majority much smaller than those charac-

TABLE 2. Values of Morisita's Index (C_λ) for interyear comparisons at a single colony, showing that interyear differences were small.

Colony	Years	C_λ
Digges Island	1980:1981	0.965
	1980:1982	0.992
	1981:1982	1.034
Prince Leopold Island	1975:1976	1.007
	1975:1977	1.000
	1976:1977	1.016
Coats Island	1981:1984	1.012

TABLE 3. Numbers of different taxa recorded in the diet of Thick-billed Murre chicks at five colonies.

Taxon	Coats Is.	Digges Is.	Akpatok Is.[a]	Hatzsch Is.	Prince Leopold Is.[b]
Capelin (*Mallotus villosus*)	59	13	38	0	0
Glacier lanternfish (*Benthosema glaciale*)	0	0	2	8	0
Arctic cod (*Boreogadus saida*)	81	100	931	10	139
Blennies (Blennioidei)	31	28	536	1	0
Sand lance (*Ammodytes* spp.)	3	27	36	2	0
Redfish (*Sebastes marinus*)	0	0	1	0	0
Sculpins (Cottidae)	51	9	728	35	32
Smooth lumpfish (*Cyclopteropsis jordani*)	0	0	0	0	1
Lumpsuckers (*Eumicrotremus* spp.)	0	2	24	0	0
Snailfish (*Liparis* spp.)	1	0	45	3	1
Greenland halibut (*Reinhardtius hippoglossoides*)	1	4	118	7	0
Squid (*Gonatus fabricii*)	2	10	70	7	0
Crustacea	2	1	98	0	5
Annelida	0	0	3	0	0
Total	231	194	2,630	73	178

[a] From Tuck and Squires (1955).
[b] From Gaston and Nettleship (1981).

teristic of the fish delivered to chicks (Gaston and Noble 1985). Comparing only the most common fish, arctic cod, the median weights of those found in adult stomachs (estimates from otolith length) during the chick-rearing period were 3.0, 4.4, and 3.7 g in 1980, 1981, and 1982, respectively. Comparable figures from the chick samples were 10.6, 7.8, and 4.5 g. This finding is consistent with the predictions of central-place foraging models (Andersson 1978, Orians and Pearson 1979).

Gaston et al. (1983) suggested that birds from Digges Island foraged at greater distances from their colony than those at Hantzsch or Coats Island. However, the mean size of fish delivered at Digges Island was smaller than those delivered at the other two colonies, although not significantly so. Superficially, this appears to contradict the predictions of central-place foraging theory. However, the theory applies only to foraging from a single center, and has not yet been generalized to intercolony comparisons. The small size of fish at Digges Island, along with a lower rate of feeding, presumably explains the low growth rate of chicks at this colony (Gaston et al. 1983).

At large colonies, where birds travel long distances to feed, a large proportion of the potential foraging area is likely to be far offshore. We therefore might expect the diet of birds at large colonies to contain a lower proportion of typically coastal fish than the diets of birds at small colonies. The fact that bottom-living blennies and sculpins were more common at Hantzsch (50,000 pairs) and Coats islands (25,000 paris) than at Digges Island (with adjacent Cape Wolstenholme, 300,000 pairs) is consistent with this expectation. However, the present sample of colonies is insufficient for any firm generalization to be possible.

TABLE 4. Morisita's Index of similarity for samples of Thick-billed Murre chick diets from five colonies (upper right), and values of Chi-square test for each combination (lower left).

	Coats Is.	Digges Is.	Akpatok Is.	Hantzsch Is.	Prince Leopold Is.
Coats Is.	—	0.815	0.869	0.601	0.703
Digges Is.	79.3[a]	—	0.822	0.362	0.862
Akpatok Is.	381.3	210.8	—	0.739	0.736
Hantzsch Is.	97.2	127.7	64.9	—	0.424
Prince Leopold Is.	102.5	90.6	133.6	103.3	—
Mean C_λ	0.747	0.715	0.791	0.531	0.681

[a] All χ^2 values significant at $P < 0.001$.

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APPENDIX 1. Formulae for estimating fresh weights from length for taxa included in Fig. 3. (Specimens of other taxa were estimated from the mean weight of fresh specimens of the same taxon from the same sample in the preparation of Fig. 3.)

