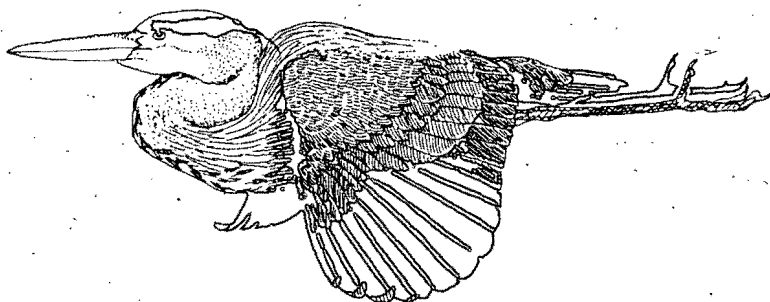


PROJECT ON THE POPULATION DYNAMICS OF THE
THICK-BILLED MURRE, *Uria lomvia* : INTERIM
REPORT ON STUDIES AT COATS ISLAND

A. J. Gaston



TECHNICAL REPORT SERIES No. 134
Headquarters 1991
Canadian Wildlife Service

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ABSTRACT

The Thick-billed Murre colony at Coats Island has been visited annually since 1984 to band nestling and adult Thick-billed Murres, to make observations on the survival of banded birds, and to record annual variations in certain breeding biology parameters. The project is designed to provide information on the demography of the population, to allow a better assessment of the effects of hunting in Newfoundland. Preliminary findings are described.

ABRÉGÉ

La colonie de Marmettes de Brunnich qui se trouve à l'île Coats a été visitée chaque année depuis 1984 pour baguer les oisillons et les adultes marmettes, pour étudier le taux de survi des oiseaux bagués, et pour effectuer des recherches sur quelques paramètres de biologie de la reproduction. Le projet fut conçu afin d'expliquer la démographie de la population, et promouvoir une meilleure entente des effets de la chasse à Terre Neuve. Résultats préliminaires sont décrit.

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Appendix 8: Summaries of chick growth data

1. INTRODUCTION

1.1 Background

The Thick-billed Murre (Aqpa, or Akpa in Inuktitut) is the commonest seabird breeding in the eastern arctic. About 70% of the Canadian population breeds in Hudson Strait and adjacent parts of northern Hudson Bay (Gaston 1980). The colony near Cape Pembroke, at the northeastern tip of Coats Island, is the furthest west in this area (Figure 1.1). It is fairly small, with about 25,000 breeding pairs (Gaston et al. 1987), compared to the other colonies in the Hudson Strait-Hudson Bay area, Digges Sound with about 300,000 and Akpatok Island with about half a million breeding pairs. In some parts of the arctic, especially western Greenland, and perhaps also in the Canadian High Arctic, Thick-billed Murre populations have decreased (Evans and Nettleship 1985).

Thick-billed Murres from all the Canadian colonies, as well as those in West Greenland, winter in waters of Newfoundland and Labrador (Gaston 1980). Between September and March, large numbers of them are shot, especially in the bays on the east coast of Newfoundland (Gaston and Elliot 1991). The Canadian Wildlife Service is carrying out studies to find out whether the hunting that goes on in Newfoundland during the winter might be the cause of observed declines.

Since 1984, a team from the Canadian Wildlife Service has visited Coats Island every summer to band young Thick-billed Murres before they leave the cliffs. We have banded between 1600 and 2700

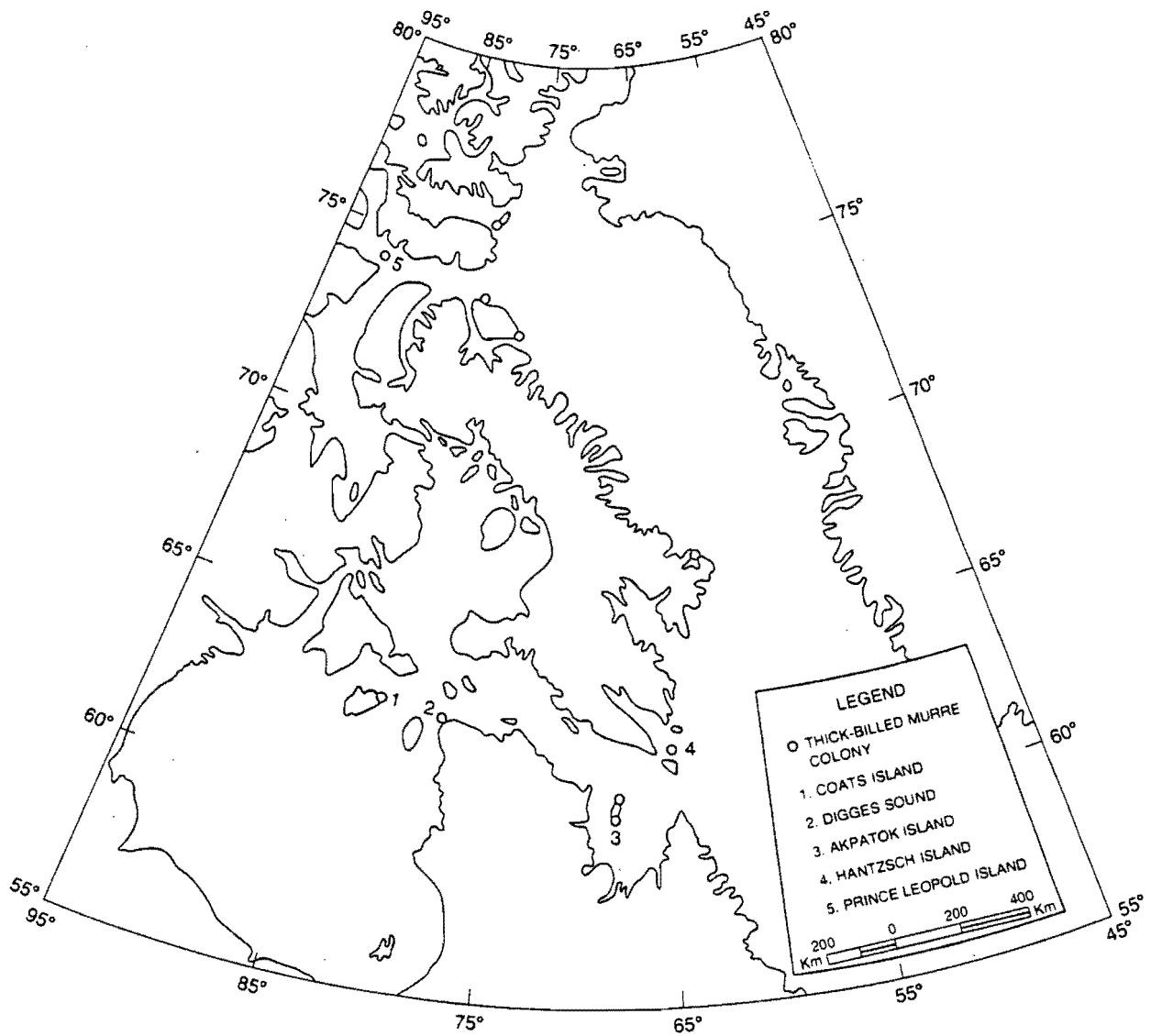


Figure 1.1 Thick-billed Murre colonies in the eastern Canadian Arctic

a year. The aim of this work is to recover banded birds in the area where they spend the winter, off Newfoundland, and to record them when they return to the colony. Information from recoveries in Newfoundland tells us how old the birds are when they are shot, while information from the observations of birds at the colony tells us what proportion of the birds survive to be a certain age, and what effect their age has on their reproductive success. The proportion of birds breeding at different ages, and their success (young birds are less successful than older ones) are important in determining the reproductive rate of the population, and hence the amount of hunting it can sustain.

Because young birds do not breed (most birds do not begin until 4 or 5 years old, see below), we obtained little information on the breeding of known-age birds for the first few years of the project. We began to collect detailed information on the age of breeders in 1988, when our eldest colour-banded cohort was 4 years old. Only a small proportion of four-year olds, and a handful of three-year olds bred in that year. In 1989 we arrived at the colony about the time that the chicks were beginning to hatch, so probably some young birds that had laid eggs had lost them before we arrived. In 1990 we arrived on the island before the start of laying, so that we could record more precisely which young birds bred, and how successful they were. Small numbers of four-year olds and progressively larger proportions of five-year- and six-year-olds bred, and we obtained good information on their reproductive success. Because conditions fluctuate a lot from year to year, we

cannot rely on observations from a single year. Consequently, the project is planned to continue for at least two more full seasons.

Progress on the project up to the 1986 season was reported by Gaston et al. (1987). The present report is an interim statement of the project's achievements during 1987-90. It deals only with the Canadian Wildlife Service programme, focussing on the demographic study, and aspects of breeding biology that have been monitored every year. Details of research carried out by associated graduate students is briefly described in Appendix 1. Incidental observations of mammals and birds, other than Thick-billed Murres, are given in Appendix 2.

1.2 Transport, camp, etc.

In all years the field party travelled to and from Coats Island by Twin-otter from Iqaluit, courtesy of Polar Continental Shelf Project. Details of dates and personnel are given in Table 1.1.

In 1985 three blinds were transported from Digges Island and set up along the top of the colony; Upper and Lower Fox Gully blinds (UFG, LFG) and North Blind (N). In 1989 a new blind was erected at the "S" observation point, and the LFG blind was moved, because breeding birds had encroached around the door, making it impossible to enter without disturbing them. Two more blinds were erected in 1990; one at "Q", the other, a standing-height blind, at "Z" (Figure 1.2). In 1988 a plywood cabin was erected at the camp site, on top of the colony hill. Some equipment is stored inside over winter.

Communications in all years were maintained with the Science Institute Research Centre (Iqaluit Laboratory) in Iqaluit via HF radio (SBX-11). Transmission conditions were often very bad, especially in 1989, when from 10 August onwards we were unable to communicate at all. This was the result of a widespread electrical storm, caused by sunspot activity, and hence beyond our control. Communications over HF frequencies were disrupted all over the arctic. Things were better in 1990, with some communication possible at least every two days. After Thomas Alogut arrived we had daily unscheduled communication (in Inuktitut) with camps elsewhere on the island, and with Coral Harbour.

Table 1.1 Details of personnel and dates of occupation of the Coats Island camp

YEAR	DATES	PERSONNEL
1987	23 July- 18 August	R.D.Elliott, C.W.S., Atlantic Region D.G.Noble, Research Associate D. Croll, University of California, San Diego, doing a Ph. D. on the physiology of diving in Thick-billed Murres J.B.Geale, Volunteer Field Assistant K. Bredin, Volunteer Field Assistant
1988	9 June- 7 August	A.J.Gaston, C.W.S., Headquarters D.G.Noble, Queen's University, Kingston, Ontario, doing M.Sc. research on the behaviour of pre-breeding T-B Murres S.D.Johnson, Field Assistant K.A.Allard, Field Assistant D.Croll, University of California E.McLaren, University of Oregon C.Rohner, Volunteer Field Assistant
1989	27 July- 20 August	A.J.Gaston, C.W.S.-HQ D.Croll, University of California L. de Forest, Volunteer Field Assistant G. Gilchrist, conducting honours research on predation by Glaucous Gulls
1990	23 May- 23 August	A.J.Gaston, C.W.S.-HQ D.G. Noble, Queen's University A. Berto, Field Assistant L. de Forest, University of Ottawa, doing an M.Sc. on age-specific reproductive success in murres G. Gilchrist, University of British Columbia, doing M.Sc. research on interactions between Glaucous Gulls and murres G. Donaldson, Field Assistant T. Alogut, Field Assistant

W colony from the sea

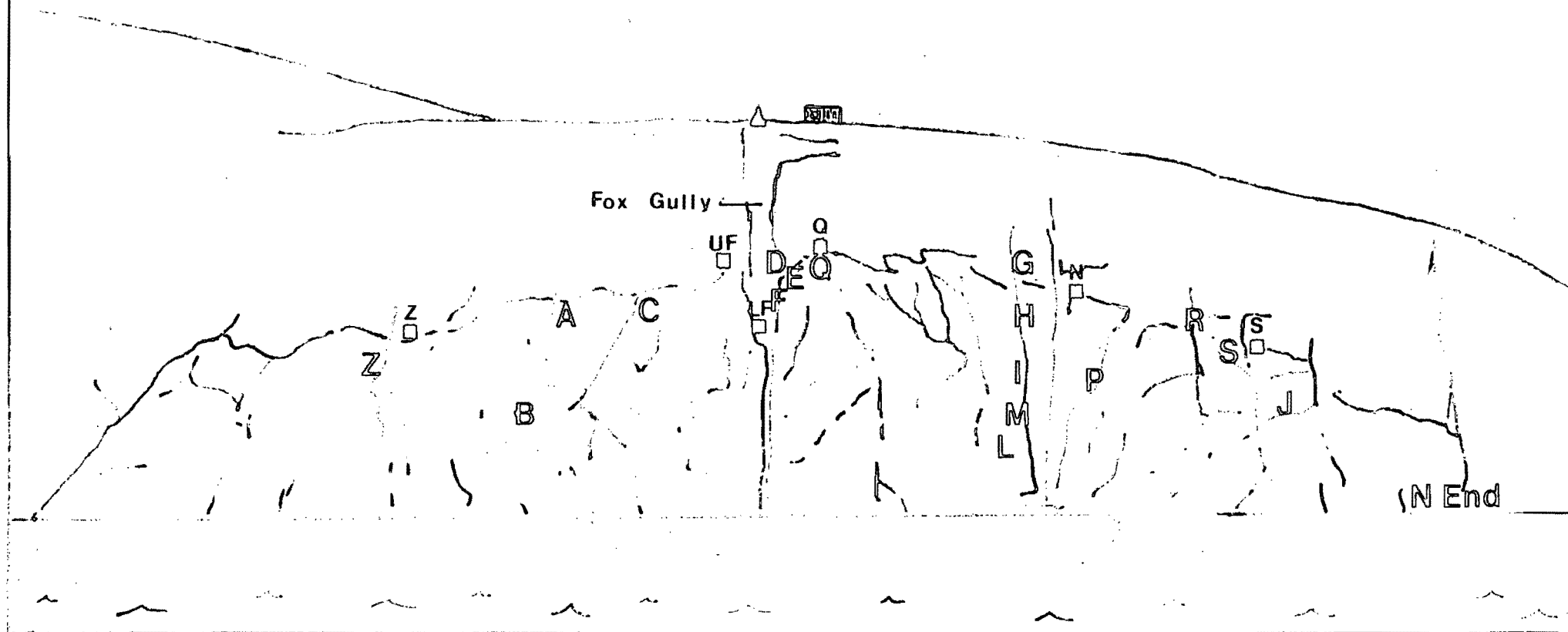


Figure 1.2 Sketch of the west colony at Coats Island, from the sea, showing the approximate position of blinds and study plots

1.3 Weather and ice

The weather conditions at camp were recorded daily at 1700 hrs EST. Full details are given in Appendix 3. Temperatures in late May 1990 were generally below zero, falling to a minimum of -8°C (Figure 1.3). The last date with frost was 26 June in 1988 and 25 June in 1990. Heavy snow fell on 26 May and 9 June, and traces up to 16 June in 1990. Maximum temperatures in 1988 and 1990 occurred on 16 July (22°) and 11-12 July (18°) respectively. The maximum temperature recorded in 1987 was 18° , on 30 July, and in 1989 22° , on 29 July. Maximum temperatures remained largely above 10° until mid-August, except in 1990, when the mean maximum temperature during the first week of August was only 9° . Frost was recorded at the end of the season only in 1990, from 18 August.

Winds were more often from the west and southwest than from other directions (54% of days in 1988, 42% in 1990). Westerlies prevailed in late July and early August in all years except 1990 (Table 1.2). Wind speeds reached or exceeded 30 km/h on 34% of days in 1988 and on 45% in 1990. In 1990, periods of strong winds, with gusts above 60 km/h occurred on 25 May, 6-7, and 14-16 June, 11-12, 16-18 and 26-30 July, and 3-5, 14-16, 19 and 22 August (Figure 1.4). Gusts exceeded 100 km/h on 16, 18 and 26 July and 15 August. Otherwise, winds of more than 60 km/h were recorded only on 31 July and 12 August 1987 and 25 June and 6 August 1988. Heavy rain fell on 12, 17, 18 and 26 July and 5 and 14 August.

Precipitation was recorded on 48% of days in 1987, 38% in 1988, 61% in 1989 and 51% in 1990. In 1988 and 1990 it was fairly evenly distributed through the season. The period of heaviest rainfall occurred on 17 and 18 July 1990, when approximately 40 mm fell in 48 h. A thunderstorm, with lightning and heavy rain, occurred on the night of 31 July 1989, following a period of very high temperatures. Comparisons of the last week of July and the first week of August show that 1990 was the coldest, wettest and windiest of the four years reported here (Table 1.2). It was also the only year in which fog was a problem for carrying out the daily counts,

with visibility from camp less than 1 km on 8 days, including 3 between 26-29 July.

Table 1.2 Weather statistics for the last week of July and the first week of August for the Coats Island camp in 1987-1990.

VARIABLE	1987		1988		1989		1990	
	25-31 Jul.	1-7 Aug.	25-31 Jul.	1-7 Aug.	27-31 Jul.	1-7 Aug.	25-31 Jul.	1-7 Aug.
<u>Temperature</u>								
Mean Maximum	14	15	13	11	15	10	7	9
Mean minimum	3	3	5	6	8	4	3	4
<u>Wind</u>								
Mean speed	22	25	27	40	16	14	59	31
Prevailing direction	SW	SW	SW	W	W	W	SE	W
<u>Precipitation</u>								
Days	4	1	3	4	3	3	6	6
7-day total(mm)	3	1	5	4	10+	[10]	33	[10]

No sea ice was seen from shore in 1987 and 1989, although "ice blink" was visible to the north on several occasions. As we arrived in 1989 we saw a large field of small ice pans at the eastern entrance to Evans Strait. Similar ice was present about 30 km north of Coats Island during the aerial survey on 13 August 1989. In 1988 land fast ice was present for several kilometers out to sea on 9 June and did not begin to break up until 16 June. No more than 30% ice cover was recorded after 9 July and the last pack ice was seen on 25 July. On the flight from Iqaluit on 23 May 1990 heavy pack ice was present from Cape Dorset to Coats Island, except for a strip a few km wide running south from Cape Pembroke down the east coast of Coats Island. At the colony, land fast ice extended 3-4 km out from the shore. Heavy pack persisted, with only small areas of

open water visible from the camp, until 12 July, except for the 6-9 June, when strong southerly winds cleared away most ice beyond the land-fast shelf. Land-fast ice in the colony cove cleared out on 7 July and, as in 1988, no pack ice was seen from shore after 25 July.

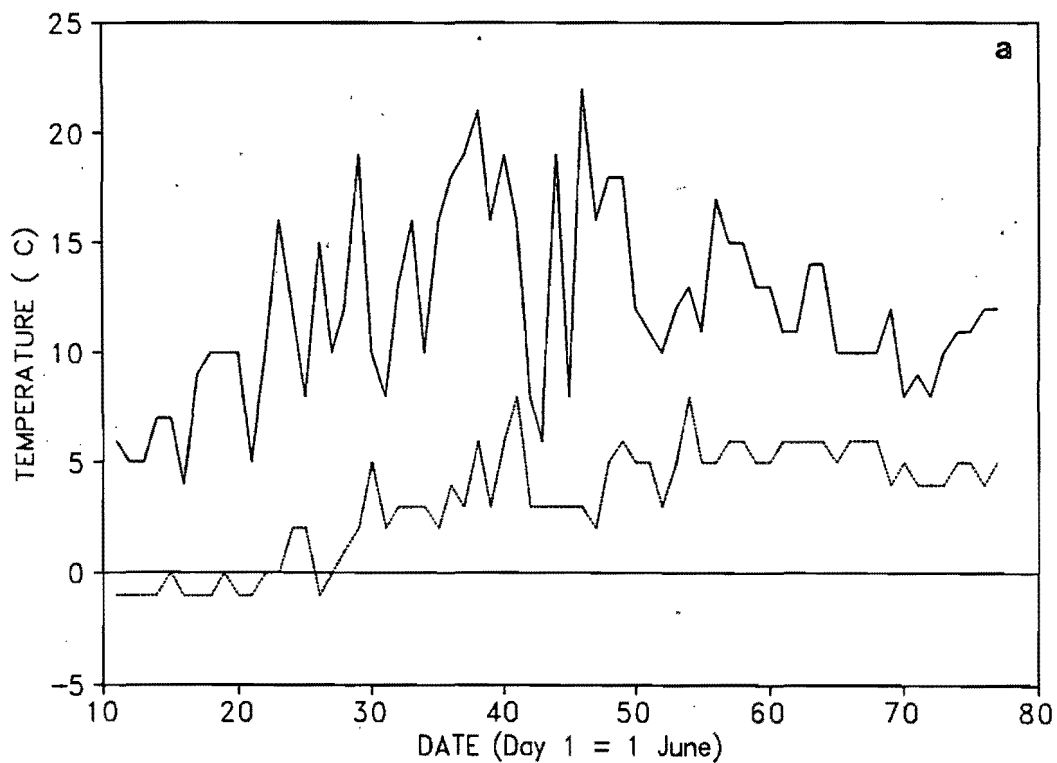
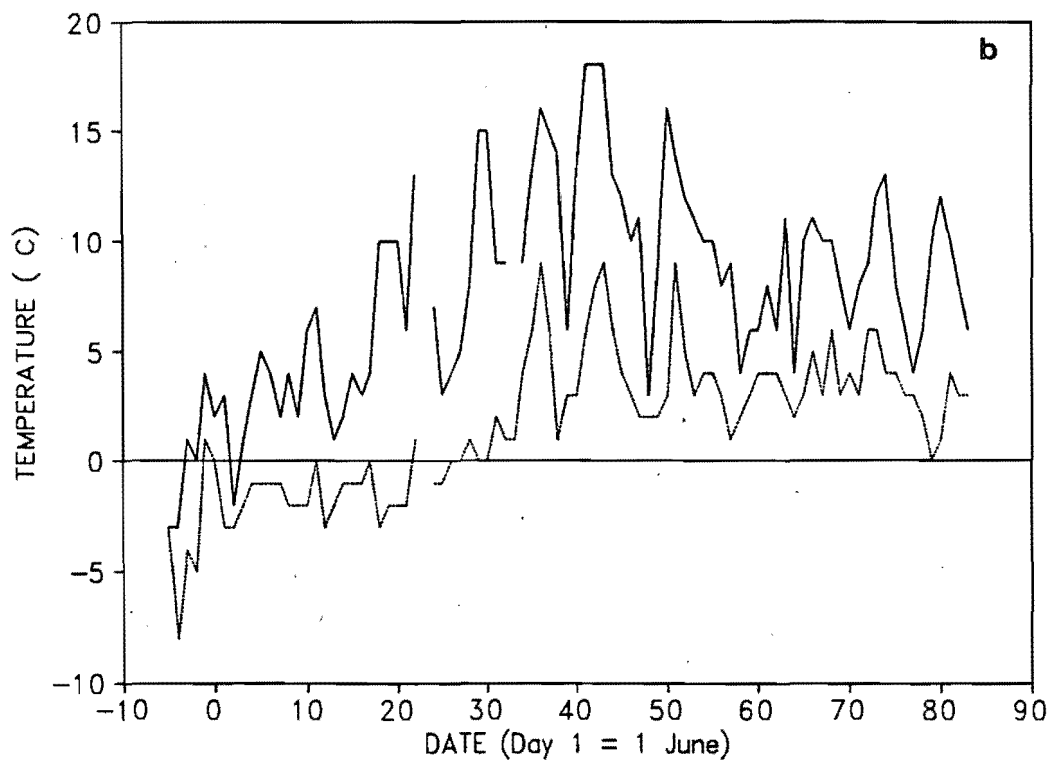


Figure 1.3 Daily maximum and minimum temperatures at camp in (a) 1988, (b) 1990

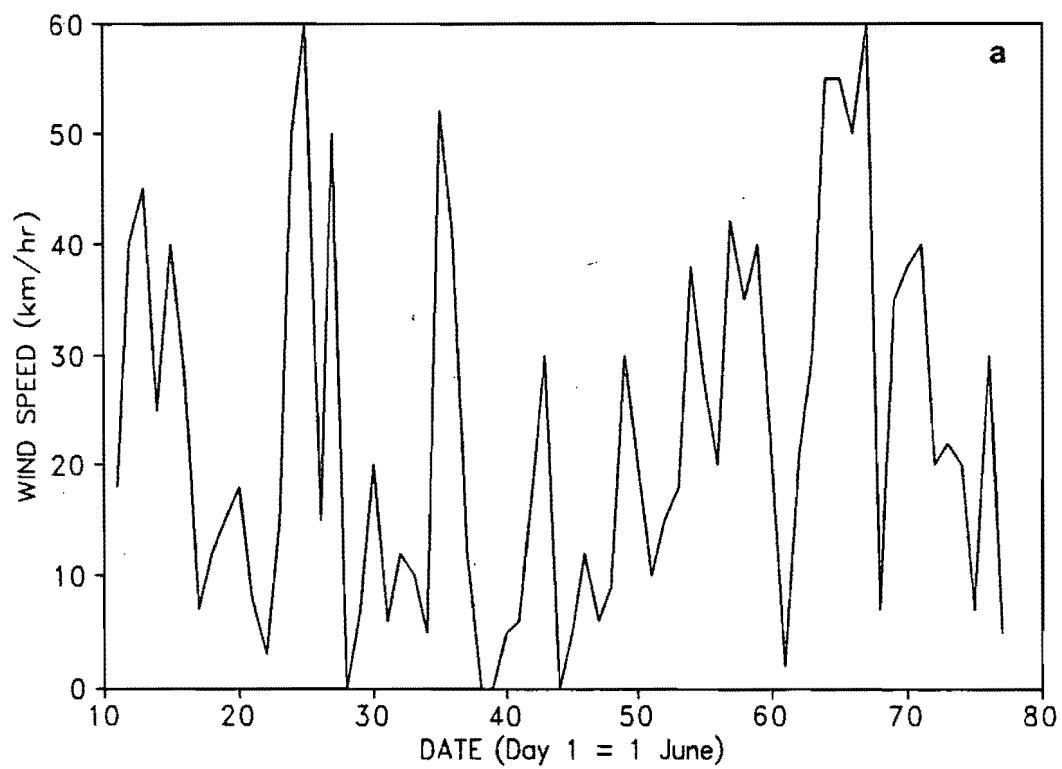
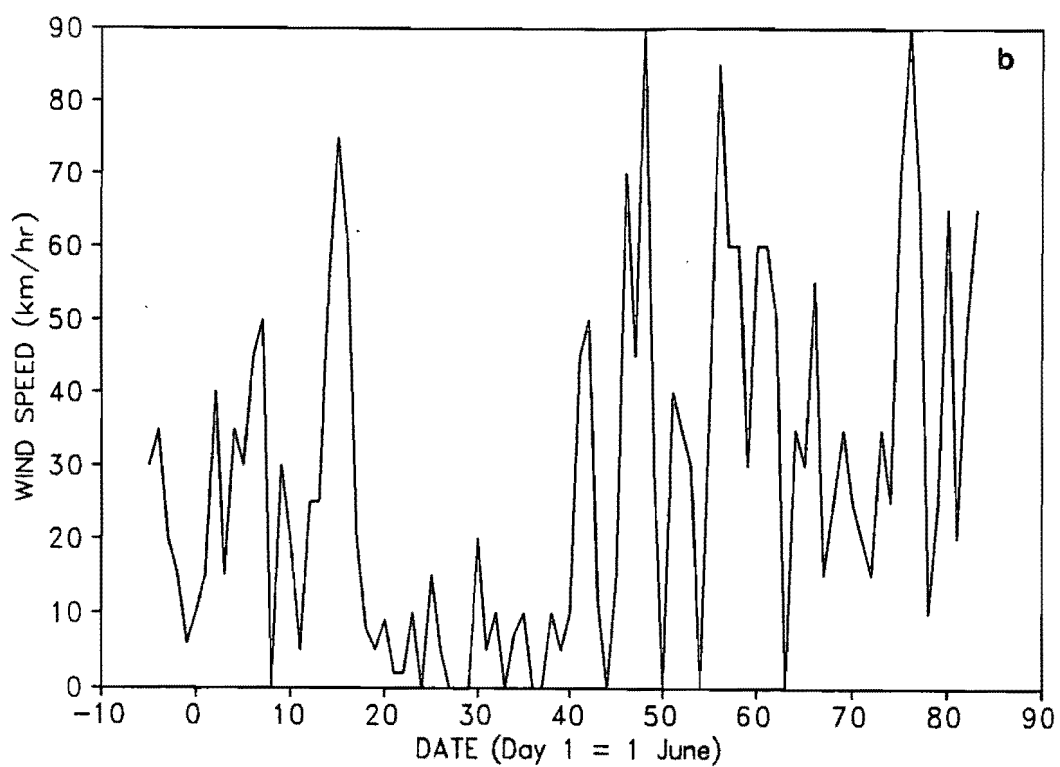


Figure 1.4 Wind speeds recorded at camp at 1700 hrs in (a) 1988, (b) 1990

2. BANDING AND RESIGHTINGS OF BANDED BIRDS

2.1 Banding

The colour band protocol established in 1984 has been maintained throughout. Birds banded as chicks are given a metal band on the right leg, with a year-specific, coloured darvic band above it. Birds caught as adults are given a light green band above a metal band on the right leg, and a year-specific colour band on the left. In a few cases, adults have been banded the other way around to help us to identify members of a pair, or to allow band numbers to be more easily read at certain sites. Details of numbers banded in the project so far are given in Table 2.1. The band sequences used in each year are given in Appendix 4.

Standard stainless-steel, U.S. Fish and Wildlife Service bands were used in 1981 and 1984. In 1985 all adults, and approximately half the chicks, were banded with special triangular murre bands designed by the British Trust for Ornithology. These bands have larger numbers, which are duplicated on both sides of the band. The address used on the new bands is that of the C.W.S. office in St. John's, Newfoundland, instead of the Washington address used on the old bands. Since 1986, the new design of bands has been used exclusively.

Altogether, 18% (N=828) of chicks banded with the new bands in 1985 had been resighted on the colony up to 1990, compared to only 8% (N=791) of those banded with the old design. Assuming that the bands do not affect the birds' survival, this indicates that the new-style bands are twice as easy to read as the old. Up to the 1989-90 winter 23 birds banded as chicks in 1985 had been recovered in Newfoundland, of which 11 had the old bands, and 12 the new. This indicates that the change in the type of bands used has had little effect on band reporting rates.

Some colour bands have been lost, practically all from birds fitted with the normal US Fish and Wildlife Service bands in 1984 and 1985 (at least 17). Two birds banded with the new type of bands have been resighted at the colony without colour bands. It is

possible that the colour bands were never placed on them, because it appears physically impossible for colour bands to slip over the new bands. Hunters who shot banded birds in the winters of 1984-85 and 1985-86 reported more of the 1984 and 1985 cohorts without colour bands (20%, N=44) than the proportion that we saw on the colony in 1988 (8%, N=94, $\chi^2=3.96$, $P=0.05$). It is possible that some colour bands were discarded by hunters and forgotten by the time they reported the metal band. We have found no evidence that any metal bands have been lost (i.e., we have seen no birds with a colour band but no metal band), although a few may have slipped off chicks immediately after they were banded.

All chicks were banded in the area to the north of Fox Gully, which supports 4-5000 pairs, approximately 25% of the breeding population. Adults were banded near the top of the cliff at numerous sites between Z and the north end of the colony, and some were also banded at Lower Fox Gully, and randomly on the central part of the cliff, in the course of chick banding.

Table 2.1 Numbers of Thick-billed Murres banded at Coats Island, and dates of main chick-banding effort:

YEAR	ADULTS		CHICKS	DATES OF CHICK BANDING	TYPE OF BANDS
	BANDED	RETRAPPED			
1981	14	0	1584	12-15 August	Old
1984	141	0	1454	3-13 August	Old
1985	0	0	791	3-13 August	Old
	134	0	828	3-11 August	New
1986	278	20	2237	31 Jul-4 Aug	New
1987	161	79	2250	3-9 August	New
1988	190	27	2686	1-6 August	New
1989	83	44	2333	3-13 August	New
1990	88	97	1351	5-8 August	New
Totals	1089	267	15514		

2.2 Resightings

Reading of band numbers was carried out intensively in 1988-1990, with most of the effort being concentrated at the North and S blinds, at Q, at plots D and E and to a lesser extent at Lower Fox Gully, R, T, and at the North End. Some additional band numbers were read casually, in the course of other work.

Since 1987, 863 birds banded as chicks have been resighted on the colony at least once. The proportion of chicks banded with new style bands which were seen in their second summer (the first year of return to the colony) varied from 1-4%. In the third summer the proportion rose to from 4-13%, and in the fourth to 5-7%. In the fifth summer 7% of the new bands used in 1985 were seen. By the end of 1990, 18% of new bands used in 1985, 11% of those used in 1986, 10% of 1987 and 4% of 1988 bands had been resighted (Table 2.2). Considering that, even with the new style bands, we can only read band numbers over a small portion of the colony, and that the young birds appear to return to the area where they were banded, it seems likely that we have recorded only a small proportion of the chicks which have survived to return. Some estimates of survival rates, based on a number of assumptions about the likelihood of birds being resighted, have been made by Noble et al. (1991).

2.3 Age at first breeding

In 1988, three birds in their third summer were members of pairs that laid eggs. Despite equally intensive observations in 1990, no evidence was obtained of three-year-olds breeding that year. Fourth summer birds were seen breeding in 1988-90; 8 in 1988, 5 in 1989 and 14 in 1990. These comprised between 7-16% of the fourth summer birds known to have been present. In 1989 and 1990 31% and 18%, respectively, of known five-year olds attempted to breed, and in 1990 41% of six-year olds did so. Other birds may have attempted to breed and failed before we detected them, especially in 1989, when we arrived at the end of incubation. Hence, these percentages represent minimum proportions of birds attempting to breed. For further details of age at recruitment, see Noble (1990).

2.4 Estimates of minimum survival rates

Although proper estimates of survival rates await a more definitive analysis, some crude estimates can be obtained directly from resightings. In 1986 20 breeding adults were banded at Plot D, a further 12 were banded there in 1987, and another 25 in 1989. The sites occupied were recorded, although the exact sites could not be identified for a few birds, which were located only to a particular ledge. In 1990 12 of the 1986 sample, 10 of the 1987 sample and 21 of the 1989 sample were present, giving a weighted mean annual adult survival of 0.90. Most of the birds were occupying the same site in 1990 as when they were banded, but six were on different sites. Most of those which had changed sites had moved less than 1 m, but one bird had moved about 3 m, and another about 5 m (the original site was not exactly specified). Even allowing for some errors in the banding records, it seems evident that birds occasionally move between sites. If so, the emigration of a few birds from the observation area may have caused the adult survival rate to be underestimated slightly.

The minimum survival of young birds from departure from the colony to their return in the second summer can be derived from the cumulative total of band numbers of a given cohort seen over all years. This reaches a maximum of 18% for birds banded with the new type bands in 1985. This is likely to be a gross underestimate because: (a) we could not read band numbers over much of the banding area, and (b) some birds had moved to other areas. The proportion of bands recorded in the third year is higher in every year than the proportion seen in the second year, despite variations in effort. Probably some birds do not visit the colony in their second year.

Birds recorded at two and three years old were less likely to be recorded in subsequent years than those recorded at four. Only 18% (N=107) of 1985 chicks (new type bands only), and only 48% (N=94) of 1986 chicks, seen at three years old (1988 and 1989, respectively), were seen again in 1990. By contrast, 36 out of 39 1985 chicks seen at four (1989) were seen again in 1990, giving a

minimum survival rate of 0.92 from the four to five years of age. Most four-year-olds were probably firmly attached to sites, to which they returned the following year. Probably three-year-olds were actively prospecting for breeding sites, and hence less likely than older birds to be seen again in the same area.

Table 2.2 Numbers of birds banded as chicks resighted in subsequent years, including only those for which complete band numbers were recorded. Figures in brackets are proportions of chicks banded.

YEAR OF BANDING	YEAR OF SIGHTING					SIGHTED IN ANY YEAR
	1986	1987	1988	1989	1990	
1984 (old)	0	1 ($<1\%$)	39 (3%)	12 (1%)	13 (1%)	50 (3%)
1985 (old)		0	48 (6%)	8 (1%)	12 (2%)	66 (8%)
(new)		12 (1%)	107 (13%)	39 (5%)	61 (7%)	149 (18%)
1986			77 (3%)	94 (4%)	162 (7%)	266 (12%)
1987				48 (2%)	201 (9%)	224 (10%)
1988					108 (4%)	108 (4%)
Totals		13	223	193	545	863

2.5 Attendance of young birds

Because birds banded in a particular year are easily identified by their year-specific colour band, we can observe changes in the numbers of a given age class attending the colony. We did this by making periodic counts of all the right legs visible from four observation points spread along the colony; two inside the banding

area, and two outside it. Counts were made by four observers simultaneously several times each season, from 1986 onwards. Inter-year comparisons were made only on the basis of the period 23 July - 16 August.

In 1990, birds more than three years old were present from the start of the season, although numbers of four-year olds increased until early July (Figure 2.1). Numbers of four-, five-, and six-year-olds were generally lower in August than in July. Three-year-old birds began to arrive in early June, reaching a peak in early July, and remaining abundant thereafter. No band numbers of second year birds were read until 5 July, and they were not present in large numbers until the last week of the month. Their representation declined after the first week of August (Figure 2.2).

The majority of birds banded as chicks were seen within the area where banding was carried out, irrespective of their age. There was a tendency for two-year-olds to be seen outside the banding area more frequently than older birds (Table 2.3). This suggests that the youngest birds prospected more widely than older birds. The 1987 cohort was seen markedly less often outside the banding area than other cohorts, but for all cohorts there was a tendency for the relative numbers seen outside the banding area to fall with age. This can be seen by inspecting the diagonals in Table 2.3.

The proportions of different year-classes seen within and outside the banding area varied among years, and within the banding area they varied among sites. In 1988 and 1990, the proportion of two- and three-year-olds seen in area S was lower than seen in area N, but the proportion of birds more than three years old was higher (Table 2.4). In 1989 the proportions of all age classes were lower at S than at N, although the difference was greatest for the two-year-olds. We can only speculate about the causes of this variation, but it is possible that the area counted at N, which includes the highest parts of the cliff, contains more loafing sites than area S. Loafing areas probably attract more two- and three-year-olds than other age classes. Differences among years in

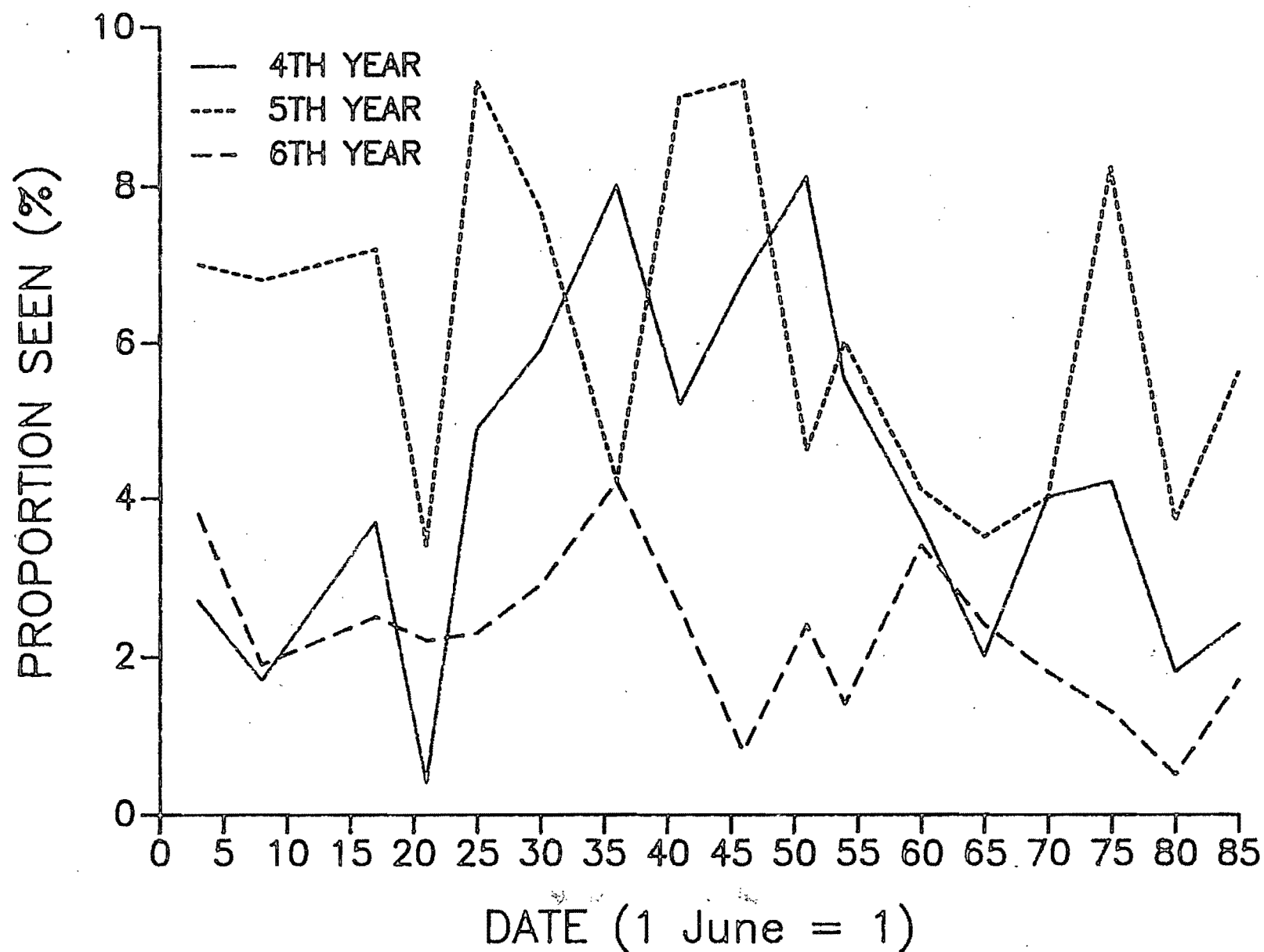


Figure 2.1 Proportions of 4-, 5-, and 6-year-old birds seen during counts of right legs made in the banding area in 1990

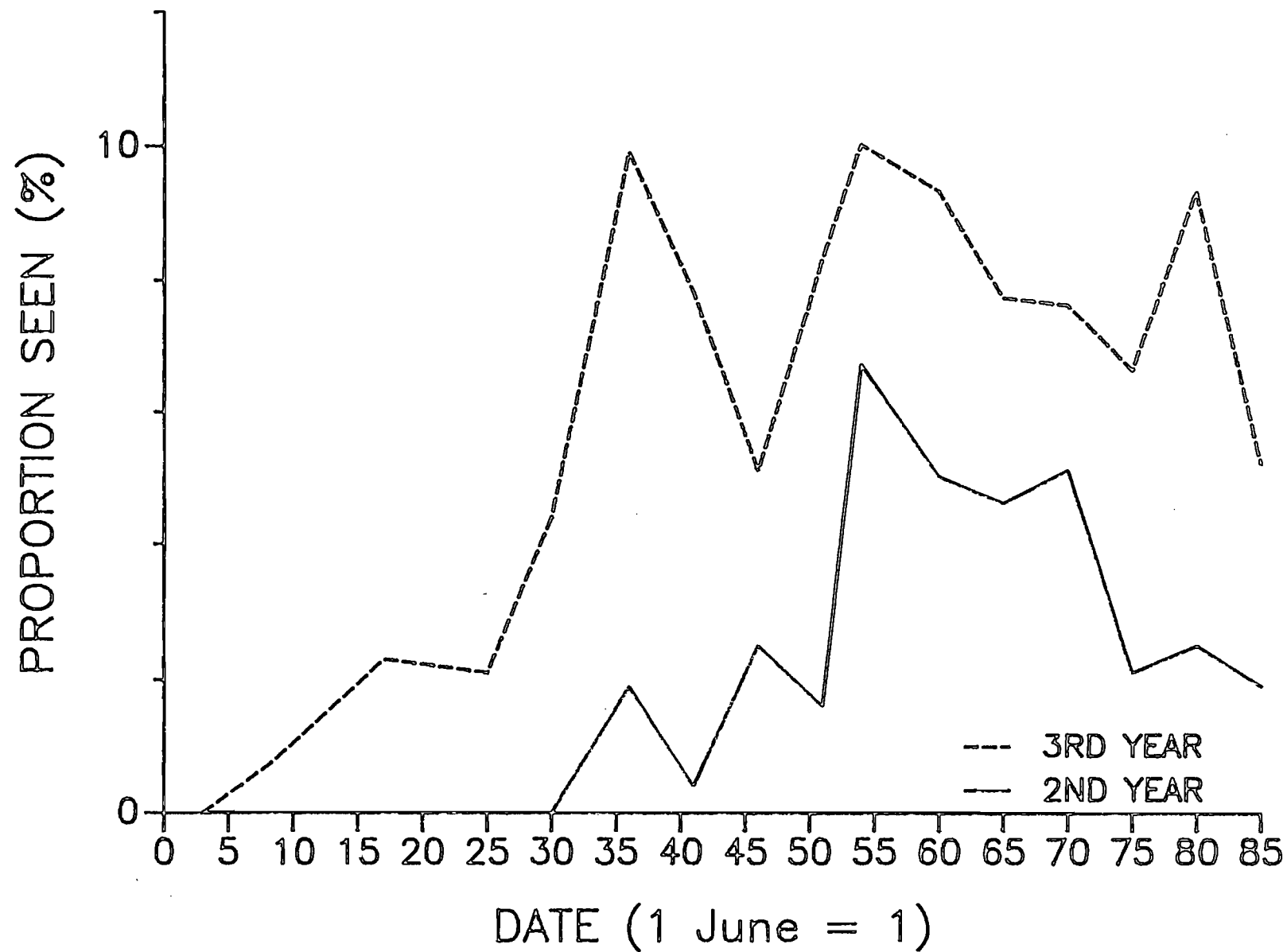


Figure 2.2 Proportions of 2- and 3-year-old birds seen

the exact areas where chicks were banded may also account for some of the variation.

Table 2.3 Ratios of the proportions of given age classes
seen within and outside the banding area in 1987-90

YEAR	AGE IN YEARS				BIRDS COUNTED	
	TWO	THREE	FOUR	FIVE	WITHIN	OUTSIDE
1987	5.0	8.6	-	-	9994	7175
1988	6.2	8.6	10.9	-	7608	11174
1989	16.4	15.5	10.7	21.4	2262	6726
1990	7.0	68.0	68.9	15.4	5765	2941
Mean	8.6	25.2	30.2	18.4		

Table 2.4 Proportions of different age classes seen (%) in areas N and S during simultaneous counts during 23 July - 16 August 1990

YEAR	AREA	AGE IN YEARS					N
		TWO	THREE	FOUR	FIVE	SIX	
<u>1988</u>	N	1.85	7.05	2.50	-	-	3845
	S	1.12	6.32	3.93	-	-	3763
<u>1989</u>	N	2.82	7.54	8.14	2.82	-	2518
	S	1.14	6.08	5.13	2.00	-	1052
<u>1990</u>	N	4.80	8.69	4.06	5.41	2.18	2291
	S	2.45	5.55	8.75	6.76	2.42	3474

In 1990 several simultaneous counts of right legs were made in the first half of August for areas at different heights above the sea in the centre of the banding area. No significant variation in the proportion of two- and three-year-old birds in relation to height was evident, but four- and five-year-old birds showed a tendency to concentrate in the centre of the cliff, rather than at the top, or bottom (Table 2.5). Six-year-olds, for which the sample size was rather small, showed a similar pattern to that of the four- and five-year-olds, although the variation was not significant. The lower representation of banded birds on the lowest part of the cliff may reflect a smaller banding effort in that area, which is the most difficult to reach. The topmost parts of the cliff tend to be used for loafing more than other areas, which may account for the higher incidence of two-year-olds at this level (not quite significant). This supports the comparison of counts at N and S.