Taxon	Regression formula[a]	r^2	n
Capelin	$W = (0.616 \times L^3/100) - 2.509$	0.907	22
Arctic cod	$W = (0.642 \times L^3/100) - 0.536$	0.921	40
Fish doctor	$W = (0.346 \times L^3/100) - 1.464$	0.778	11
Sand lance	$W = (0.247 \times L^3/100) + 0.086$	0.813	17
Sculpin spp.	$W = (0.790 \times L^3/100) + 0.576$	0.904	21

[a] Where W is in g and L in cm.

APPENDIX 2. Mean weights (g) of fish collected at low-arctic Thick-billed Murre colonies.

	Coats 1984			Digges 1980			Digges 1981			Digges 1982			Hantzsch 1982		
	$\bar{x}$	SD	n	$\bar{x}$	SD	n	$\bar{x}$	SD	n	$\bar{x}$	SD	n	$\bar{x}$	SD	n
Capelin	5.3	1.34	13	4.09	1.63	8	16.0	—	1	4.80	0.99	2			
Lanternfish													2.00	0.82	4
Arctic cod	18.00	12.67	12	12.35	8.91	22	9.63	7.24	18	6.40	4.33	9	16.06	6.02	9
Blennies	9.3	4.41	8	13.95	10.14	9	8.83	5.58	3	9.9	4.24	2	12.0	—	1
Sand lance				2.69	1.93	14	2.70	1.34	4	2.00	0.42	2			
Sculpin															
Large	10.6	4.40	6	7.10	2.55	2	14.12	7.12	4	3.4	—	1	12.62	6.53	12
Small[a]	0.8	0.14	3												
Lumpsucker							14.40	7.92	2						
Snailfish													5.67	3.79	3
Greenland halibut				15.35	7.71	2	4.75	1.06	2				3.50	1.32	3
Squid				6.5	0.64	2	4.75	1.77	2	2.9	—	1	4.00	3.46	3

[a] A small number of recently postlarval fish delivered at Coats Island in 1984.

APPENDIX 3. Numbers of different prey taxa identified in six samples of chick diets. Figures in parentheses include those identified visually; these were the figures used in calculating Morisita's indices.

	Coats Island		Digges Island			Hantzsch Island
	1981	1984	1980	1981	1982	1982
Capelin (*Mallotus villosus*)	5 (7)	13 (52)	8 (8)	3 (3)	2 (2)	1 (1)
Glacier lanternfish (*Benthosema glaciale*)	(0)	(0)	(0)	(0)	(0)	4 (8)
Arctic cod (*Boreogadus saida*)	11 (24)	12 (57)	40 (40)	47 (47)	13 (13)	9 (10)
Fish doctor (*Gymnelus viridis*)		2	9	7	1	1
Fourline snakeblenny (*Eumesogrammus praecisus*)		3	2	2		
Stout eelblenny (*Anisarchus medius*)			1			
Daubed shanny (*Leptoclinus maculatus*)		3		2		
Slender eelblenny (*Lumpenus fabricii*)		1	1		1	
All blennies (Blennioidei)	2 (6)	(25)	(13)	(11)	(2)	(1)
Northern sand lance (*Ammodytes dubius*)	2 (3)	(0)	18 (18)	7 (7)	2 (2)	1 (1)
Arctic staghorn sculpin (*Gymnocanthus tricuspis*)		2				
Spatulate sculpin (*Icelus spatula*)		1				
Shorthorn sculpin (*Myoxocephalus scorpius*)		4				
Moustache sculpin (*Triglops murrayi*)			1			
Bigeye sculpin (*Triglops nybelini*)				4	1	18
Ribbed sculpin (*Triglops pingelii*)		2	1			9
All sculpins (Cottidae)	7 (10)	(41)	(2)	(5)	(1)	(35)
Leatherfin lumpsucker (*Eumicrotremus derjugini*)				1		
Atlantic spiny lumpsucker (*Eumicrotremus spinosus*)				1		
All lumpsuckers	(0)	(0)	(0)	(2)	(0)	(0)
Gelatinous snailfish (*Liparis fabricii*)		(1)				3 (3)
Greenland halibut (*Reinhardtius hippoglosoides*)	(1)		2 (2)	2 (2)	(0)	5 (7)
Unidentified fish		1	1	2		
Squid (*Gonatus fabricii*)	(0)	1 (2)	3 (3)	6 (6)	1 (1)	5 (7)
Crustacea	(0)	(2)	1 (1)	(0)	(0)	(0)
Total	27 (51)	45 (180)	88 (87)	85 (83)	21 (21)	56 (73)