Table 2.5 Proportions of different age classes counted in the area around N and S during 4-14 August 1990, in relation to height above the sea. Figures in brackets are percentages.

POSITION ON CLIFF	AGE (Years)					N
	TWO	THREE	FOUR	FIVE	SIX	
(1) TOP	40 (3.9)	74 (7.3)	41 (4.0)	61 (6.0)	18 (1.8)	1015
(2)	31 (3.3)	55 (5.9)	110 (11.9)	86 (9.3)	23 (2.5)	927
(3)	7 (2.3)	25 (8.1)	38 (12.4)	26 (8.5)	7 (2.3)	307
(4) BOTTOM	8 (1.5)	34 (6.6)	15 (2.9)	21 (4.1)	3 (0.6)	517
Chi ²	7.39	2.40	70.30	16.76	6.99	
<u>P</u>	0.06	>0.4	<0.01	<0.01	0.07	

3. ATTENDANCE AND POPULATION MONITORING

From 1985 onwards, we counted ten permanent monitoring plots daily at 1700-1800 hrs. Unfortunately, it transpired that two (G & H) were incorrectly identified in 1989 and hence the counts at these plots had to be discarded. In addition, because of the timing of visits, the only dates represented in all years since 1985 were 1-7 August.

In 1990, faeces stains showed that some birds had landed on the cliffs before our arrival, on 23 May. None approached the cliffs thereafter until the early hours of 29 May, and attendance was intermittent up to 16 June, the day after the first egg was laid. Some visits were very brief, with large numbers of birds present on the cliffs for only a few hours, as on 1, 6 and 7 June (Figure 3.1). All approaches to the colony after periods of absence were made at about midnight. They were preceded by spectacular swirls of birds circling, first over the distant area of open water on which they had congregated, and then in the colony cove, for an hour or more before the first birds landed.

In 1988 no birds were present on the cliffs when the field party arrived on 9 June, although the cliffs had clearly been occupied earlier. None landed again until 13 June, but the cliffs were occupied continuously thereafter.

Peak numbers recorded during the pre-laying period were higher than those recorded during the early part of the incubation period in 1990. Peak counts in both 1988 and 1990 were in late July to mid-August, when most birds were rearing chicks (Figure 3.2, Appendix 5). Counts during 1-7 August averaged highest in 1989 and lowest in 1986 (Table 3.1). Increases over the period were significant at plots A, D and E, but numbers at all plots averaged lower in 1990 than in 1989. Weather conditions were generally better in 1989 than in 1988 and 1990, when strong winds may have depressed counts. Comparing 1990 with 1985, the mean attendance at plot A increased by 12%, and at plots D and E (which are adjacent), by 44% and 48%, respectively. All three plots are at the top of the

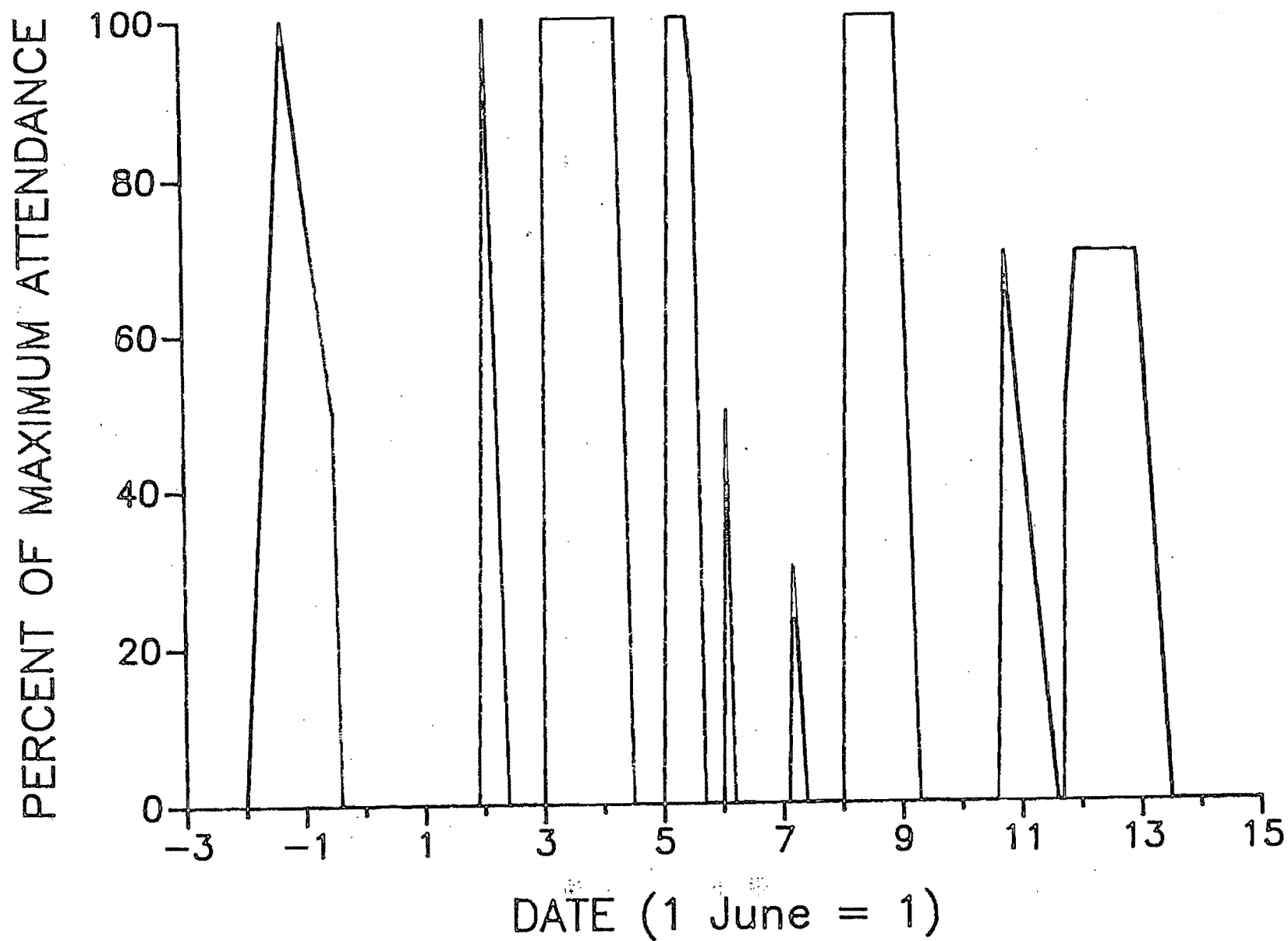


Figure 3.1 Numbers of birds present on the cliffs during the pre-laying period in 1990, in relation to the peak count

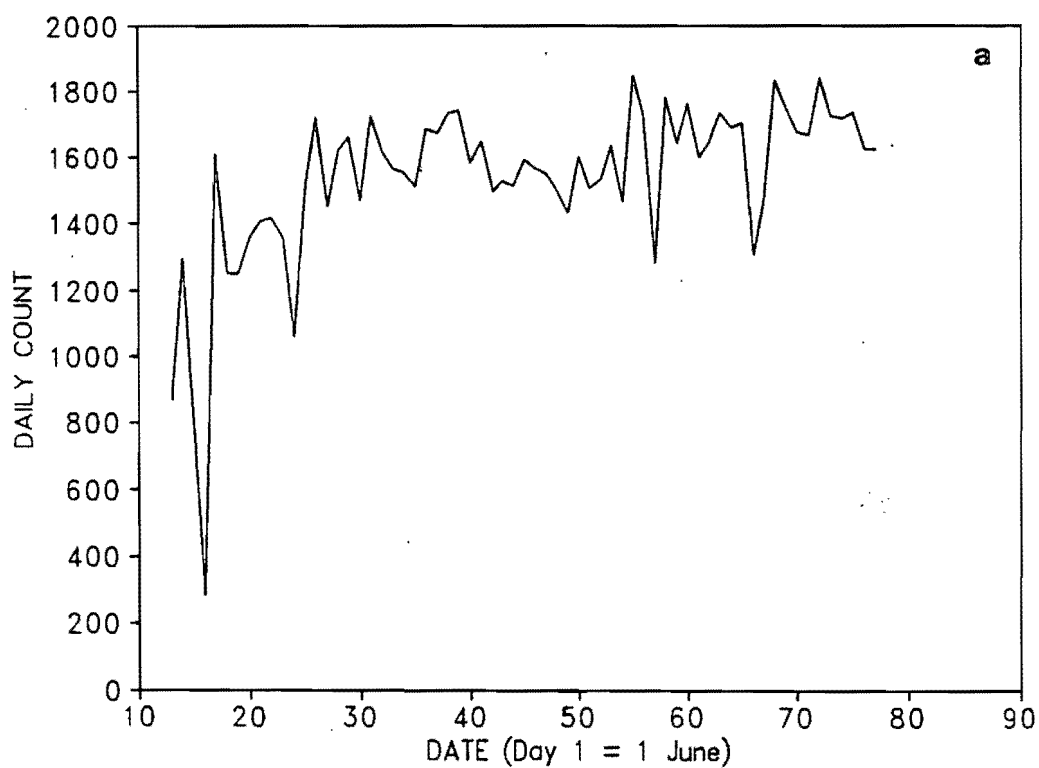
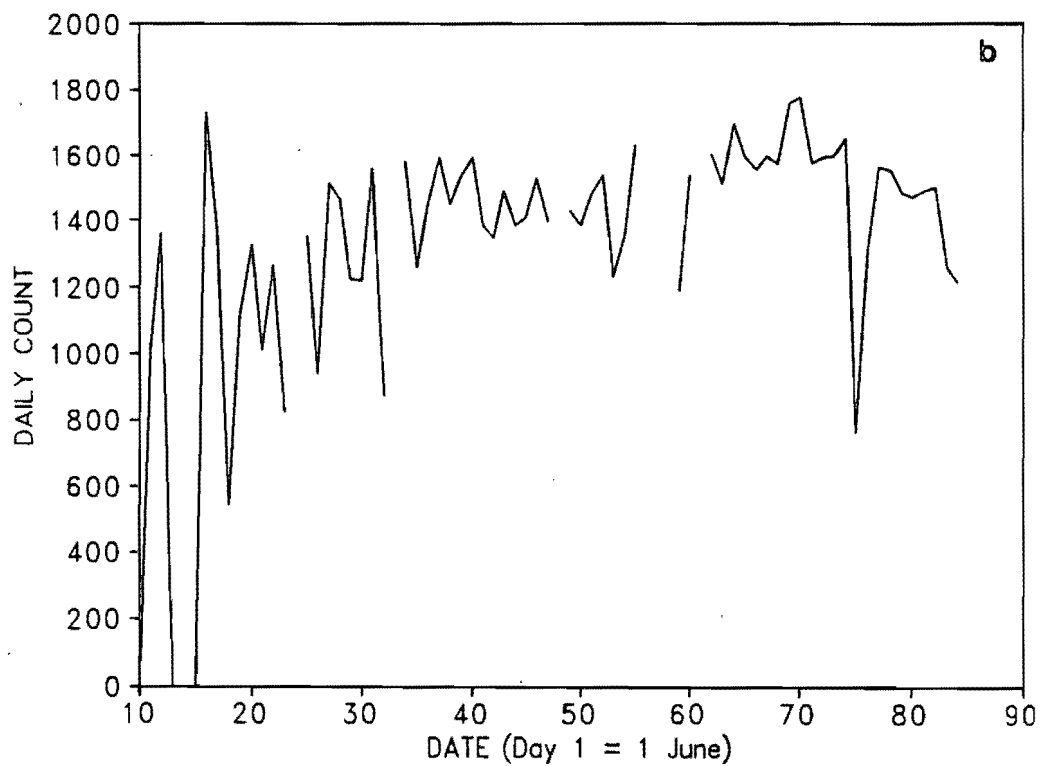


Figure 3.2 Daily count totals for (a) 1988, (b) 1990

occupied area, and much of the increase in numbers has taken place through the occupation of previously unused ledges at the upper edge. In contrast, counts at plots I and J, which consist of densely packed ledges, part-way down the cliff, declined by 29 and 19% over the same period, while other areas below the top of the occupied area (B, H) remained relatively stable. Overall, there was no significant change in the total number of birds on the study plots, over the six years that they have been counted.

When photographs taken in 1984 and 1985 were compared with observations in 1989 and 1990, signs of expansion in the area of the colony was visible along most of the upper margin. A similar expansion appears to have taken place at the east colony. Many new sites were occupied in 1988-90 around the Lower Fox Gully Blind. In 1989 at least 20 pairs were breeding in an area immediately behind the blind, which was unoccupied when the blind was erected in 1986. At the end of the 1989 season the blind was shifted to avoid disturbance to those birds. To the south of Fox Gully, hundreds of sites are placed on peat, the residue left after continual prospecting by the murre has killed the grass with their defaecation. Comparison with photographs taken by G.R.Parker in 1971, shows that most of these sites have been newly occupied since then.

Practically all of the sites newly occupied during the past two decades are easily accessible to foxes, because they can be reached without encountering any sheer faces. In 1990, at least two adult and four young arctic foxes foraged on the colony for most of the season. They cleared extensive portions of the newly occupied areas, taking a minimum of several hundred eggs. The expansion of the occupied area that has taken place since 1984 may have been facilitated by the fact that no foxes were active on the colony during our visits in 1987-89. We do not know what happened during 1971-1984. In 1981 arctic foxes were seen taking eggs and chicks on the colony several times. Presumably fox predation is a periodic factor in reproductive success for birds breeding on accessible ledges. It may limit permanent occupation of certain areas.

Table 3.1 Mean daily counts during 1-7 August in six years.

PLOT	1985			1986			1987			1988			1989			1990	
	x	sd	N	x	sd	N	x	sd	N	x	sd	N	x	sd	N	x	sd
A	258	43	7	249	20	7	276	15	7	280	31	7<<326	16	7	288	26	
B	240	41	7	244	25	7	260	25	7	253	26	7	265	15	7	237	13
C	[107]	-	-	107	9	7	112	3	7	114	7	7	115	7	7	115	6
D	135	41	7	155	18	7	170	19	7	177	26	7<<202	8	7	194	17	
E	109	19	7	134	23	7	165	21	7	130	27	7 <163	11	7	161	20	
F	100	20	7	102	12	7	117	9	7	103	24	7	111	8	7	98	7
G	104	12	7	100	8	7	105	5	7	108	8	7	-	-	-	92	6
H	112	16	7	93	9	7	107	6	7	107	8	7	-	-	-	104	8
I	277	64	7	204	26	7	235	20	7	219	28	7	211	13	7	197	7
J	147	14	7	126	15	7	130	14	7	133	19	7	136	10	7	119	10
TOT.	[1588]	238	7	1514	139	7	1677	58	7	1625	178	7	-	-	-	1591	57
TOT.	1438	150	6	1381	97	5	1465	59	7	1461	106	6	1528 ⁺	24	7	1395	51
(8 PLOTS)*																	

* Excluding days of very strong winds

< 1989 mean significantly higher than 1988 mean

<< 1989 mean significantly higher than 1987 and 1988 means

⁺ 1989 mean significantly higher than 1987 mean

t values and probabilities

Plot	1989 vs 1988		1989 vs 1987	
	t	P	t	P
A	3.39	0.005	6.00	<0.001
D	2.32	0.04	4.08	0.001
E	2.93	0.013	NS	
Total (8 plots)	NS		2.61	0.023

4. TIMING OF BREEDING

4.1 Methods

The timing of hatching in all years was determined from the ages of chicks measured soon after hatching (determined from their wing-length, Appendix 6) and the density indices of unhatched eggs measured at the same time, using the method of Collins and Gaston (1987). Confidence limits on the hatching dates estimated for individual eggs by this method were 4-5 days, but the 95% limits on the estimated sample means were all less than 2 days. Consequently extreme hatching dates estimated from density indices are probably rather inaccurate, but means and medians should be very close to true population figures. Pipped eggs were assumed to have hatched either on the day of measurement, or in the next two days, and were apportioned to these dates in the ratio 3:7:7, based on the fact that inspections were made in the early afternoon. Hatching dates were converted to laying dates by subtracting 32 days. In 1988 dates of laying were also recorded by daily observations at plot D, and in 1990 laying dates were determined from similar observations at plots D, N, P, Q and S.

4.2 Results

Median dates of laying, estimated from egg densities and chick ages, ranged from 19 June in 1984 to 30 June in 1987 (Table 4.1). In 1988 the median date of laying determined by egg densities was 27 June, whereas direct observations at plot D gave a median of 21 June, perhaps because earlier eggs are easier to detect. In 1990 the median based on observed layings was 26 June, and on egg densities, 29 June. For plot D alone, the median based on observed dates of laying was 25 June. In most years the distribution of laying dates was skewed, with an initial peak, and a long tail, which may have included some replacement eggs at sites where the first egg was not seen. The peak 3 days of laying preceded the median in all but two years. The proportion of chicks hatching during the peak six days ranged from 35% in 1988 to 62% in 1989.

Table 4.1 Proportion of eggs hatching at Coats Island (%) in 1981 and 1984-90, by three-day periods

DATE	1981	1984	1985	1986	1987	1988	1989	1990
< 17 July	0	6	15	6		2	0	0
17-19 July	5	32	18	8	 26 ¹	5	0	0
20-22 July	14	25	20	16		6	4	20
23-25 July	22	14	20	24		10	10	8
26-28 July	18	6	7	13	14	20	35	11
29-31 July	14	4	8	3	11	15	27	22
1-3 August	1	2	2	6	7	10	3	14
4-6 August	8	2	5	5	9	5	2	6
7-9 August	8	1	1	4	7	12	4	6
10-12 Aug.	7	6	1	3	7	5	1	0
13-15 Aug.	1	0	1	3	8	2	3	2
16-18 Aug.	0	0	1	3	4	4	3	5
>18 August	0	0	2	5	9	2	6	6
Med. hatch	27 Jul	21 Jul	22 Jul	26 Jul	1 Aug	29 Jul	29 Jul	31 Jul
Totals	437	114	111	143	169	128	89	64

N.B. Dates for 1981, 1984 and 1985 derived from chick wing lengths; dates 1986, 1987 and 1989 partly from wing lengths, partly from egg density indices; dates for 1988 and 1990 all from egg density indices.

¹ Chicks were not measured in 1987, hence date of first hatching cannot be estimated. The estimate of median hatching is not affected.

5. EGG SIZE

5.1 Methods

It was not until 1986 that we visited the colony early enough to measure a substantial number of eggs from the main laying period. In all years except 1988 and 1990 some eggs hatched before our arrival. As there was generally a negative correlation between egg volume index and date of laying, it was not possible to compare the volume indices of whole samples measured in years when different proportions of eggs had hatched. Instead, we compared the mean volume index of those that hatched during the central 50% of hatching (based on their density indices).

In 1990, 49 eggs were removed early in the laying period, so that the birds would lay replacements. All were replaced, and 27 of the replacement eggs were measured.

5.2 Results

The mean volume of eggs laid within the central 50% of laying ranged from 204 cm² in 1990 to 214 cm² in 1986 (Table 5.1). In 1989, two eggs laid by pairs comprising a known 4-year-old bird and a bird of unknown age, and eight laid by pairs comprising a 5-year-old and a bird of unknown age were measured, as well as one laid by a pair comprising one 4-year-old and one 5-year-old. The mean volume index of eggs laid by the three pairs including a 4-year-old was 177.5 ± 9.55 cm². The corresponding value for pairs including a 5-year-old, but excluding the 4-year-old-5-year-old pair, was

187.6 + 16.74 cm². These means do not differ significantly from one another, but both are significantly smaller than the mean for eggs laid during the central 50% of laying. In 1990 we measured the eggs of two pairs that included a 4-year-old (mean volume index = 184.3 cm² and one that included a 5-year old (volume index = 197.8 cm²). All of the measured eggs laid by pairs including 4- and 5-year-old birds hatched after 75% of those laid.

Table 5.1 Egg volume indices for eggs laid during the middle 50% of laying.

YEAR	VOLUME INDEX		
	MEAN	SD	N
1986	211.9	16.24	69
1987	210.5	16.75	41
1988	210.0	15.09	57
1989	213.8	17.81	16
1990	204.1	15.72	35

Egg volumes declined with date of laying in all years, although the decline was more marked in 1986 and 1987 than in 1988 and 1990 (Table 5.2). The fact that 4 and 5-year-old birds tend to lay late in the season, and lay comparatively small eggs, may explain this decline, at least in part. In addition, 17 replacement eggs laid in 1990 averaged 5% smaller than the first eggs laid at the same sites

(191.9 vs 202.0, paired $t=3.24$, $P<0.01$). The difference in mean volume indices (10.1 cm^2) was somewhat larger than that predicted by the regression of volume index on date for measured eggs (6.6 cm^2).

Table 5.2 Regression formulas for the relationship of egg volume index to date of laying in 1986-90.

YEAR	VOLUME AT START (cm^2)	REGRESSION COEFFICIENT	RANGE	N
1986	220.0	-0.91	153-253	111
1987	210.0	-0.76	173-237	125
1988	220.0	-0.43	145-248	128
1989*	-	-	163-223	16
1990	204.3	-0.47	143-244	64

* Only eggs laid in the second half of the laying period were measured in 1989

6. ADULT MASS

6.1 Methods

Adult birds were trapped for banding, and for the attachment of various measuring devices, in all years. Practically all were weighed inside a cloth bag to within 5 g on a 1500 g Pesola spring balance. The weight of the cloth bag was checked regularly. Where possible, the breeding status of birds captured was recorded. Where we were not certain whether the captured bird was associated with an egg or chick we took the presence of a large, vascularized brood-patch to indicate that the bird was an active breeder. From 1987 onwards we recorded whether breeders were incubating an egg, or brooding a chick. In the latter case, the age of the chick was estimated from the condition of its down and/or feathers.

6.2 Results

In 1988 and 1990 adult weights increased during incubation, then dropped sharply at hatching, so that birds brooding chicks averaged about 50 g lighter than birds incubating eggs at the same date. A similar difference between incubating and brooding birds was apparent in other years. Data for all years are combined in Figure 6.1. There was little indication that the weights of birds with chicks declined over the chick rearing period, except in the first few day after hatching. Incubating birds weighed in 1988 averaged heavier than those weighed in 1990 in all but one five-day period (Table 6.1). Breeders trapped while brooding chicks during 31 July - 9 August were lightest in 1986, and heaviest in 1990 (Table 6.2)

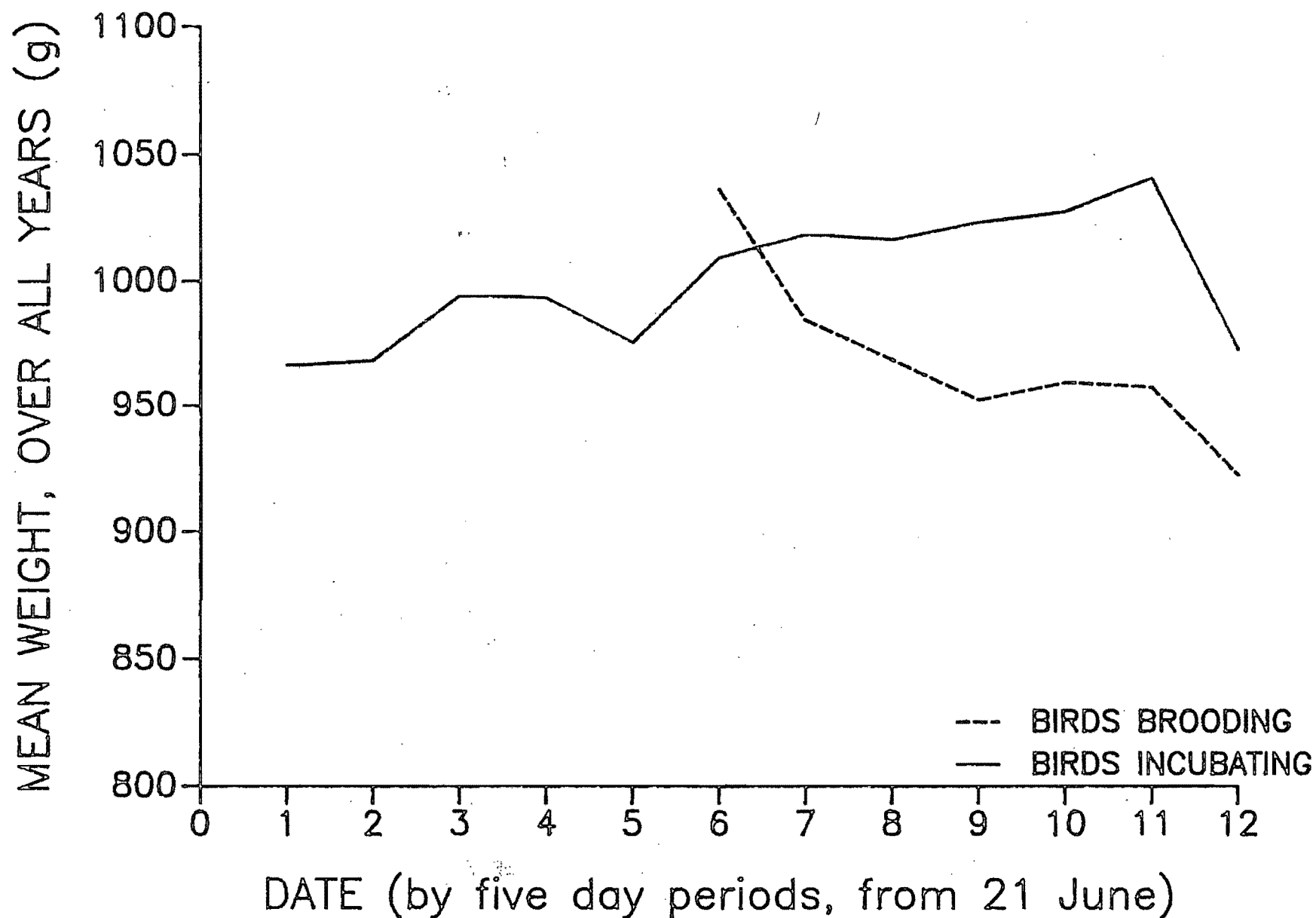


Figure 6.1 Mean weights of birds incubating eggs, or brooding chicks, averaged over all years, in relation to date

Table 6.1 Mean weights of incubating birds in 1986-1990, by five-day periods

DATE	1986		1987		1988		1989		1990		Grand mean
	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd	
21-25	-	-	-	-	987 (12)	24.3	-	-	941 (10)	47.2	966 (22)
26-30	-	-	-	-	997 (16)	54.6	-	-	935 (14)	48.6	968 (30)
31-35	-	-	-	-	1022 (11)	53.7	-	-	961 (9)	23.1	994 (20)
36-40	-	-	-	-	1012 (8)	62.7	-	-	945 (3)	127.6	993 (11)
41-45	-	-	-	-	1012 (3)	65.3	-	-	970 (20)	61.5	975 (23)
46-50	-	-	-	-	1045 (5)	33.2	-	-	987 (8)	38.4	1009 (13)
51-55	-	-	-	-	1016 (14)	65.4	-	-	1030 (3)	52.9	1018 (17)
56-60	1007 (12)	46.7	900 (1)	-	1046 (4)	41.9	1033 (13)	67.9	977 (3)	56.9	1016 (33)
61-65	977 (4)	47.9	1017 (8)	38.5	1036 (4)	57.6	1185 (1)	-	1026 (8)	46.3	1023 (25)
66-70	1030 (1)	-	905 (3)	105.0	-	-	1064 (9)	54.2	1055 (1)	-	1027 (14)
71-75	-	-	-	-	-	-	1040 (5)	51.0	-	-	1040 (5)
76-80	-	-	972 (4)	43.5	-	-	-	-	-	-	972 (4)
81-85	-	-	-	-	-	-	-	-	1040 (1)	-	

Table 6.2 Mean weights of birds brooding chicks in 1986-1990, by five-day periods

DATE	1986		1987		1988		1989		1990		Grand mean
	Mean	sd	Mean	sd	Mean	sd	Mean	sd	Mean	sd	
51-55	-	-	-	-	1036 (9)	76.5	-	-	-	-	1036 (9)
56-60	971 (12)	68.9	-	-	972 (4)	53.2	1029 (13)	74.5	-	-	984 (49)
61-65	950 (4)	58.1	957 (8)	59.9	986 (4)	63.9	1000 (1)	66.9	965 (8)	40.4	968 (104)
66-70	904 (14)	58.1	939 (15)	49.6	966 (34)	64.4	957 (23)	73.6	1007 (6)	45.4	952 (58)
71-75	-	-	957 (9)	30.4	981 (17)	48.5	943 (10)	82.1	916 (5)	27.0	959 (41)
76-80	-	-	952 (10)	31.6	860 (1)	-	962 (32)	61.2	956 (30)	59.9	957 (73)
81-85	-	-	-	-	-	-	-	-	922 (10)	63.2	922 (10)

7. OBSERVATIONS AT PLOT D

7.1 Methods

The presence or absence of chicks at numbered sites on plot D was recorded in early August from 1986 onwards. During 1986 and 1987 only a portion of the sites were checked, but from 1988 onwards the whole plot was observed. Sites 1-39 were checked in all years. In 1988 and 1990 numbered sites were checked regularly from the start of laying.

7.2 Results

In 1986 chicks hatched at a minimum of 25 of the 39 sites, in 1987 and 1988 at 27 sites, in 1989 at 28 sites and in 1990 at 17 sites. In 1988 and 1990, when observations were made at least every two days throughout the breeding season, a minimum of 121 and 117 eggs were laid on the entire plot, of which at least 74% and 59% hatched. The much lower hatching success observed in 1990 resulted, in part, from predation of some eggs by an arctic fox. Foxes were not seen on the colony in 1988. In 1989 86 chicks were present on the plot in early August, compared to 89 in 1988. Hence, assuming that similar numbers of eggs were laid in both years, hatching success in 1989 must have been similar to 1988.

In 1989 at least 93 sites were observed to have either eggs or chicks. This compares with 125 sites where laying is known to have occurred in 1988. Assuming that a similar number of eggs were laid in 1989, this suggests that egg losses before the start of our observations amounted to about 30%. At least 88 chicks hatched, of which 7 disappeared without having fledged and 51 (63% of those surviving) had departed by 20 August.

The number of occupied sites at plot D has increased since 1981. Two ledges, on which approximately 15 pairs laid eggs in 1988, were unoccupied before 1986. A further two ledges occupied in 1984 and 1985 were apparently unoccupied in 1981, because no birds are present on them in a photograph taken in 1981. New sites have continued to be added since 1986, though mainly by addition to

existing breeding ledges (Figure 7.1).

In 1988 reproductive success and timing of laying were compared among sites occupied at least since 1985 ("old", N=95), those occupied for the first time that year ("new", N=13), and those occupied for the first time in intervening years ("intermediate", N=17). Reproductive success at old sites was 73%, at intermediate sites 53%, and at new sites 31%. The timing of laying at old and intermediate sites was similar, with a median date of 20 June. The median date of laying for new sites was 1 July, significantly later than at old sites (Mann-Witney U = 134.5, $z = 4.45$, $P < 0.001$). Presumably, many of the birds which had colonized intermediate and new sites were relatively inexperienced in 1988.

PLOT D

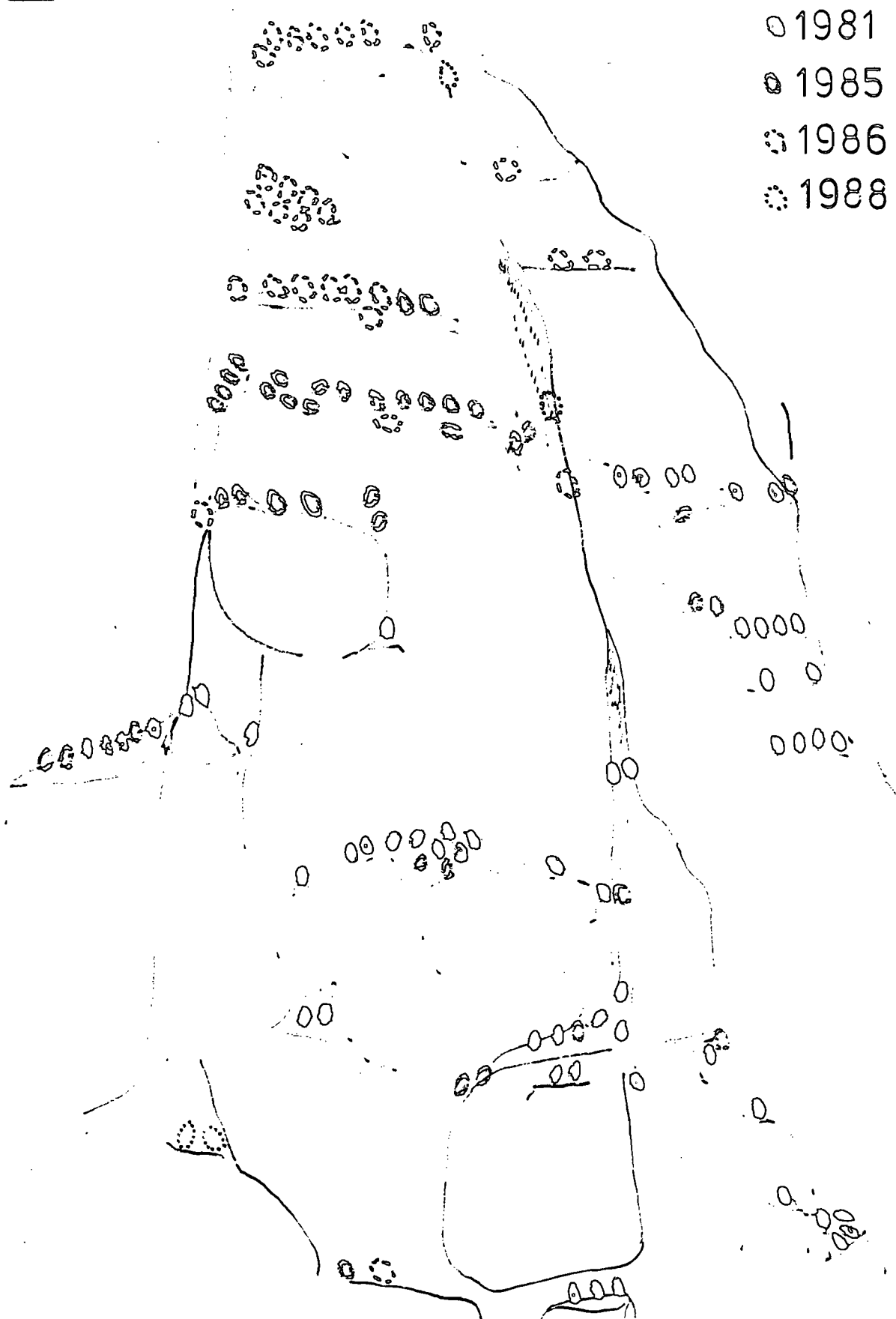


Figure 7.1 Breeding sites on plot D, showing the years of first permanent occupation

8. CHICK MEALS AND FEEDING RATES

8.1 Methods

Food items delivered to chicks were recovered from the cliffs in all years and either identified on the spot, or brought back to Ottawa for identification (most sculpins, blennies and invertebrates). Those found in fresh condition were weighed to ± 0.1 g on an electronic balance, and their overall length was measured (fork length, in the case of Capelin, Arctic Cod and Sand Lance). Many were also identified by sight, some during feeding watches, and some in the course of other work. No difference was seen in any year between the proportions of different prey taxa in the samples collected and those identified at a distance. Consequently, these samples were combined for analysis. No attempt was made to differentiate between the different species of Triglops in the sight identifications, and many blennies seen at a distance also were not determined to genus.

All-day watches to determine the rate at which chicks were fed were carried out at plot D from 1986 onwards. The exact timing of watches depended to some extent on weather conditions and on the timing of breeding, but at least one watch was carried out in both the first and second weeks of August in every year. The exact area watched, and hence the number of chicks observed, was varied to ensure a suitable sample size; sufficient, but not so large as to strain the attention of the observer. On two watches in 1990 a sample of birds were fitted with electronic activity recorders. On both watches, chicks with one parent fitted with a recorder were fed more frequently than control chicks, although the differences were not significant. Hence, there was no evidence that the recorders reduced the rate at which parents provisioned their chicks.

8.2 Results: diet

Arctic Cod dominated the diet in all years, forming 50% of food delivered to chicks (by fresh weight) in all years, except 1986.

Sculpins, mainly Triglops spp. were the next most important component, ranging from 8-29%, followed by blennies, mainly Stichaeus, Eumesogrammus, and Leptoclinus, which comprised 5-17% of the chicks' diet (Table 8.1). Other fishes never made up more than 4% of the diet by weight. Full details are given in Appendix 6.

The mean size of Arctic Cod delivered ranged from 14.4 g in 1986 to 19.8 g in 1989, while the mean size of Triglops spp. ranged from 8.2 g in 1985 to 15.4 g in 1988 (Table 8.2). The median size of meals was between 12-15 g in all years. In 1989, several small chicks were seen having great difficulty in swallowing large Arctic Cod. Probably the majority of fish delivered in 1989 were in their fourth year, or older (Lowry and Frost 1981, Craig et al. 1982, Gaston 1987). Also in 1989, the proportion of Arctic Cod delivered fell from 60% (N=84) before 6 August to 36% (N=114) thereafter ($\chi^2 = 10.8$, $P < 0.01$), which suggests that they became harder to catch later in the season. A similar analysis of data for 1986 and 1990 showed no comparable trend in the frequency of Arctic Cod. In 1990 they made up 50% of deliveries up to 6 August (N=38) and 49% (N=149) thereafter.

Table 8.1 Proportion of different taxa, by weight, in the diet of chicks at Coats Island in 1981 and 1984-1990.

TAXON	% BY WEIGHT							
	1981	1984	1985	1986	1987	1988	1989	1990
<u>Boreogadus</u>	65	53	65	42	67	70	76	73
<u>Mallotus</u>	5	14	5	8	1	5	6	6
Sculpins	22	20	8	29	21	18	8	8
Blennies	5	12	17	17	10	6	10	9
Other fish	2	<1	4	4	1	1	<1	1
Invertebrates	1	<1	1	<1	0	<1	<1	2

Table 8.2 Mean fresh weights of major prey taxa collected at Coats Island in 1981 and 1984-1990.

TAXON	FRESH WEIGHT (g)							
	1981	1984	1985	1986	1987	1988	1989	1990
FISH								
<u>Boreogadus</u>	17.6	18.0	15.9	14.4	15.3	14.4	19.8	18.5
<u>Mallopus</u>	5.0	5.3	4.8	6.9	9.7	6.8	3.8	5.5
<u>Ammodytes</u>	5.0	-	5.0	8.5	3.7	4.2	-	-
<u>Gymnelus</u>	-	-	-	-	7.2	6.3	5.8	12.1
<u>Stichaeus</u>	-	-	-	-	11.5	12.9	20.6	-
<u>Eumesogrammus</u>	-	-	-	-	15.8	13.9	19.9	-
<u>Leptoclinus</u>	-	-	-	-	3.7	4.9	4.3	3.7
<u>Triglops</u>	14.4	9.6	8.2	12.7	13.7	15.4	9.1	11.9
<u>Gymnocanthus</u>	-	-	-	-	-	-	11.4	9.8
<u>Liparis</u>	-	5.0	-	-	-	-	-	-
<u>Eumicrotremus</u>	-	-	8.0	-	-	5.0	-	-
INVERTEBRATES								
Squid	-	2.0	-	5.5	-	-	-	-
Amphipods	-	0.2	0.3	-	-	-	0.8	0.5

8.3 Results: feeding rates

Daily feeding rates averaged between 3 and 5 deliveries per chick per day on all but one of the 16 watches (Table 8.3). Highest rates were observed in the first and second weeks of August in 1988 and the second week of August 1990 (4.9–5.0 feeds/chick/day). The lowest feeding rate (2.8 feeds/chick/day) occurred in the first week of August 1990. However, feeding rates in 1989 were consistently low, with modal rates of 1 or 2 feeds/chick/day on 3 out of 4 watches (Table 8.4). A modal rate of less than 3 feeds/chick/day was recorded only once in other years. In 1988 median and modal feeding rates were 4 feeds/chick/day, or more, on all three watches. This corresponds with evidence from adult weights that suggests feeding conditions were particularly favourable in 1988.

Practically all chicks received at least one meal during a 24 h period (97.5%), and some received 10 or more (1.7%). The maximum number of meals delivered in a day was 22. Most meals delivered to chicks which received 10 or more feeds over 24 h consisted of very small items, including several amphipods, probably Parathemisto. A handful of meals included two small fishes, but otherwise virtually all consisted of a single fish.

Table 8.3 Mean daily feeding rates to chicks at plot D recorded during 24-h watches.

YEAR	DATE			
	25-31 July	1-7 Aug.	8-14 Aug.	15-22 Aug.
1986	3.7 (45)	4.1 (38)	3.9 (33)	-
1987	3.0 (45)	3.9 (44)	4.0 (35)	-
1988	4.3 (53)	5.0 (70)	4.9 (39)	-
1989	-	3.1 (66)	3.5 (37)	-
	-	3.2 (69)	3.6 (38)	-
1990	-	2.8 (19)	5.0 (41)	3.6 (14)

Table 8.4. Numbers of feeds to chicks at Plot D over 24 h

DATE	NUMBERS OF CHICKS RECEIVING x FEEDS															MEAN	MEDIAN	MODE	N
	0	1	2	3	4	5	6	7	8	9	10	11	12	15					
<u>1986</u>																			
29 July	2	7	4	11	7	3	7	1	2	0	1		0	0	3.69	3	3	45	
3 Aug.	2	2	5	6	7	6	7	1	1	0	0		1	0	4.13	4	4/6	38	
8 Aug.	0	2	6	8	6	5	1	4	1	0	0		0	0	3.91	4	4	33	
Totals	4	11	15	25	20	14	15	6	4	0	1	0	1	0	3.90	3	3	116	
<u>1987</u>																			
29 July	1	6	9	10	8	6	3	0	0	0	0	0	0	0	3.12	3	3	43	
5 Aug.	1	5	3	11	11	6	5	4	0	0	0	0	0	0	3.83	4	3/4	46	
14 Aug.	0	5	4	9	7	4	3	0	1	0	0	1	0	1	4.00	3.5	3	35	
Totals	2	16	16	30	26	16	11	4	1	0	0	1	0	1	3.63	3	3	124	
<u>1988</u>																			
25 July	1	4	4	7	13	9	11	3	0	1	0		0	0	4.26	4	4	53	
5 Aug.	1	2	2	6	18	12	17	6	2	4	0		0	0	5.03	5	4	70	
12 Aug.	0	5	4	7	8	3	3	7	0	0	0		[1, 22]		4.90	5	4	39	
Totals	2	11	8	20	39	24	31	16	2	5	0	[1, 22)			4.59	4.5	4	162	
<u>1989</u>																			
2 Aug.	3	12	14	11	11	7	4	3	1	0	0		0	0	3.11	3	2	66	
5 Aug.	4	11	15	12	11	8	4	2	1	0	0		1	0	3.17	3	2	69	
9 Aug.	0	5	9	5	9	4	2	1	2	0	0		0	0	3.49	3	2/4	37	
13 Aug.	2	8	4	6	6	7	2	0	1	0	1		0	1	3.63	3	1	38	
Totals	9	36	42	34	37	26	12	6	5		1		1	1	3.35	3	2	210	
<u>1990</u>																			
3 Aug.*	0	1	8	5	4	1	0	0	0	0	0	0	0	0	2.79	3	2	19	
13 Aug.	0	1	2	8	10	10	4	2	0	0	0	2	1	1	5.02	4.5	4/5	41	
23 Aug.*	0	1	1	6	3	1	1	1	0	0	0	0	0	0	3.64	3	3	14	
Totals	0	3	11	19	17	12	5	3	0	0	0	2	1	1	4.19	4	3	74	

* Feeding rates included 6 birds equipped with activity recorders weighing c. 10 g. On both watches, feeding rates of birds equipped with activity recorders averaged higher, though not significantly higher, than those of control birds.

9. CHICK GROWTH

9.1 Methods

Weights and wing-lengths of chicks were measured in 1986-1989 at plots R and S, using a 300 g Pesola spring balance and calipers. In 1990 we could not use these plots to weigh chicks because of the risk of disturbing breeding pairs containing birds of known age that were under observation. Consequently, we selected three new areas, at Q, T and Z. Measurements were made every three days, except when measuring had to be deferred because of bad weather. In 1987 and 1989 the first measurements were made after some chicks had hatched. These chicks were aged on the basis of their wing length, using the relationship of age to wing-length derived in 1986 (Appendix 7). Chicks which reached the age of 14 days were assumed to have departed successfully. Those dying or disappearing before this age were excluded from all growth comparisons. Ages at departure were assumed to be one day more than the age at last measurement, and the last weights were taken to approximate departure weights.

9.2 Results

Chick weights at 14 days ranged from 153-269 g, with yearly means between 192-218 g (Table 9.1, Appendix 8). Maximum and departure weights were recorded only in 1987-1990, and ranged from 182-295, and from 178-295 g, respectively. Mean weights at all three stages were highest in 1988. Mean maximum weights were above 225 g in all four years, making the chicks from Coats Island consistently heavier than those reported from any other colony in the eastern Canadian Arctic (cf., Gaston and Nettleship 1981, Birkhead and Nettleship 1981, Gaston et al. 1983)

Table 9.1 Comparison of growth statistics recorded for Thick-billed Murres at Coats Island.

YEAR	HATCH DATE (July)	WEIGHT (g)			WING LENGTH (mm)		AGE AT DEPART (Days)	N
		14 DAYS	MAX.	DEPART.	14 DAYS	DEPART.		
1986	20.0 (2.0)	192.0 (26.2)	-	-	-	-		33
1987	26.5 (3.7)	192.9 (24.8)						32
1988	21.8 (1.9)	218.1 (19.2)	244.7 (17.7)	239.0 (19.6)	55.4 (4.3)	78.2 (4.5)	22.5 (1.8)	35
1989	28.0 (2.7)	202.5 (28.7)	235.0 (25.1)	238.4 (18.3)	50.9 (4.7)	71.9 (5.9)	21.5 (1.3)	37
1990	28.6 (2.5)	208.0 (21.9)	226.5 (23.4)	223.6 (24.8)	51.2 (1.5)	73.8 (6.5)	22.9 (2.1)	30

In 1989, one chick with a 4-year-old parent had the lowest weight at 14 days (153 g) of those weighed. In 1990, chicks with four, or five-year-old parents (1 each) were lighter at a given age than the mean of chicks hatched up to 30 July (Figure 9.1). However, the weights of the chicks of young parents were similar to those of a sample of early-laying adults which were forced to relay their eggs by removal of the first egg. Hence, at least part of the reduction in growth rates observed for the chicks of young parents may have been caused by a deterioration in feeding conditions towards the end of the season.

Mean wing-lengths at 14 days were significantly greater in 1988 than in 1989, or 1990. In addition, in all three years there was a significant positive correlation between wing length and weight at 14 days of age (1988, $r = 0.551$, $P < 0.01$; 1989, $r = 0.545$, $P < 0.01$; 1990, $r = 0.600$, $P < 0.01$). Hence, chicks that were heavy for their age grew their feathers more quickly than lighter chicks.

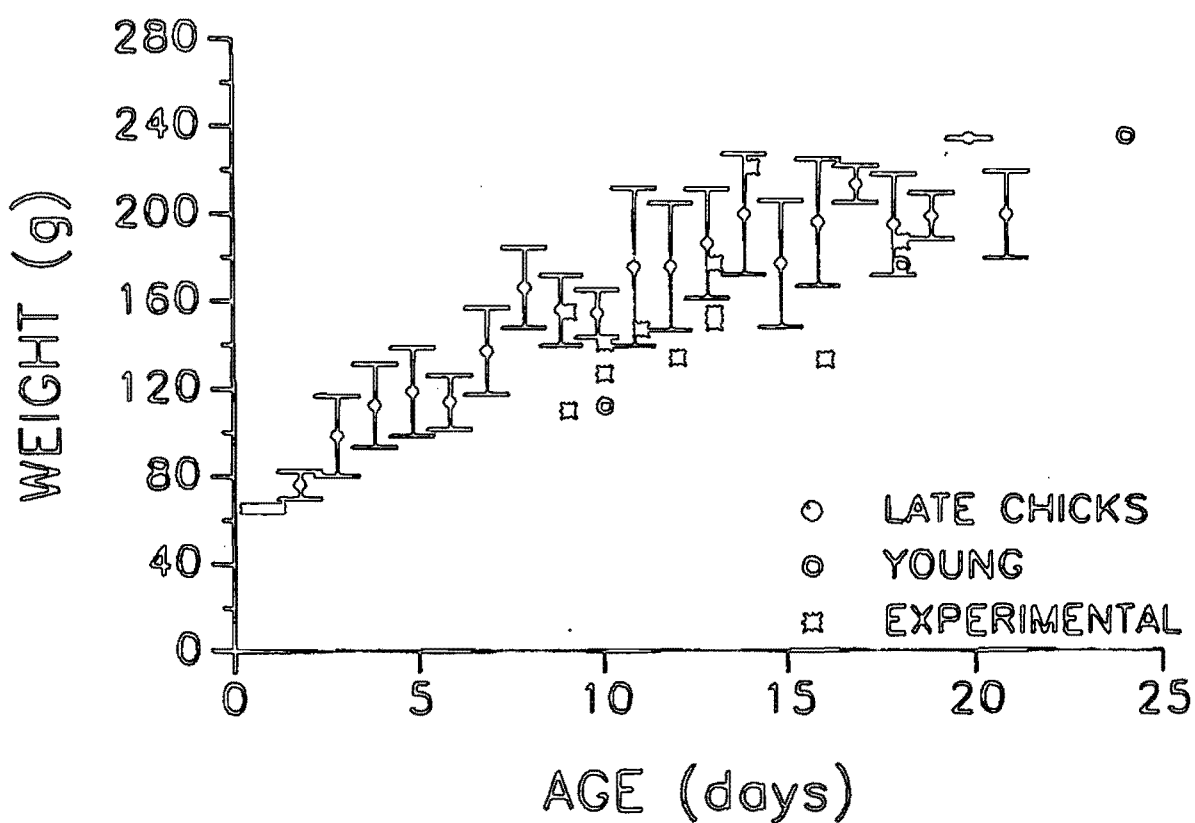
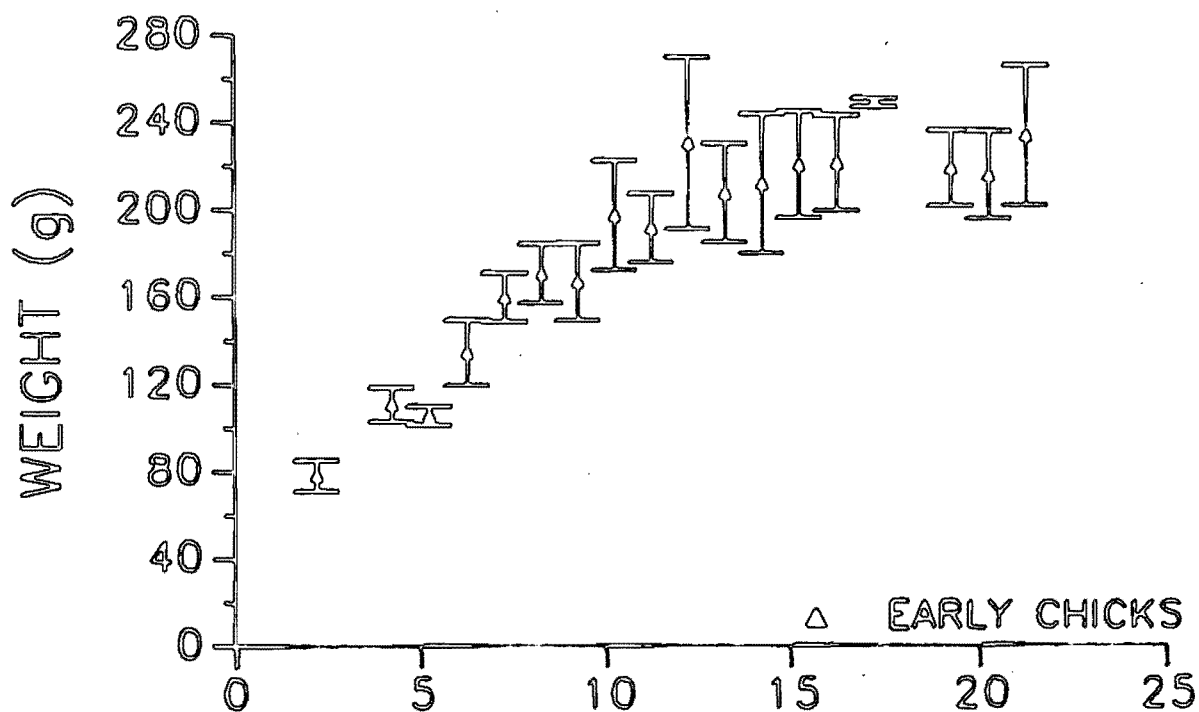


Figure 9.1 Growth curves for chicks hatched before 30 July (early), and later (late), and single weighings of young and experimental chicks

Apparently the nutritional state of the chick determines the rate of growth of its feathers, to some extent.

10. FUTURE DIRECTIONS

After four years of limited visits, and two seasons of intensive observations, we are close to completing the initial phase of the work. Good information on age at first breeding and age-specific reproductive success was obtained in 1990, and further data will be collected in 1991 and 1992. Adult survival rate has received little attention so far, but the sites occupied by more than 100 banded birds were mapped in 1990, and these should yield better estimates of the survival of breeding adults over the next two years. In addition, the use of capture-recapture techniques (based on resightings over a number of years) should allow us to estimate survival to age of first return, and age-specific survival for several cohorts.

Once good information on age-specific reproductive success has been obtained over three seasons (1990-92), it may be necessary to reduce the scale of operations. However, annual and age-specific survival can continue to be monitored by shorter field visits. This would probably be the most effective way to monitor whether regulations imposed on the Newfoundland hunt (if they are ever implemented) have detectable consequences on population parameters. At the same time, the run of data allowing year to year comparisons (evening counts, chick growth parameters, egg volumes, chick diets and feeding rates, etc.) provides an excellent basis for monitoring environmental changes occurring in northern Hudson Bay, especially those relating to climatic change, with their consequent effects on the distributions and abundance of the murres prey organisms. At present, the Coats Island study is the only one available for the whole of Hudson Strait and northern Hudson Bay, that might allow us to use marine birds to monitor changes in the marine environment.

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APPENDIX 1. ASSOCIATED GRADUATE STUDENT PROJECTS

FACTORS AFFECTING RECRUITMENT OF THICK-BILLED MURRES (*Uria lomvia*)
ON COATS ISLAND, N.W.T.

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(completed December 1990)

ABSTRACT

Factors related to the age of first breeding and prebreeding patterns of attendance were investigated in a Thick-billed Murre *Uria lomvia* colony on Coats Island, N.W.T. The theory of natural selection predicts that long-lived iteroparous animals should trade off current reproductive commitment against residual reproductive value, because of the ecological and physiological costs of breeding. Although directional selection on such traits as the ability to acquire nutrient reserves should occur, individuals whose life history tactics most closely match environmental optima are expected to achieve greatest fitness. Alternatively, life history parameters such as the age of first breeding may be more strongly influenced by physiological constraints, extrinsic environmental factors, or by social competition for limited resources.

Because I could test few hypotheses directly, I set out to determine which factors constituted current constraints, upon which selection might be expected to act. I investigated factors affecting the process of recruitment by comparing behavioural and morphological characteristics of known-age birds, with respect to age, breeding status and gender.

Thick-billed Murres banded as chicks on Coats Island were found to return to the colony as early as two years, with numbers of the age cohort increasing over the season and during their third summer. Over all years of this study, only three three-year-olds were detected breeding, all unsuccessfully. The proportion detected breeding increased with age to about 40% in six-year-olds, but most attempts still failed. There were significant age-related effects on temporal and spatial patterns of attendance; the most significant findings were that older birds arrived much earlier in the season, and were more site-attached. Prebreeding birds of all ages exhibited sexual and agonistic behaviour. Young females were highly receptive to copulation attempts, and therefore more frequently achieved cloacal contact than young males, who improved from a 0% success rate at two years old to about 50% at six years old. Although some significant age-related changes in agonistic behaviour were recorded, there was little evidence of improvement in the outcome of interactions with age.

Age was found to have a significant effect on body weight and condition among all known-age birds captured at the colony. Birds known to breed were heavier than nonbreeders of the same age,

and their weights showed no age effect. In contrast, weights and condition indices of Thick-billed Murres originally banded on Coats Island recovered during the winter off the coast of Newfoundland, showed no trend with age, suggesting little difference in general foraging skills.

These results support the hypothesis that the ability to acquire and maintain nutrient reserves is an important factor in the recruitment process, and limits the time available for occupying potential sites in the colony. This constraint is particularly severe early in the season when open water feeding areas in the ice are scarce. With respect to the influence of age on attendance, the most parsimonious explanation for the few improvements in social skills is gain in experience. There was no evidence of overt competition for sites, and no evidence that young males attempt to obtain extra-pair fertilizations.

ABSTRACT OF THE DISSERTATION

DIVING AND ENERGETICS OF THE
THICK-BILLED MURRE, Uria lomvia

by

Donald Angus Croll

Doctor of Philosophy in Marine Biology

Scripps Institution of Oceanography

University of California, San Diego, 1990

Doctor Gerald L. Kooyman, Chair

The diving behavior and energetics of the Thick-billed Murre, (Uria lomvia), were examined in breeding murres on Coats Island, Northwest Territories, Canada, and in the laboratory. Electronic dive recorders were used to find that most dives were a flattened U-shape in profile, and occurred in bouts lasting 10 to 15 minutes. Most dives occurred in the evening between 2000 and 0400, and were less than 20 meters deep, indicating that murres follow the diurnal migration of their prey. The maximum dive depth and duration recorded were 210 m and 216 s. Eighty percent of dives were less than 80 s in duration and less than 40 meters in depth. Blood volume,

hematocrit, and hemoglobin, and muscle myoglobin levels were high, indicating adaptation to increase oxygen storage capacity. Oxygen stores were estimated at 47.3 ml kg^{-1} . Forty-nine percent of all dives exceeded the estimated ADL of 47 s. A foraging efficiency model demonstrated that anaerobic dives which exceed the ADL are probably more efficient given the murres' relatively small size. The observed diving behavior raised questions concerning the murres' ability to avoid decompression sickness and lung collapse during diving.

Field metabolic rate (FMR), measured at $1860 \pm 416 \text{ kJ day}^{-1}$ with doubly labeled water, was 6.5 to 5.5 times greater than predicted basal metabolic rate. This was exceptionally high compared to other seabirds. Murres spent 65% of their time at sea sitting on the water surface, 15% diving, and 15 to 20% flying. Measurement of the resting metabolic rate in water demonstrated that murres are not thermally neutral in water colder than 15°C , and must spend 22 W kg^{-1} to maintain body temperature in the 0 to 5°C water they are normally found. A time-energy model indicated that the cost of sitting on the water surface and a high cost of flight probably account for their high FMR. Models of prey requirements found that murres require 45 g ww of prey per day, and the study population of 24,000 pairs and dependent chicks consume an

14,812 kg of prey per day, requiring a prey capture success rate of 53%. Energetic models indicated that murres may undergo an adaptive loss of weight to increase flying efficiency during chick brooding.

THE EFFECT OF AGE ON THE REPRODUCTIVE SUCCESS OF THE
THICK-BILLED MURRE (*Uria lomvia*)

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The aim of this project, which began in 1990, is to detect the presence and magnitude of differences in reproductive success between young and older breeding Thick-billed Murres, and to examine how these differences in age contribute to the seasonal decline in reproductive success. I am also collecting evidence relating to seasonal changes in the availability of prey, to determine whether food resources decline as the season progresses, and if so, what impact this trend has on late laying birds.

I examined the effect of breeders' age on timing of breeding and reproductive success, in order to determine what proportion of the seasonal decline in reproductive success can be attributed to the late laying of younger birds. I followed the progress of a sample of 4, 5, and 6 year old breeders on previously defined study plots, as well as birds known to have bred at least three years previously. Because younger birds often lay later in the season, I manipulated the timing of laying of a sample of early breeding Thick-billed Murres in order to induce them to relay. There is usually a delay of about 14 days between loss of the first egg and relaying. The success of this group of experimentally delayed early breeders was then compared to that of younger birds laying at a similar date, and to a group of unmanipulated birds laying early in the season (controls). This comparison was designed to distinguish the effects of age from those related to date of laying.

If a reduction in food supply is the main cause of the seasonal decline in reproductive success then all late layers should have poor success, regardless of their age. Alternatively, if young

birds are less efficient than older birds at foraging, or at certain reproductive behaviours, then some, or all of the seasonal decline in reproductive success may be caused by a preponderance of young, inexperienced breeders among those laying late in the season. Age-related foraging ability under similar feeding conditions can be assessed by comparing experimentally late breeders with young breeders laying at a similar date. Trends in the seasonal availability of prey are determined by comparing the foraging effort of early laying controls with that of experimentally delayed breeders.

I adopted the following terminology in defining different groups of breeding birds:

- 1) pairs which included at least one bird banded as a chick and known to be 4, 5, or 6-year old (YOUNG, n= 11, 25, and 15 respectively),
- 2) birds banded as breeders at least 3 years previously and hence almost certainly at least 7 years of age (BAD's, n=72),
- 3) early laying birds of unknown age (some known to be BAD) which were not manipulated (CONTROLS, n=85),
- 4) early laying birds, mainly of unknown age, but including some BAD's, which were induced to relay by removing their first egg immediately after laying (under CWS permit) (EXPERIMENTALS, n=49).
- 5) Non-experimental birds of unknown age (neither YOUNG, nor BAD) are referred to as OTHERS. The entire sample, irrespective of age, but excluding experimentals, is referred to as BREEDERS.

I tested the following hypotheses:

- H1: Reproductive parameters, such as timing of laying, egg size, hatching success, chick growth, fledging success, reproductive success, etc., vary with age.
- H2: CONTROL breeders have higher reproductive success than both EXPERIMENTAL and YOUNG breeders.
- H3: EXPERIMENTAL breeders have higher reproductive success than YOUNG breeders laying at the same date.
- H4: EXPERIMENTAL breeders forage more efficiently than YOUNG breeders laying at the same date.

H5: There is a decline in the availability of prey as the season progresses.

METHODS

TIMING OF LAYING AND BREEDING SUCCESS.

During the 1990 field season, I followed the progress of laying, incubation and chick rearing for 489 pairs of breeding Thick-billed Murres. Information on reproductive success was collected using non-intrusive Type 1 methods as described by Birkhead and Nettleship (1980). The number and fate of all eggs laid was established by observations of 6 study plots (Plot D, N, P, Q, R, and S) from blinds. Study birds were mapped and each site was observed without disturbance at least once every two days in order to determine laying, hatching, and fledging dates.

Reproductive outcome was established for 224 non-experimental sites where the laying dates of first eggs were known within 3 days. Some young, BADs, and control birds were included in this sample, which can be considered a representative sample of the colony. I defined hatching success as the proportion of eggs laid which hatched, fledging success as the proportion of chicks hatched which survived at least 15 days, and reproductive success as the proportion of pairs which laid eggs which reared a chick to at least 15 days. Hatching, reproductive and fledging success, in relation to date of laying, were analyzed using logistic regression. Hatching and reproductive success of young (4 & 5-year olds, N=32) were compared with older birds (BADs, N=61) using χ^2 to test for age differences. Hatching and reproductive success of control (N=69) and experimental (N=32) birds were compared using χ^2 to test for differences due to date of lay. Experimental and young birds were compared to assess the effect of age, corrected for laying date.

INCUBATION SHIFT DURATION/REGULARITY.

During the incubation period, we conducted 48-hour watches consisting of hourly checks on presence or absence of marked pairs of control and experimental breeders in order to determine shift length. During experimental observations of birds, at least one member of each pair was identifiable by leg bands, felt marks or topknots (bright pieces of material glued to the crown feathers).

We conducted three such checks:

- 1) during early incubation of control eggs (27-29 June)
- 2) near hatching of control eggs and early incubation of experimental eggs (13-14 July)
- 3) near hatching of experimental and young breeder eggs (2-3 August).

These checks coincided with continuous 24-hour activity budget watches (see below).

CHICK FEEDING RATES.

Chick feeding rates of a sample of control and experimental breeders were observed every three days throughout the chick rearing period (6 August to 23 August) during 4-hour watches at Plot D. During 24-hour watches on Coats Island, the highest feeding rates have been recorded in the early morning and late evening. The 4-hour watches were conducted during the late evening peak in order to compare changes in feeding as the season progresses, at a time when the maximum number of birds is returning to the colony.

FEEDING/FORAGING EFFORT:

There were five 24 or 48 hour incubation and feeding watches during the 1990 breeding season.

- 1) early incubation by control birds**
- 2) early incubation by experimental birds/late incubation by control birds**
- 3) early chick rearing by control birds/late incubation by

experimental and young birds**

4) late chick rearing by control birds/early chick rearing by experimental and young birds

5) late chick rearing by experimental and young birds

** Both incubation shift duration/regularity data and foraging data were collected simultaneously (see above).

Two electronic activity timers (Cairns et al. 1987) were attached to each of 5 to 7 control or experimental birds on each watch; one knotted to the upper tail feathers, the other attached to the band on the tarsus. The activity timers switch off when submerged in water, and switch on again when they emerge. If time spent by the birds on the breeding cliffs is recorded, the data from the activity timers can be used to break down foraging time (time away from the colony) into time spent flying, diving, and sitting on the surface. Approximate foraging range is calculated using known flight speed.

The total weight of the two timers was c. 10-11 g, c. 1% of total body weight. Recorders were attached at the start of each watch. Most birds resumed incubation/brooding within 1 to 5 minutes after the recorders were attached. At the end of each watch, birds were recaptured and timers were removed. We attempted to read the time on the timers while the birds were on their sites, but this was usually not possible. Data from timers which could not be read while on the bird were averaged for all trips. Whenever activity timers were deployed, control birds were also observed to determine any negative effects (i.e. in incubation shift length, number of foraging trips, etc.) caused by the added weight, disruption of streamlining, or disturbance due to the attachment of the equipment.

RESULTS

TIMING OF LAYING

The date of laying of first eggs was known within 3 days for 10 4-year olds, 20 5-year olds, 14 6-year olds, 61 BAD's, and 239

others (total N=344). Dates of laying of first eggs ranged from 15 June to 16 July (median = 26 June). The pattern of laying was skewed right, with 79% of all eggs laid by 1 July. Mean laying date increased with age of the breeding bird (Table 1). BADs and OTHERS did not differ significantly in their mean date of laying, although BADs laid slightly earlier. The mean dates of laying for 4 and 5-year olds differed significantly from all older birds, but were not significantly different from each other. They were therefore combined to increase the sample size for young breeders. Six-year olds were intermediate in date of laying between BADs and 4 and 5-year olds, but were statistically indistinguishable from BADs and OTHERS.

Table 1. Mean laying dates of first eggs of Thick-billed Murres in 1990 (1 June = day 1).

AGE	N	MEAN \pm SE
Others	239	26.96 \pm 0.37
BADs	61	25.54 \pm 0.61
6 yrs	14	27.36 \pm 1.54
5 yrs	20	31.35 \pm 1.36
4 yrs	10	33.60 \pm 1.82
4 & 5 yrs	30	32.10 \pm 1.09

OVERALL REPRODUCTIVE SUCCESS AND SEASONAL DECLINE

Hatching success was 60.7% (N=224), fledging success was 91.7% (N=133), and reproductive success was 54.5% (N=224).

Hatching and reproductive success decreased significantly with date of laying (logistic regression - χ^2 on slopes: hatching success - $\chi^2=29.37$; $P<.001$; reproductive success - $\chi^2=25.06$; $P<.001$). There was a similar, but insignificant trend in fledging success ($\chi^2=0.196$; $P>.05$).

The proportion of eggs laid which hatched was significantly higher in older than in younger birds. Reproductive success was also significantly higher (Table 2). Control and experimental breeders did not differ significantly in either hatching or reproductive success (Table 3), although both were slightly lower in the experimental group. Experimental and young breeders also differed, with experimental breeders having significantly higher hatching and reproductive success (Table 4).

Table 2. Comparisons of reproductive success of young and older birds.

SUCCESS	YOUNG	BAD	chi ²	P
HATCHED	4	46		
NOT HATCHED	28	15	33.39	<.001

SUCCESS	YOUNG	BAD	chi ²	P
SUCCESSFUL	4	39		
UNSUCCESSFUL	28	22	22.35	<.001

Table 3. Comparisons of reproductive success of control and experimental birds.

SUCCESS	CONTROL	EXP'TAL	Chi ²	P
HATCHED	47	19		
NOT HATCHED	22	13	0.74	>.25

SUCCESS	CONTROL	EXP'TAL	Chi ²	P
SUCCESSFUL	37	15		
UNSUCCESSFUL	32	17	0.40	>.50

Table 5: Comparisons of reproductive success of experimental and young birds.

SUCCESS	EXP'TAL	YOUNG	Chi ²	P
HATCHED	19	4		
NOT HATCHED	13	28	9.06	<.005

SUCCESS	EXP'TAL	YOUNG	Chi ²	P
SUCCESSFUL	15	4		
UNSUCCESSFUL	17	28	15.27	<.001

FEEDING/FORAGING EFFORT

Time spent flying, diving and sitting on the water will be compared between control and experimental birds to assess differences in foraging behaviour during incubation and chick rearing. Preliminary analysis of these results indicates that there was little difference between controls and experimentals at the same stage of breeding in time spent actively foraging (flying and diving) later in the same period. The data obtained suggests that Thick-Billed Murres at Coats Island spend a much larger proportion of their time underwater, hence actively foraging, than the Common Murres studied by Cairns et al. (1987).

CONCLUSIONS

The following interim conclusions can be drawn from results obtained in 1990:

Hypothesis 1: There is a very distinct decline in reproductive success as the breeding season progresses. The earlier a Thick-billed Murre can lay its egg, the greater the chance that its chick will successfully fledge. However, most mortality occurs at the egg stage. Once the chick has hatched, its chance of fledging remains high throughout the season. Young birds lay later than older birds, and have lower hatching and reproductive success than experimentals laying around the same date. Further analysis in 1991 will look at egg size, chick growth, and fledging success.

Hypothesis 2: Control and experimental breeders did not differ in either hatching or overall reproductive success. Hence, date of laying appear to have very little effect on the performance of experienced breeders. Age and experience may increase the ability to succeed at a time during the season when expected reproductive success is quite low.

Hypothesis 3: Both control and experimental birds differed from young breeders in hatching and reproductive success. Even though experimental birds relaid after most young birds had laid their first eggs, they had higher hatching and reproductive success than young birds. This suggests that the lower success of young breeders cannot be accounted for solely by their timing of laying.

Hypothesis 4: To be tested in 1991

Hypothesis 5: The lack of evidence for an increase in time spent foraging as the season progressed did not support the hypothesis that the availability of prey declines late in the season. However, late hatching chicks grew more slowly than earlier chicks. Given the variability in time spent feeding, sample sizes may have been insufficient to detect differences.

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STUDIES OF GLAUCOUS GULL PREDATION ON THICK-BILLED MURRES**GRANT GILCHRIST**

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Preliminary work on this project was carried out in 1989 and 1990. The main field work will take place in 1991.

Up to 16 pairs of Glaucous Gulls have been recorded breeding on the West colony at Coats Island during the years that it has been visited, rearing between 12 and 18 young annually. In addition, a variable number of non-breeders, including a few birds in sub-adult plumage, were generally present in August. Eggs had hatched before our arrival in most years. Laying apparently occurred in the first week of June, and the young gulls had begun to fly by mid-August in all years. In 1990, 38 eggs were present on 1 July, in 16 nests, but only 11 young were reared. In the same year, periodic counts of Glaucous Gulls numbers present on the murre colony were made throughout the season, from the far side of the colony cove. There was little indication of any trend over the course of the breeding season (Figure 1).

Systematic observations of predation by Glaucous Gulls on the eggs and chicks of Thick-billed Murres were made in 1990. Weather conditions affected foraging behaviour, with the number of patrol flights made along the colony increasing with wind speed up to about 60 km/h (Figure 2). The number of eggs, or chicks seen taken by gulls was highest in late June, low during most of July, but increasing in late July, to a second peak in August (Figure 3). The heavy egg losses in late June may have been caused by very low attendance by the murres in the early part of the incubation period, so that birds which laid early were relatively unprotected by neighbours. The August peak probably resulted from the increased food requirements of those birds that were feeding large chicks.

Experiments carried out in 1989 and 1990 showed that chicken eggs, painted to resemble murre eggs, were taken most rapidly by gulls when they were placed on broad ledges unoccupied by murres. Those placed on narrow, unoccupied ledges were taken less rapidly. Those placed close to incubating murres, where they were not dislodged by the murres, were either not taken at all, or taken only after up to 48 h. These experiments demonstrate the protection from predation afforded to the murres by breeding in dense groups, and on narrow ledges. Further observations of gull predation tactics and murre defensive strategies will be made in 1991, as well as estimates of total numbers of eggs and chicks removed, and the overall impact of gull predation on the reproductive success of the murres.

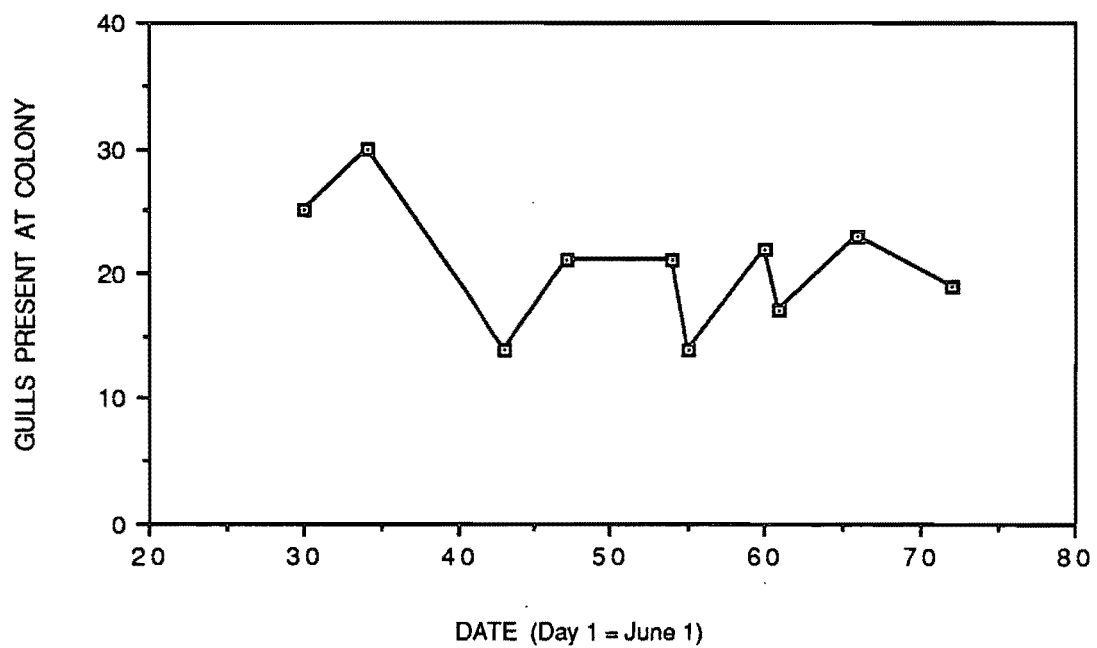


Figure 1. Counts of Glaucous Gulls present on the West colony, Coats Island in 1990

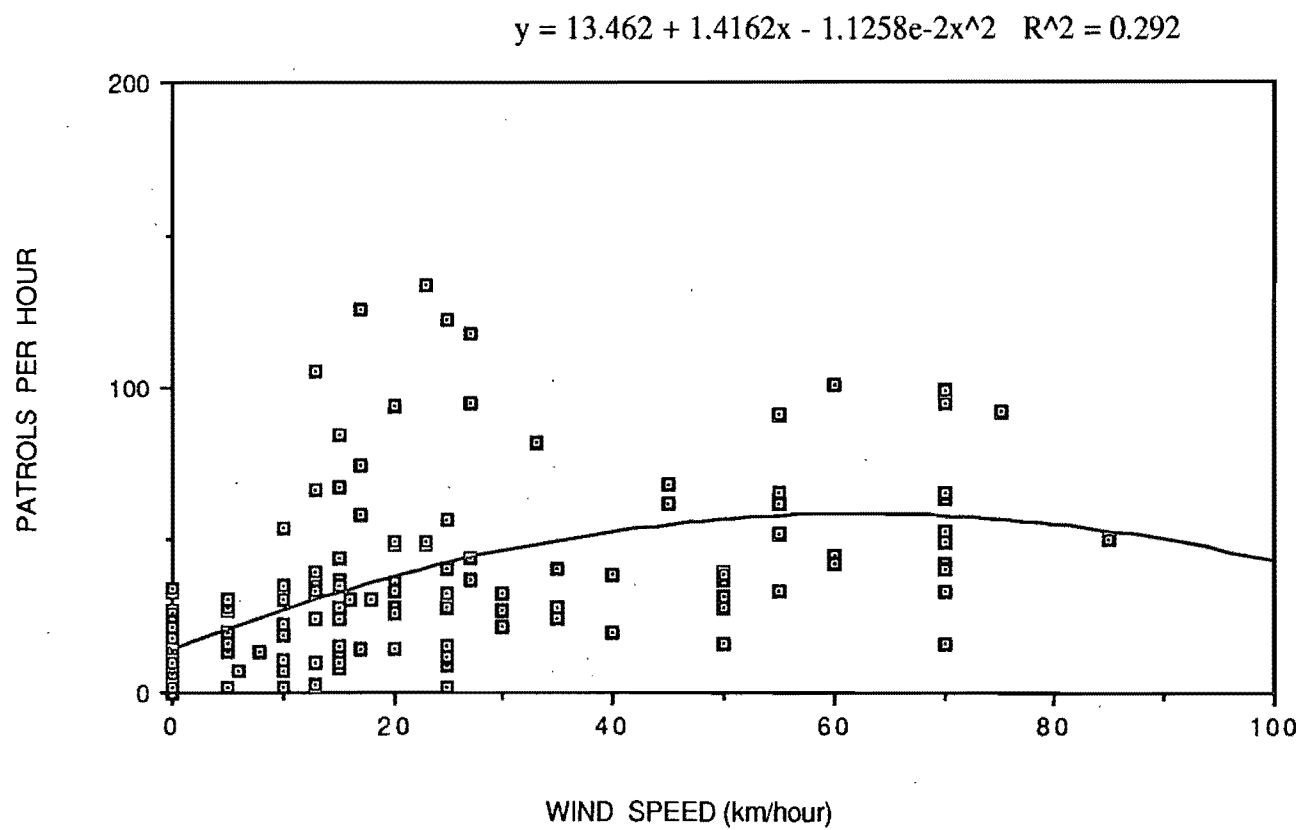


Figure 2. Frequency of patrols by Glaucous Gulls at the West colony, Coats Island in 1990, in relation to wind speed

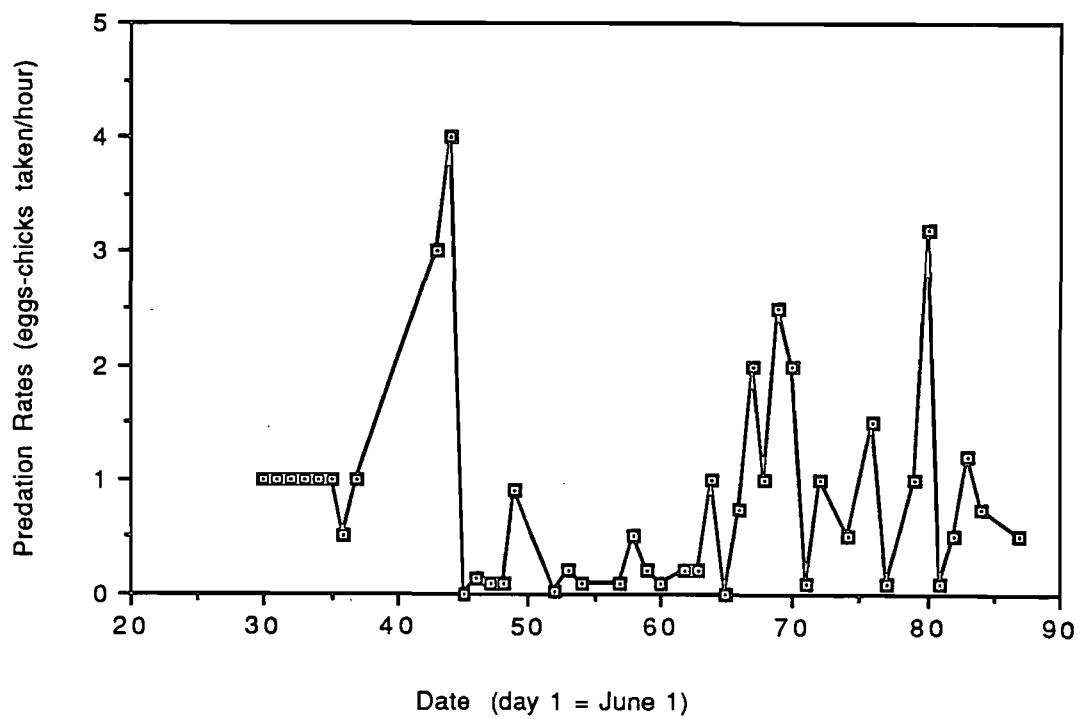


Figure 3. Rates of predation on murre eggs and chicks observed at the West colony, Coats Island in 1990

APPENDIX 2. NOTES ON BIRDS AND MAMMALS RECORDED ON COATS ISLAND DURING THE PROJECT

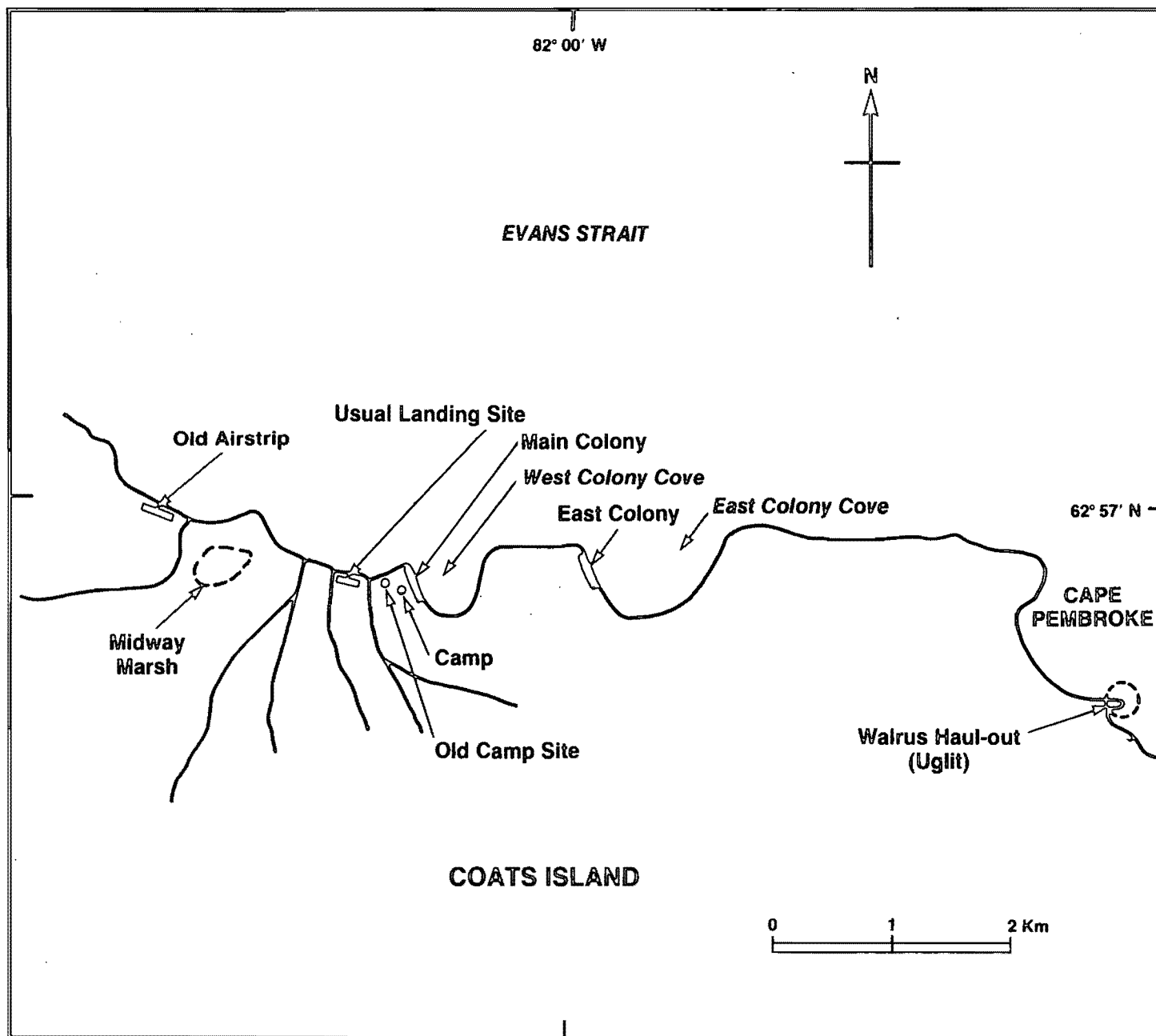
Locations referred to are shown on the map.

MAMMALS

Caribou Rangifer tarandus. None were seen alive in 1981, 1984, 1985 or 1986. In 1987 two were seen near camp on several days. In 1988 up to four were seen in the vicinity of camp until mid-July, after which only one male was seen. In 1989 one male was seen near camp on 16 August. In 1990 up to four were seen in the camp area occasionally. Two dead animals on the ice at the foot of the colony cliffs when we arrived must have fallen over during the winter. There was much caribou sign everywhere along the cliff tops. Many caribou corpses were found scattered over the area inland from camp; perhaps 25 within 6 km. This was the largest number of dead caribou seen in any year, and suggested a major die-off in the 1989-90 winter.

Arctic Fox Alopex lagopus. 1981: 2 adults seen in Fox Gully on several dates, and a cub was seen nearby. One adult took an adult murre. 1984: a den with at least five kits was present on the east colony, but no foxes were seen at the west murre colony. 1985: a den with at least two kits was located in a boulder pile near the base of the colony hill. On 31 July at least 42 murre carcasses were found in the vicinity, as well as some eggshells. 1986: the same den as in 1985 was occupied, containing at least three kits. There was evidence of heavy predation on adult murre. 1987: the same den was again occupied, but was vacated within a few days of our arrival, possibly because of the dog that was kept in camp that year. 1988: one or two foxes were present near camp on 12-18 June, but thereafter only one was recorded until 13-15 August when a very tame juvenile visited camp. 1989: One at camp at 2100 hrs on 7 August, ran off as soon as we approached it.

In 1990 a den containing at least five kits was active at the



base of the camp hill. Adult foxes were seen catching murrens stranded on the fast ice at the foot of the colony cliffs in June, and they began to take murrens eggs soon after laying began. On 26 June a fox took four eggs in less than 30 minutes near R, and other eggs were taken by gulls as the murrens panicked. Many eggs were removed at Lower Fox Gully in late June and early July, wiping out all reproduction at accessible sites. The top ledge on Plot D was also cleared.

Polar Bear Ursus maritimus. 1981: fresh tracks were found, but none was seen. 1984: Two large solitary bears seen near the western camp site. One slept on top of a nearby hill for 36 h. 1985: On 29 July the Coast Guard reported 4-5 between Cape Pembroke and the navigation beacon, but none was recorded near camp. 1986: Four solitary animals were seen near camp, and two near the uglit. Tracks near camp looked like a mother and cub. 1987: 16 were seen in or near camp, many in late July when heavy ice was present just offshore. One was seen to chase two caribou, without success. A nuisance bear, which could not be deterred with noises or plastic bullets, had to be shot. It proved to be an old male with very worn teeth, bleeding gums and no fat. 1988: on 14 July one attacked two walruses on an ice pan, but was unsuccessful. Otherwise, two were seen near camp, on 30 July and 7 August, and the remains of a freshly killed walrus pup was found near the uglit. 1989: When we arrived on 27 July one was present on the colony islet. On 1 August a female with a large cub was seen about 1.5 km west of camp. 3 August; a large, presumed male rested on the islet for several hours, then swam off northwards. A similar looking bear, extremely fat, climbed the hill across the cove from the murre colony on 15 August and spent the next 24 h feeding on vegetation, or resting, on the slopes of the hill, coming within about 300 m of camp at the closest. It eventually returned to the sea and swam off eastwards. 17 August; DC, GG and LDF encountered a mother with two cubs near Cape Pembroke and a large male near the Kumlien's Gull colony. 12 August; a bear, not seen, rummaged through our garbage fire on the

beach. 1990: Only one sighting near camp, on 31 July. A large bear was present near the uglit on 13 August.

Ringed Seal Phoca hispida. Up to 10 could be seen from camp at leads and breathing holes in fast ice during the period before ice break-up in 1990. Once the ice had gone, very few were seen.

Bearded Seal Erignathus barbatus. One or two were recorded in 1988 and 1990 in association with pack ice.

Walrus Odobenus rosmarus. Seen regularly off the colony, in small groups, throughout the open water season. Up to 20 fed in the colony cove occasionally, and groups of 5-15 often fed in the bay to the west of the colony. In 1981 about ten were hauled out on the islet close to the colony on 9 August, but none were ever seen there subsequently. In the same year 1000 were estimated present on the uglit in mid-August. Otherwise, the only substantial count at the uglit was in 1990, when 400 were present on 13 August. The first sightings were on 10 July in 1988 and on 9 July in 1990.

Killer Whale Orcinus orca. Three seen passing towards the east on 16 July 1990.

Beluga Delphinapterus leucas. 1984: one in the east colony cove on 9 August. 1987: four offshore on 10 August. 1988: between 21 June and 6 July many small groups were seen passing in both directions. The largest was of 50 on 2 July. Three were seen on 3 August. One adult and one calf were seen in the colony cove on 31 July 1989. On 21 July 1990 76 swam eastwards, including about 25% dark (immature) animals.

BIRDS

Pacific Loon Gavia pacifica. One or two birds were seen occasionally flying over camp, or offshore in most years. Up to 3 were seen almost daily in 1984.

Red-throated Loon Gavia stellata. Single birds were seen occasionally in all years, either flying over, or on the sea. 1988: birds on a pond west of camp behaved as though nesting, but no nest was found.

Tundra Swan Cygnus columbianus. Two flew over camp on 5 and 26 June 1990. Two were feeding on midway marsh on 30 June.

Greater White-fronted Goose Anser albifrons. One on the beach close to camp with five Canada Geese on 10 June 1990.

Snow Goose Chen caerulescens. 1988: flocks of up to 45 seen almost daily between 12-29 June flying northwards. 1990: recorded almost daily from 23 May - 4 July, and from 11 August, with more than 400 passing south on 18 August. Main spring passage occurred between 28 May - 7 June, with hundreds passing daily. After 10 August, flocks of up to 50 were seen flying south or west in most years. Directions of arrival were mainly from the east, suggesting that birds may have originated from Baffin Island, rather than Southampton Island. Blue phase birds made up about 50% of most flocks. Flocks sometimes landed to feed within sight of camp.

Brant Branta bernicla. Two flying near camp on 13 June 1990.

Canada Goose Branta canadensis. 1981: flocks of 15-40 seen along the coast daily. 1984: 17 flew over on 15 August. 1988: up to 18 were seen daily from 9 June - 6 July, mostly flying over camp. About 50 were seen near tundra ponds 6 km south of camp in July. Return migration was seen on 11 and 12 August. 1989: seven were seen near the old camp site on 13 August. Two flocks of c. 12 seen SW of camp on 17 August. 1990: seen almost daily from 28 May - 10 July, with a maximum of 40 on 30 June. Many small flocks passed over between 1-5 July. Thereafter, only two records in July, and none in August.

Black Duck Anas rubripes. Three seen offshore on 12 August 1984.

Northern Pintail Anas acuta. Two males at midway marsh on 18 June 1990.

Common Eider Somateria mollissima. Small flocks of females and juveniles were seen offshore on several dates in most years.

King Eider Somateria spectabilis. Seen occasionally in small numbers every year. In 1984, 50-100 juveniles and females were seen on the sea near camp. One male and two females were present on a pond 4.5 km south of camp on 11 July 1988. A nest containing 5 eggs was found on bare ground about 1 km inland from midway marsh on 30 June 1990. Up to 48 were seen off the landing strip beach in August 1990.

Oldsquaw Clangula hyemalis. Broods of ducklings were seen in 1985, 1986, and 1987. In 1988 many males were seen on ponds south of camp on 11 July, and solitary females were seen in the same area later in July. Six fed daily in the colony cove from 11-18 August 1989.

Black Scoter Melanitta nigra. Five flew past the old camp on 5 August 1984.

White-winged Scoter Melanitta deglandi. A pair and a single male seen in the cove to the west of the walrus uglit on 15 August 1981.

Red-breasted Merganser Mergus serrator. 1989: One drake on the sea close to the old camp site on 19 August.

Peregrine Falcon Falco peregrinus. A site just above the south end of the western murre colony was occupied in all years, although in 1989 only one bird was ever seen, and the nest contained just a single egg on 12 August. In that year, another pair nested on a very small bluff at the west end of the airstrip beach. The nest

contained 2 downy chicks on 15 August. A third bird was seen in the same area twice and it seems possible that one male was mated to two females. The colony site contained 3 young in August 1981, 3 in 1984, 2 in 1986, 2 in 1987, 3 in 1988, and 1 (and an unhatched egg) in 1990. A site near the old airstrip, about 3 km west of camp, was occupied in every year, but produced young only in 1990, when three fledged successfully by 20 August. A pair was present near the Iceland Gull colony 5 km SE of camp in 1985, 1986, and 1988, but breeding success was not known.

Food remains found near nest and roost sites over the years included Ptarmigan, Black Guillemot, Golden Plover, Sandpiper spp., Water Pipit, Lapland Longspur and Snow Bunting, but no Thick-billed Murres. On 18 June 1990 the remains of 5 Longspurs, 1 Snow Bunting and 1 Water Pipit were found at the site at the west end of the airstrip beach. In May 1990 a peregrine was seen to make several strikes on murres circling the colony, knocking some to the ice. Later, it was seen feeding on a murre carcass on the ice.

Rock Ptarmigan Lagopus mutus. Pairs and small covies were common inland from camp in 1981. In 1987 a recently hatched brood was seen, and in 1990 up to 3 were seen on 8 days spread over the entire season. A nest with 6 eggs was found on 7 July. Not recorded in other years.

Black-bellied Plover Pluvialis squatarola. One on the beach on 13 June, and one flying over on 15 June 1990.

Golden Plover Pluvialis dominica. One seen on 9 August 1984. A brood of chicks was found inland from camp in 1987.

Semipalmated Plover Charadrius semipalmatus. Birds giving territorial and distraction displays were seen near the airstrip in all years, and occasionally elsewhere. Broods were seen in 1986 and 1988. First seen on 9 June in 1990.

Whimbrel Numenius phaeopus. Three flew over camp on 18 August, one on 19th and one on 20th in 1989.

Ruddy Turnstone Arenaria interpres. One on 1 June and one on 17 June 1990.

Semipalmated Sandpiper Calidris pusilla. One seen on 22 July 1988. Singles seen near camp on 16 and 17 June, and c. 20 at midway marsh on 18 June 1990.

White-rumped Sandpiper Calidris fuscicollis. One near the old camp on 11 August 1981. Broods recorded in 1986 and 1987. Up to five were seen in the vicinity of camp on 15-17 June and 20 at midway marsh on 18 June 1990.

Baird's Sandpiper Calidris bairdii. One near the old camp on 11 August 1981 and one on 9 and 12 August 1984. In 1986 a brood was located south of camp. 1990: one near camp on 1 June, several foraging on bare hillsides on 9 June.

Pectoral Sandpiper Calidris melanotos. Two were seen on the camp beach on 7 June 1990.

Purple Sandpiper Calidris maritima. Several present on rocky shores in 1981. Broods of chicks were located inland from camp in 1986, 1987 and 1988.

Dunlin Calidris alpina. Seven feeding on bare ground on 9 June, and c. 10 at midway marsh on 18 June 1990.

Stilt Sandpiper Calidris himantopus. One on the beach near camp on 7 June, and 5-6 on midway marsh on 18 June 1990.

Common Snipe Gallinago gallinago. One on colony cliffs on 25 May 1990.

Parasitic Jaeger Stercorarius parasiticus. Several light phase birds seen in 1981, 1984 and 1988. Two flew over camp on 7 August 1989. Singles seen on 31 May and 5 June 1990.

Bonaparte's Gull Larus philadelphia. One very bedraggled immature on the beach near camp on 7 June 1990.

Herring Gull Larus argentatus. Small numbers (maximum 25), including a large proportion of sub-adults, were seen in the area of the camp in August in all years, usually standing on the beach, or flying out to sea. In 1990 1-2 Herring Gulls were seen sporadically throughout the season. They were never seen attempting to forage along the murre cliffs, although Iceland and Thayer's Gulls sometimes did so.

Thayer's Gull Larus thayeri. Small numbers seen in all years, but most could not be distinguished with certainty from Herring Gulls. Frequent sightings between 29 May - 9 June 1990 may indicate a passage period.

Iceland Gull Larus glaucoides. Up to four were seen frequently patrolling the murre cliffs in all years except 1981, when they may have been overlooked. None bred on the murre colony. In August 1990, up to 40 fed in the colony cove by dipping from the surface. Sub-adults in a previously undescribed plumage, grey on the mantle and coverts, but completely white on the primaries, were seen in all years. Details of a colony situated 6 km south of the camp are given by Gaston and Elliot (1990, Can. Field-Nat. 104: 477-78).

Glaucous Gull Larus hyperboreus. Up to 16 pairs were recorded annually on the western murre colony. One or two nests were seen on the east colony in 1984, and up to ten birds were present there. 1989: GG located 13 breeding pairs on the west colony, although there is some uncertainty about the breeding status of one of them. Of the other twelve, eight succeeded in rearing at least one chick

and altogether 17 chicks had either fledged, or were still surviving, at our departure. First fledging was observed on 16 August. In 1990 sixteen pairs were present on the west colony (see Gilchrist, Appendix 1).

Ring-billed Gull Larus delawarensis. One bird in second summer plumage seen on the beach near camp on several days in 1981.

Common Murre Uria aalge. One present at S on several dates from 12-19 July, and from 11-20 August 1990.

Black Guillemot Cepphus grylle. Seen occasionally in the colony cove in all years. Up to 50 birds were seen on boat surveys between the murre colony and the walrus uglit in 1981, 1986, and 1988.

Snowy Owl Nyctea scandiaca. One plucking a murre carcass on the sea ice about 500 m from the colony on 29 May 1990.

Horned Lark Eremophila alpestris. One was seen on 16 August 1984, fledged broods were seen on 28 July 1985 and 6 August 1986, singles were recorded on seven dates between 1 July and 11 August 1988, and 6 were present near camp on 27 May 1990. Not seen in 1987 or 1989.

Barn Swallow Hirundo rustica. One near the airstrip, 23 May 1990.

Raven Corvus corax. Six birds, probably a family party, were present at the east colony on 14 August 1981, and five in the same place on 9 August 1984. One flew past the west colony on 21 June 1988. One was seen plucking a dead murre on the ice and two were seen flying over camp on 2 June 1990.

Varied Thrush Ixoreus naevius. A male was seen feeding on the murre colony on 13 June 1988, following strong SW-W winds over the previous day.

Northern Wheatear Oenanthe oenanthe. A pair with recently fledged young was seen near the gull colony south of camp on 22 July 1988, and a single bird was present on the murre colony on 14 and 15 August. In 1989 one was seen near the old camp site on 15 August.

Water Pipit Anthus spinoletta. Common around camp in all years. In 1988 recently fledged young were first seen on 16 July. In 1990 birds were present on 24 May, a nest with 6 eggs was found on 10 July, and one with 5 chicks on 17 July.

Dark-eyed Junco Junco hyemalis. Single birds on the colony cliffs on 29 May and 3, 4, and 11 June 1990.

Lapland Longspur Calcarius lapponicus. Apparently uncommon as a resident (if it breeds at all), but abundant on spring migration in 1990. Only recorded once in 1981. Seen occasionally in 1984 and 1986, and daily in 1985. In 1988 one male was present and singing 3 km south of camp on several dates in July. In 1989 the species was common around camp after 12 August. In 1990 they were present on 24 May and seen daily up to 19 June, with 25 on the beach on 7 June, but seen only twice thereafter.

Snow Bunting Plectrophenax nivalis. A common breeder and passage migrant. Birds were present when we arrived in May 1990. Small flocks along the colony cliffs and around camp occurred after mid-July in all years. The first fledged young were seen on 10 July in 1988. Nests with 5 eggs found on 19 June and 1 and 10 July 1990.

Red-winged Blackbird Agelaius phoenicius. One male around the cliffs on 8 June, and singing at camp on 12 June 1990.

Yellow-headed Blackbird Xanthocephalus xanthocephalus. A female foraged around the west murre colony from 13-30 June 1988. It arrived at the same time as the Varied Thrush, presumably as a result of the same weather conditions.

Common Redpoll Carduelis flammea. Up to 3 recorded on seven dates in May and June 1990.

Pine Siskin Carduelis pinus. Heard flying over on 3 August 1985. Two were seen near camp on 16 August 1989.

**APPENDIX 3.1 WEATHER RECORDS AT CAMP AT 1700 HRS EASTERN STANDARD,
PLUS PRECIPITATION OVER THE PREVIOUS 24 h, 1987**

DATE	TEMPERATURE		CLOUD (/10)	PRECIP	WIND		PRESS. (Mb)	VIS. (km)	SEA
	MIN	MAX(°C)			SPEED	DIR			
24 July	1	4	10	3	28	NE	991	5	2
25 July	1	10	10	1.5	5	E	1000	>15	1
26 July	0	13	2	0	13	NE	1011	>15	1
27 July	2	14	8	0	2	E	1015	>15	1
28 July	5	15	7	0	3	W	1015	>15	0
29 July	6	14	9	1	36	SW	1011	5	3
30 July	3	18	1	0	35	SW	1018	>15	3
31 July	7	16	10	tr	60+	SW	1008	>15	6
1 Aug.	3	13	1	0	15	NW	1009	>15	2
2 Aug.	4	14	5	0	37	SW	1005	>15	3
3 Aug.	3	14	9	0	27	SW	1003	>15	3
4 Aug.	3	17	1	0	34	SW	1003	>15	3
5 Aug.	3	16	7	0	15	SE	1010	>15	2
6 Aug.	4	15	10	0	40	S	1006	>15	5
7 Aug.	3	15	0	1	6	SW	1012	>15	1
8 Aug.	3	9	10	tr	22	E	1011	1	2
9 Aug.	5	8	10	7	12	W	1007	10	2
10 Aug.	4	10	5	1	28	SW	1010	>15	3
11 Aug.	3	12	1	0	40	S	1020	>15	4
12 Aug.	4	12	10	8	60	E	997	1	6
13 Aug.	4	11	7	1	42	SE	1002	10	3
14 Aug.	3	11	9	6	25	SW	1007	>15	2
15 Aug.	4	13	0	0	15	E	1010	>15	2
16 Aug.	5	11	7	0	10	W	1006	>15	1
17 Aug.	4	10	1	tr	17	SW	1005	>15	2

APPENDIX 3.2 WEATHER RECORDS FOR 1988

DATE	TEMPERATURE		CLOUD (/10)	PRECIP	WIND		PRESS. (Mb)	VIS. (km)	SEA (10ths)	ICE
	MIN	MAX(°C)			SPEED	DIR				
11 Jun	-1	6	9	0	18	N	1032	-		10
12 Jun	-1	5	10	0	40	W	1031	-		10
13 Jun	-1	5	10	0	45	SW	1028	-		10
14 Jun	-1	7	2	1	25	SW	1031	-		10
15 Jun	0	7	10	1	40	SW	1030	-		10
16 Jun	-1	4	10	4	29	SE	1016	-		9
17 Jun	-1	9	8	2	7	S	1028	-		9
18 Jun	-1	10	3	0	12	S	1029	-		9
19 Jun	0	10	3	0	15	N	1026	-		9
20 Jun	-1	10	10	0	18	N	1015	-		9
21 Jun	-1	5	9	0	8	N	1016	-		9
22 Jun	0	10	7	0	3	NW	1020	-		9
23 Jun	0	16	1	0	15	W	1026	-		9
24 Jun	2	12	8	0	50	S	1021	-		8
25 Jun	2	8	10	5	60	S	1017	-		5
26 Jun	-1	15	0	0	15	N	1031	-		5
27 Jun	0	10	0	0	50	N	1036	-		5
28 Jun	1	12	0	0	0	0	1041	-		6
29 Jun	2	19	9	0	7	SW	1040	-		4
30 Jun	5	10	10	1	20	S	1035	-		3
1 Jul	2	8	9	2	6	SW	1017	-		4
2 Jul	3	13	9	0	12	SW	1016	-		3
3 Jul	3	16	2	0	10	SW	1018	-		3
4 Jul	3	10	9	0	5	SW	1017	-		2
5 Jul	2	16	9	1	52	SW	1018	-		4
6 Jul	4	18	2	1	41	SW	1024	-		3
7 Jul	3	19	0	0	12	SW	1027	-		2
8 Jul	6	21	9	0	0	0	1021	-		5
9 Jul	3	16	2	0	0	0	1021	-		2

DATE	TEMPERATURE		CLOUD (/10)	PRECIP	WIND		PRESS. (Mb)	VIS. (km)	SEA (10ths)	ICE
	MIN	MAX(°C)			SPEED	DIR				
10 Jul	6	19	3	0	5	SW	1017	-		3
11 Jul	8	16	7	7	6	SW	1011	-		2
12 Jul	3	8	10	2	18	N	1014	-		1
13 Jul	3	6	0	1	30	N	1013	-		1
14 Jul	3	19	1	0	0	0	1011	-		2
15 Jul	3	8	1	0	5	SW	1011	-		2
16 Jul	3	22	1	0	12	W	1012	-		3
17 Jul	2	16	2	0	6	W	1016	-		1
18 Jul	5	18	1	0	9	SE	1016	-		1
19 Jul	6	18	9	0	30	SE	1011	-		1
20 Jul	5	12	10	1	20	W	1012	-		1
21 Jul	5	11	10	1	10	E	1017	-		1
22 Jul	3	10	10	0	15	E	1023	-		1
23 Jul	5	12	0	0	18	NE	1022	-	2	1
24 Jul	8	13	10	1	38	NE	1013	-	3	2
25 Jul	5	11	9	3	28	W	1014	-	3	1
26 Jul	5	17	6	0	20	NE	1016	-	3	0
27 Jul	6	15	10	1	42	E	998	-	4	0
28 Jul	6	15	10	0	35	SW	100	-	3	0
29 Jul	5	13	8	1	40	SW	1002	-	3	0
30 Jul	5	13	0	0	20	SW	100	-	3	0
31 Jul	6	11	0	0	2	W	1005	-	2	0
1 Aug	6	11	5	1	21	W	1009	-	3	0
2 Aug	6	14	6	1	30	W	1010	-	3	0
3 Aug	6	14	9	0	55	SW	1002	-	5	0
4 Aug	5	10	1	1	55	W	1005	-	5	0
5 Aug	6	10	9	1	50	SW	996	-	6	0
6 Aug	6	10	3	0	60	W	1003	-	6	0
7 Aug	6	10	10	0	7	NW	-	-	2	0
8 Aug	4	12	9	11	35	W	990	-	6	0
9 Aug	5	8	8	0	38	NW	988	-	5	0
10 Aug	5	9	10	1	40	W	989	-	4	0

DATE	<u>TEMPERATURE</u>		CLOUD (/10)	PRECIP	<u>WIND</u>		PRESS. (Mb)	VIS. (km)	SEA (10ths)	ICE
	MIN	MAX(°C)			SPEED	DIR				
11 Aug	4	8	4	1	20	W	995	-	3	0
12 Aug	4	10	1	1	22	W	1003	-	2	0
13 Aug	5	11	1	0	20	W	1006	-	3	0
14 Aug	5	11	1	0	7	E	1006	-	3	0
15 Aug	4	12	8	0	30	E	1004	-	2	0
16 Aug	5	12	1	0	5	W	0	-	1	0

APPENDIX 3.3 WEATHER CONDITIONS AT CAMP AT 1700 hrs, 1989.

DATE	TEMPERATURE		CLOUD (/10)	PRECIP (mm)	WIND		PRESS. (Mb)	VIS. (km)	SEA
	MIN	MAX(°C)			SPEED	DIR			
28 Jul	10	15	3	0	30	W	1008	>15	3
29 Jul	12	22	8	tr.	5	W	1005	>15	2
30 Jul	6	13	10	light	8	S	997	5	2
31 Jul	3	9	10	heavy	22	N	994	5-15	3
1 Aug	3	10	10	heavy	18	SE	992	>15	2
2 Aug	3	7	5	0	35	NE	993	>15	4
3 Aug	4	9	1	0	25	WNW	998	>15	3
4 Aug	4	10	9	0	30	E	998	>15	3
5 Aug	3	11	1	0	15	WNW	1008	>15	2
6 Aug	4	13	4	tr.	8	WNW	1003	>15	2
7 Aug	4	11	9	light	40	W	996	>15	3
8 Aug	4	10	8	light	10	ENE	995	>15	2
9 Aug	4	12	10	light	25	W	996	>15	3
10 Aug	3	12	5	0	13	W	1003	>15	2
11 Aug	4	8	10	heavy	10	NW	1010	>15	2
12 Aug	4	11	7	0	18	W	1015	>15	2
13 Aug	4	10	7	0	12	SSE	1015	>15	2
14 Aug	4	9	10	mod.	20	SSE	1002	3	3
15 Aug	4	9	4	tr.	28	W	1010	>15	3
16 Aug	4	9	10	mod.	55	SW	1000	5	4
17 Aug	4	10	4	0	25	W	1008	>15	3
18 Aug	4	10	2	heavy	33	W	1002	>15	3
19 Aug	4	7	10	tr.	45	W	1001	>15	3

APPENDIX 3.4 WEATHER CONDITIONS AT CAMP AT 1700 HRS, 1990

DATE	TEMPERATURE		CLOUD (/10)	PRECIP (mm)	WIND		PRESS. (Mb)	VIS. (km)	SEA ICE (10ths)
	MIN	MAX(°C)			SPEED	DIR			
24 May	-	-	3	0	30	SE	1008	>15	9
25 May	-	-	8	sn tr	25	W	997	>15	9
26 May	-3	-3	10	sn 20cm	30/55	NE	984	0.2	9
27 May	-8	-3	8	0	35	NNW	995	>15	10
28 May	-4	1	10	sn tr	20	NW	994	>15	10
29 May	-5	0	2	0	15	W	998	>15	10
30 May	1	4	10	sn tr	6	S	993	5	10
31 May	0	2	10	sn 5cm	10	SW	972	2	3
1 Jun	-3	3	10	sn 5cm	15	WNW	970	2	8
2 Jun	-3	-2	10	sn light	40	W	983	10	10
3 Jun	-2	1	8	0	15	W	1000	>15	10
4 June	-1	3	0	0	35	SW	995	>15	9
5 Jun	-1	5	0	0	30	SSE	995	>15	9
6 Jun	-1	4	9	0	45/50	S	998	>15	4
7 Jun	-1	2	4	tr rain	50/60	W	999	>15	2
8 Jun	-2	4	2	0	0	0	1010	1-15	3
9 Jun	-2	2	10	sn 10cm	30/40	WNW	998	0.5-2	3
10 Jun	-2	6	5	0	20	SE	1010	>15	7
11 Jun	0	7	4	tr rain	5	W	1009	>15	9
12 Jun	-3	3	0	0	25/40	E	1005	>15	9
13 Jun	-2	1	10	heavy	25	E	985	0.5	8
14 Jun	-1	2	10	sn lt	55/65	WSW	983	>15	9
15 Jun	-1	4	10	sn lt	75/85	WSW	975	5	8
16 Jun	-1	3	10	sn tr	60	W	998	15	9
17 Jun	0	4	10	0	20	WNW	1010	15	9
18 Jun	-3	10	0	0	8	W	1011	>15	9
19 Jun	-2	10	1	0	5	W	1011	>15	9
20 Jun	-2	10	1	0	9	NE	1014	>15	9
21 Jun	-2	6	1	0	2	W	1012	>15	9
22 Jun	1	13	1	0	2	W	1013	>15	8
23 Jun	-	-	2	0	10	S	1008	>15	8

DATE	TEMPERATURE		CLOUD (/10)	PRECIP (mm)	WIND		PRESS. (Mb)	VIS. (km)	SEA ICE (10ths)
	MIN	MAX(°C)			SPEED	DIR			
24 Jun	-1	7	10	0	0	0	1005	1	8
25 Jun	-1	3	9	0	15	NW	1002	>15	9
26 Jun	0	4	10	light	5	NNW	1005	1	9
27 Jun	0	5	1	0	0	0	1010	>15	9
28 Jun	1	8	2	0	0	0	1011	15	9
29 Jun	0	15	1	0	0	0	1011	>15	9
30 Jun	0	15	9	0	20/45	SE	1009	>15	7
1 Jul	2	9	10	tr	5	S	1007	>15	7
2 Jul	1	9	10	10	10	E	988	0.5	8
3 Jul	1	-	10	2	-	-	1000	>15	9
4 Jul	4	9	1	0	7	E	1006	>15	9
5 Jul	6	13	5	0	10/15	W	1008	>15	9
6 Jul	9	16	9	1	0	0	1008	12	8
7 Jul	6	15	5	0	0	0	1008	>15	8 ¹
8 Jul	1	14	10	light	10/15	E	1007	0.5	8
9 Jul	3	6	10	0	5	E	1008	>15	9
10 Jul	3	13	0	0	10	SW	1011	>15	9
11 Jul	6	18	0	0	45/55	SW	1012	>15	7
12 Jul	8	18	6	10	50/60	SW	994	>15	3
13 Jul	9	18	5	2	12	NE	995	>15	6
14 Jul	6	13	2	0	0	0	1007	>15	2
15 Jul	4	12	2	0	15/20	SW	1009	>15	2
16 Jul	3	10	7	tr	70/85	NE	1002	>15	1
17 Jul	2	11	10	20	45/60	NE	998	>15	<1
18 Jul	2	3	10	20	90/110	NE	1000	<0.5	<1
19 Jul	2	9	3	0	30/50	NE	1002	>15	<1
20 Jul	3	16	7	0	0	0	1010	>15	2
21 Jul	9	14	10	tr	40	SW	994	>15	1
22 Jul	5	12	2	2	35	SW	1001	>15	2
23 Jul	3	11	10	5	30	SW	987	10	0
24 Jul	4	10	0	1	0	0	1001	>15	1
25 Jul	4	10	1	2	40	SW	1003	>15	<1

DATE	TEMPERATURE		CLOUD (/10)	PRECIP (mm)	WIND		PRESS. (Mb)	VIS. (km)	SEA ICE (10ths)
	MIN	MAX(°C)			SPEED	DIR			
26 Jul	3	8	10	12	85/100	SE	1005	0.5	0
27 Jul	1	9	10	8	60	E	1010	>15	0
28 Jul	2	4	10	4	60/90	NE	999	0.25	0
29 Jul	3	6	10	4	30	SE	976	0.5	0
30 Jul	4	6	10	3	60	SW	970	>15	0
31 Jul	4	8	4	0	60	W	978	>15	rough
1 Aug	4	6	9	tr	50	SW	997	>15	rough
2 Aug	3	11	10	tr	-	-	1001	>15	calm
3 Aug	2	4	10	tr	35	E	1006	>15	v.rough
4 Aug	3	10	1	tr	30	W	1012	>15	2 ²
5 Aug	5	11	10	heavy	55/60	W	1006	2	4
6 Aug	3	10	2	0	15	W	1008	>15	3
7 Aug	6	10	10	tr	25	SSW	1009	>15	3
8 Aug	3	8	10	3	35	NE	999	15	5
9 Aug	4	6	3	0	25	NW	1000	>15	4
10 Aug	3	8	6	0	20	WNW	1004	>15	2
11 Aug	6	9	10	0	15	W	1009	>15	1
12 Aug	6	12	1	0	35	WSW	1006	>15	1
13 Aug	4	13	4	0	25	SW	1004	>15	4
14 Aug	4	8	10	heavy	70/80	NE	999	5	5
15 Aug	3	6	10	light	90/110	NE	970	2	6
16 Aug	3	4	10	heavy mist	65	ENE	990	2	5
17 Aug	2	6	6	0	10	E	1008	>15	4
18 Aug	0	10	5	0	25	-	-	>15	2
19 Aug	1	12	10	0	65/75	SW	1007	>15	4
20 Aug	4	10	9	light	20	W	1006	>15	2
21 Aug	3	8	2	light	50	W	989	>15	5
22 Aug	3	6	10	0	65	W	992	>15	6
23 Aug	0	12	10	0	-	-	1007	>15	-

1 land fast ice in colony cove cleared out

2 figures from this date relate to Beaufort sea condition

APPENDIX 4.1 Band numbers used at Coats Island in 1981

Band numbers	Date	Adult	Chick
785-43801-43900	13 Aug.		100
44001-44041			41
44042-44084	14 Aug.		43
44086-44150			65
44151-44169	13 Aug.		19
44170-44539	14 Aug.		370
44540-44650	16 Aug.		111
44651-44664		14	
44665-44800			136
45001-45500	12 Aug.		500
45501-45698	13 Aug.		198
45700-45800			101
Totals		14	1784

APPENDIX 4.2 Bands used at Coats Island in 1984

Band numbers	Date	Adult	Chick
785-			
37901-37987	7 Aug.		87
37988-37992	8 Aug.		5
37993-37995		3	
37996-38000			5
41101-41150			50
42079-42100	7 Aug.	22	
42701-42728	8 Aug.		28
42729-42730		2	
42731-42751			21
42752		1	
42753-42804			52
42805-42806		2	
42807-42810			4
42811		1	
42812-42824			13
42825		1	
42827-42850		24	
42856-42890	7 Aug.		35
42891-42989	8 Aug.		99
42890-42900	10 Aug.		11
43101-43109	8 Aug.		9
43201-43230	7 Aug.		30
43231-43250	8 Aug.		20
43401-43450			50
43901-44000	10 Aug.		100
45951-45983	8 Aug.		83
45984		1	
45985-46000			16
58522-58584	12 Aug.		63
58586-58635			50
58636-58683	13 Aug.		48
58684-58700		17	
58701-58714	12 Aug.		14
58715-58716		2	
58717-58750	13 Aug.		34
58751-58753		3	
58754-58759	17 Aug.	6	
58901-59000	13 Aug.		100
60101-60150	12 Aug.		50
60151-60343	10 Aug.		183
60344-60400	12 Aug.		57
60401		1	
60402-60450			49
60451		1	
60452-60500			49

APPENDIX 4.2 Bands used at Coats Island in 1984 (continued)

Band numbers	Date	Adult	Chick
785-			
60501-60550	13 Aug.		50
846-			
46472-46477	10 Aug.	6	
47345-47348		4	
50945-50947		3	
50949-50950		2	
55014-55019	12 Aug.	6	
55020-55050	13 Aug.	31	
Totals		139	1365

APPENDIX 4.3 Numbers of #5 metal bands used on chicks on Coats Island in 1985.

Band numbers	N
785-59051 - 100	50
59101 - 200	100
59201 - 250	50
59301 - 400	100
59401 - 500	100
59501 - 600	100
59601 - 700	100
59701 - 710	10
59751 - 800	50
59801 - 900	100
59930 - 960	31
Total	791

APPENDIX 4.3 (cont.) Numbers of special "Guillemot" bands used on chick and adult thick-billed murres on Coats Island in 1985

a)	Adults	Chicks
1001-1010	10	
1011-10344		24
1035-1043	9	
1044-1088		45
1089-1100	12	
1101-1113		13
1114-1115	2	
1116-1117		2
1118-1122	5	
1124-1200		77
1201-1299		99
1300	1	
1301-1315		15
1317-1393		77
1394-1400	7	
1401-1440		40
1441-1450	10	
1451-1540		90
1541-1548	8	
1551-1688		138
1690, 1692		2
1689, 1691, 1693	3	
1694-1697		4
1701-1800		100
1801-1828		28
1830-1863		34
1864-1870	7	
1901-1940		40
1941-2000	60	
Totals	134	828

APPENDIX 4.4. Bands used on Coats Island in 1986

Band #	Date	Adults	Chicks	Locality	Band
02001 to 02004	24 July	4		Beside LFG Blind	AJG
2005 to 2017	25 July	13		Near N. Blind	DGN
2018 to 2033	26 July	15		'Q'	DGN
2034 to 2045	27 July		12	Weight plots	AJG
2046 to 2050	27 July	5		?	AJG/DG
2051 to 2072	25 July		22	Weight plots	AJG
2073 to 2100	27 July		28	Weight plots	AJG
2101 to 2106	27 July	6		In front of LFG Blind	DGN
2107 to 2140	28 July	34		-119 Q, 120-Nr. LFG Blind	AJG
2141 to 2149	30 July		9	Weight plots	AJG
2150	31 July		1	Weight plots	AJG
2151 destroyed					
2152 to 2170	30 July	19		Just N. of Plot 'R'	JBG
2171 to 2180	3 Aug.		10	Below Fox Gully	AJG
2181 to 2200	31 July		20	Below Fox Gully	AJG
2201 to 2235	30 July	35		Upper part of plot 'H'	DGN
2236 to 2238	31 July	3		Below plot 'H'	DGN
2239 to 2250	1 Aug.	12		Between 'Q' and N. Blind	DGN
2251 to 2300	31 July		50	Below plot 'H'	DGN
2401 to 2450	31 July		150	Below N. Blind	AJG
2451 to 2455	31 July	5		Below N. Blind	AJG
2456 to 2460	1 Aug.	5		In front of LFG Blind	AJG
2461 to 2467	31 July		7	Below N. Blind	AJG
2468 to 2470	2 Aug.		3	Weight plots	AJG
2471 to 2490	1 Aug.	20		In front of LFG Blind	JBG
2491 to 2500	3 Aug.		10	Below Fox Gully	AJG
2501 to 2508	31 July	8		Below plot 'S'	JBG
2509 to 2514	3 Aug.	6		Below plot 'S'	JBG
2515 to 2517	4 Aug.	3		Just S. of Plot 'G'	JBG
2518 to 2537	6 Aug.	20		Plot 'D'	JBG
2551 to 2558	31 July		8	Below Plot 'S'	JBG
2559 lost					
2560 to 2642	31 July		83	Below Plot 'S'	JBG
2643 lost					
2644 to 2645	31 July		2	Below Plot 'S'	JBG
2646 to 2711	3 Aug.		66	Below Plot 'S'	JBG
2712 lost					
2713 to 2800	3 Aug.		88	Below Plot 'S'	JBG
2801 to 2975	4 Aug.		175	Just S. of Plot 'G'	JBG
2976 destroyed					
2977 to 3000	4 Aug.		24	Just S. of Plot 'G'	JBG
3001 to 3040	31 July		40	Below Plot 'R'	DD
3041 to 3044	31 July	4		Below Plot 'R'	DD
3045 to 3050	3 Aug.	6		Below Plot 'R'	DD
3051 to 3085	3 Aug.		35	Below Plot 'R'	DD
3086 to 3120	3 Aug.		35	Below Plot 'R'	DD
3121 to 3130	3 Aug.	10		Below Plot 'R'	DD

APPENDIX 4.4 Bands used on Coats Island in 1986 (Cont'd.)

Band #	Date	Adults	Chicks	Locality	Bander
3131 to 3262	3 Aug.		132	Below Plot 'R'	DD
3263 to 3264	4 Aug.		2	N. end of colony	DD
3265 to 3268	4 Aug.	4		N. end of colony	DD
3269 to 3404	4 Aug.		136	N. end of colony	DD
3405 to 3500	4 Aug.		96	Below Plot 'R'	DD
3501 to 3635	31 July		135	Below Plot 'G'	DGN
3636 to 3650	1 Aug.	15		Between 'Q' and N. Blind	DGN
3651 to 3659	2 Aug.	9		Below Plot 'J'	DD
3660 to 3680	3 Aug.		21	Below Plot 'H'	DGN
3681 to 3690	12 Aug.	10		Below Plot 'J'	DD
3691 to 3721	3 Aug.		31	Below Plot 'H'	DGN
3722 to 3723	3 Aug.	2		Below Plot 'H'	DGN
3724 to 3754	3 Aug.		31	Below Plot 'H'	DGN
3755	3 Aug.	1		Below Plot 'H'	DGN
3756 to 3838	3 Aug.		83	Below Plot 'H'	DGN
3839 to 3895	4 Aug.		57	Below Plot 'H'	DGN
3896 to 3898	4 Aug.	3		Below Plot 'G'	DGN
3899 to 3912	4 Aug.		14	Below Plot 'G'	DGN
3913	4 Aug.	1		Below Plot 'G'	DGN
3914 to 3956			43	Below Plot 'G'	DGN
3957 lost					
3958 to 400	4 Aug.		43	Below Plot 'G'	DGN
4001 to 4182	3 Aug.		182	Below Fox Gully	AJG
4183 to 4450	4 Aug.		268	Plot 'E' and below	AJG
4451	5 Aug.		1	Plot 'S'	AJG
4501 to 4571	4 Aug.		71	Below Plot 'G'	DGN
4601 to 4613	4 Aug.		13	Just S. of Plot 'G'	JBG
TOTALS		278	2237		

<u>Numbers used</u>	<u>Total</u>	<u>Chicks found predated on colony</u>
02001 to 02537	536	02035
02551 to 04451	1896	02034
04501 to 04571	71	03404
04601 to 04613	<u>13</u>	
	2516	

APPENDIX 4.5. Bands used on Coats Island in 1987

Band #	Date	Adults	Chicks	Locality	Band
996-					
05001-05034	5 Aug.		34	Below R & S	
05035-05041	8 Aug.	7		South of S	
05042	7 Aug.	1		Above Q	
05043-05046	12-13 Aug.	4		LFG	
05047-05049	13 Aug.	3		Near J	
05050	14 Aug.		1		
05051-05100	9 Aug.		50	Q and Below	
05101-05114	5 Aug.		14	Below R & S	
05115-05300	7 Aug.		186	Below Gull Ledge	
05301-05442	5 Aug.		142	South of N. Bl	
05443-05500	7 Aug.		58	South of N. Bl	
05501-05700	6 Aug.		200	Plot G and Below	
05701-05900	7 Aug.		200	South of N. Bl	
06901-05950	7 Aug.		50	Below Gull Ledge	
05951-0600	8 Aug.		50	South of Gull L.	
06001-06002	26 July	2		LFG	
06003-06004	28 July	2		LFG	
06005-06007	2 Aug.	3		N.BL. / Plot J	
06008-06010	9 Aug.	3		Near S	
06032-06033	10 Aug.	2		Above G	
06034-	12 Aug.		1	Plot S	
06035-06038	14 Aug.		4	Plot D	
06051	30 July	1		North of N.BL	
06052	31 July	1		North of N.BL	
06053-06056	1 Aug.	4		Q / Near N.BL	
06057	2 Aug.	1		Near J	
06058	3 Aug.	1		Plot Q	
06059-06060	4 Aug.	2		Plot Q	
06061-06096	6 Aug.		36	Below G	
06097-06100	6 Aug.	4		Below G	
06101-06106	28 July	6		Plot D (Top)	
06107-06111	30 July	5		Plots R and S	
06112-06122	2 Aug.	11		Near S	
06123-06130	3 Aug.	8		Near N. BL	
06131-06140			10		
06141-06142	3 Aug.	2		Below N. BL	
06146-06150	8 Aug.		5	South of N.BL	
06151-06163	30 July		13	Plots R and S	
06161	2 Aug.		1	Plots S	
06165-06171	30 July		7	Plots S	
06172	2 Aug.		1	Plots S	
06173-06177	30 July		5	Plots S	
06178-06180	3 Aug.		3	Below N.BL	
06181-06184	2 Aug.		4	Plot R	
06185-06187	5 Aug.		3	Plot R	
06188-06293	3 Aug.		106	Below N.BL.	

Appendix 4.5 (cont.) Bands used on Coats Island in 1987

Band #	Date	Adults	Chicks	Locality	Bander
06294-06300	7 Aug.		7	Below Gull Ledge	RE
06301-06308	4 Aug.	8		Below D and E	KB/DC
06309-06310	5 Aug.	2		Below R	
06311-06320	8 Aug.		10	South of N.BL	RE
06321-06327	8 Aug.	7		South of N.BL	RE
06328-06350	8 Aug.		33	South of N.BL	RE
06351-06491	3 Aug.		141	South of S	JG
06492-06500	5 Aug.		9	South of N.BL	JG
06501-06603	7 Aug.		103	South of N.BL	DC
06604	7 Aug.	1		Orange Webbing	
06605-06700	8 Aug.		96	South of N.BL	RE
06701-06800	8 Aug.		100	KLM Area	DN
06801-06958	8 Aug.		158	South of N.BL	JG
06959-07000	9 Aug.		42	Below Q	DN
07001-07007	8 Aug.		7	Below Q	DN
07088	8 Aug.	1		Near LFG BL	
07009	8 Aug.		1	Below Q	DN
07010	8 Aug.	1		North of LFG BL	
07011-07036	8 Aug.		26	Below Q	DN
07037-07050	13 Aug.	14		N.BL/Orange Web.	DN
07051-07223	8 Aug.		173	KLM Area	DN
07224-07240	9 Aug.		17	Q Area	DN
07241-07250	9 Aug.	10		Plot D	
07251-07270	13 Aug.	20		Above G	DN/DC
07271-07279	14 Aug.		9	Plot D (Top)	DN
07280-07281	15 Aug.	2		J Count PT	JG
07282-07294	16 Aug.		13	Below J Count PT	JG
07295-07297	16 Aug.	3		Near S	
07301-07302	15 Aug.	2		Above G/ N.BL	DN
07303-07311	16 Aug.	9		Blue Tie/Below J	DN/DC
07351-07399	15 Aug.		49	Just North of S	JG
07400-07401	15 Aug.	2		Just North of S	JG
07402-07404	15 Aug.		3	Just North of S	JG
07405	15 Aug.	1		Just North of S	JG
07406-07420	15 Aug.		15	Just North of S	JG
07421-07422	15 Aug.	2		Just North of S	JG
07423-07425	15 Aug.		3	Just North of S	JG
07426	15 Aug.	1		Just North of S	JG
07427-07441	15 Aug.		15	Just North of S	JG
07442	15 Aug.	1		Just North of S	JG
07443-07478			36	Just North of S	JG
07479	15 Aug.	1		Just North of S	JG
07480	16 Aug.		21	Below J Count PT	JG
Total		161	2250		

APPENDIX 4.6. Bands used on Coats Island in 1988

Band #	Date	Adults	Chicks	Locality	Band
08001-08082	-	82		Various	
08083-08093	24 July		11	Plots R and S	
08094	band destroyed				
08095-08115	27 July		21	Plots R and S	
08116-08117		2		Lower Fox Gully	
08118-08133	30 July		16	Plots R and S	
08134-08140	3 Aug.		7	Plots R and S	
08141-08150	6 Aug.		10	Below R	
08151-08200	-	50		Various	
08201-08438	1 Aug.		238	Between Q2 and Q3	
08439-08500	2 Aug.		62	Plots E and F	
08501-08800	1 Aug.		300	Just east of Q2	
08801-09100	1 Aug.		300	Just east of Q1	
09101-09400	2 Aug.		300	Between Q3 and Q4	
09401-09434	2 Aug.		34	Plots E and F	
09435-09469	2 Aug.		35	Top Q; and banding area	
09470-09530	2 Aug.		61	Q1 to mid-section	
09531-09666	2 Aug.		136	Top of cliff below G	
09667-09700	6 Aug.		34	Below R	
09701-09741	2 Aug.		41	Q5	
09742	band lost				
09743-09900	2 Aug.		158	Q5	
09901-10000	3 Aug.		100	Lower part below plot G	
10001-10261	3 Aug.		261	N2 and below	
10262-10263	6 Aug.		2	N1B	
10264-10269	11 Aug.		6	Below N6	
10270-10277	15 Aug.	8		Z	
10278-10290	used on captive chicks				
10291	16 Aug.		1	?	
10292-10293	16 Aug.	2		Z	
10301-10600	3 Aug.		300	Below R	
10601-10750	3 Aug.		150	Lower part below plot G	
10751-10768	6 Aug.		18	Below R	
10769	band destroyed				
10770-10807	6 Aug.		38	Below R	
10851-10888	6 Aug.		38	Below S	
10889-10896	7 Aug.		8	Below S	
10897-10900	used on captive chicks				
10951-10952	7 Aug.	2		Z	
10953-10956	8 Aug.	4		Y	
10957-10961	9 Aug.	5		Various	
10962-10970	10 Aug.	9		Various	
10971-10978	11 Aug.	8		Various	
10979-10989	13 Aug.	11		Various	
10990-11000	14 Aug.	11		Various	
Totals		197	2686		

APPENDIX 4.7 BANDS USED IN 1989

NUMBERS	DATE	LOCALITY	ADULTS	CHICKS
04461-04473	29 July	LFG	13	
04474-04476	30 July	Z	3	
04477-04481	31 July	Z	5	
04482-04484	2 Aug.	Top of E	3	
04485-04491	5 Aug.	D	4	
04492	6 Aug.	N7	1	
04493-04500	6 Aug.	N End	8	
07501-07522	1 Aug.	R	22	
07523-07549		S		27
07550-07554	4 Aug.	R		5
07555-07565		S		11
07566-07610	15 Aug.	Below J, to the N end		45
07651-07711	12 Aug.	Below G11 and G13		61
07713-07745				33
07747-07840				94
07841-07850	15 Aug.	Below J, to the N end		10
07851-07890	12 Aug.	Below G11 and G13		40
07891-07893		Plot G		3
07894-07900	15 Aug.	Below J, to N end		7
07901-08000	12 Aug.	Below R, to the NE		100
50001-50128	4 Aug.	Q and below		128
50129-50190	7 Aug.	E		62
50191-50200		F		10
50201-50250		Below F		50
50251-50300		D		50
50301-50400	4 Aug.	Just South of N-G		100
50401-50500	7 Aug.	Just South of N-G (lower)		100
50501-50586	10 Aug.	N1, N6, G12, G1 and below		86
50587-50600	12 Aug.	S1, S2 and below		14
50601-50709	7 Aug.	Below R		109
50710-50750	10 Aug.	Just below N blind		41
50751-50800	12 Aug.	Below R, towards NE		50
50801-50980	10 Aug.	Below Q, bottom half of cliff		180
50981-51000	12 Aug.	Below S, to the South		20
51001-51010	7 Aug.	Below Q		10
51011-51024	10 Aug.	Below Q, bottom half of cliff		14
51025-51030	7 Aug.	Below Q		6
51031-51040	10 Aug.	Below Q, bottom half of cliff		10
51041-51100	7 Aug.	Below Q		60
51101-51130	8 Aug.	Q		30
51131-51250	10 Aug.	Above G7 and behind N1		120
51251-51300	7 Aug.	D		50
51301-51350	12 Aug.	S1, S2 and below		50
51401-51482	10 Aug.	Just below N blind		82
51483-51500	12 Aug.	Below R, towards NE		18
51501-51511	10 Aug.	Above G7 and behind N1		11
51512-51524		G7, near far end		13

APPENDIX 4.7 Bands used in 1989 (continued)

NUMBERS	DATE	LOCALITY	ADULTS	CHICKS
51525-51575		G9 and G10		51
51576-51605		G11		30
51606-51640		G13		35
51641-51700		Below G11 and G13		60
51701-51800	12 Aug.	S1, S2 and below		100
51801-51970		Below S, to the South		170
51971-51980	15 Aug.	Below J, to the N end		10
51981-51990	12 Aug.	Below S, to the South		10
51991-52000	15 Aug.	Below J, to the N end		10
51351-51356	9 Aug.	D	6	
51357	10 Aug.	UFG	1	
51358	12 Aug.	Z	1	
51359-51364	13 Aug.	D	6	
51365-51366	13 Aug.	N End	2	
51367-51370	15 Aug.	D	4	
51371-51378	17 Aug.	D	8	
51379-51393	17 Aug.	S	15	
Totals			102	2386

APPENDIX 4.8 Bands used in 1990

NUMBERS	DATE	LOCALITY	ADULTS	CHICKS
52501-52550	Various	Various	50	
52551-52560	31 July	Growth plot T		10
52561-52568		Z		8
52569-52577	2 Aug.	Q		9
52578-52585	4 Aug.	Z		8
52586-52600				
52601-52610	6 Aug.	Top of N, below N4		10
52611-52650	5 Aug.	Top of Q		40
52651-52684	6 Aug.	Top of N (below N4/N7)		34
52685-52690	7 Aug.	Below R		6
52691-52700	6 Aug.	Top of N (below N4/N7)		10
52701-52750	7 Aug.	Below R		50
52751-52843	5 Aug.	Top of Q		93
52844-53000	6 Aug.	Below plot Q		157
53001-53054	5 Aug.	Plot D		54
53055-53138	6 Aug.	Below plot G, behind N1		84
53139-53154		Far end of G7		16
53155-53160		Near end of G7		6
53161-53199		G9 (plot H)		39
53200-53238		G13		39
53239-53250		G15		12
53251-53300		Below plot Q		50
53301-53350	7 Aug.	Plots E and F		50
53351-53370	6 Aug.	Plot Q		20
53371-53496		Below plot Q		126
53497-53500	7 Aug.	S7		4
53501-53505	6 Aug.	G15		5
53506-53600		Below G15 (588-600 bo BK band)		95
53601-53660	7 Aug.	E and F		60
53661-53662	11 Aug.	Growth plot T		2
53663-53664		Q		2
53665		Z		1
53666-53668	17 Aug.	Q		3
53669		Z		1
53670-53680	23 Aug.	S4, S10, S16		11
53681-53700				
53701-53703	9 Aug.	R	3	
53704-53708	13 Aug.	N7	5	
53709-53711	16 Aug.	N1B	3	
53712	17 Aug.	T1, site 2	1	
53713-53714		Plot Q	2	
53715-53717	19 Aug.	Growth plot Q	3	
53718-53732		Z (blood samples)	15	
53733-52735	20 Aug.	Below T	3	
53736	22 Aug.	D, site 26	1	
53737				
53738	22 Aug.	D, site 60	1	
53739	destroyed			

APPENDIX 4.8 BANDS USED IN 1990 (Continued)

NUMBERS	DATE	LOCALITY	ADULTS	CHICKS
53740	22 Aug.	D, site 17	1	
53741	destroyed			
53742-53750				
53751-53761	7 Aug.	S7		11
53762-53776		Below S10		15
53777		S16		1
53778-53950		Below S		173
53951-53952		Growth plot T		2
53953-53954				2
53955-53956				2
53957-53965	8 Aug.	N7		9
53966-53996		Below N7		31
53997-34000				
TOTALS			88	1361

Bands picked up from gull nests in 1989 and 1990

785-42857, 785-46058
 996-07515, 07522, 07550, 07557, 07571, 07712, 07746, 07900, 07913
 07971
 996-09414, 09515, 10421
 996-50380, 50392, 50397, 50400, 50433, 50436, 50617, 50629, 50645
 50846, 50858, 50990
 996-51221, 51489, 51558, 51606, 51670, 51887, 53138

**APPENDIX 5.1 Daily plot counts, made between 1700-1830
hrs, 1987**

DATE	A	B	C	D	E	F	G	H	I	J	TOTAL
July 25	272	251	107	184	175	122	-	-	-	-	-
July 26	241	225	104	160	145	108	98	106	211	117	1515
July 27	160	254	97	94	122	90	77	99	184	101	1278
July 28	196	230	105	124	144	95	101	106	216	121	1438
July 29	248	264	98	160	128	112	102	111	226	122	1571
July 30	258	276	97	165	170	117	104	110	217	124	1638
July 31	301	272	118	151	159	105	110	112	214	108	1650
Aug. 1	278	214	117	195	184	111	98	113	259	144	1713
Aug. 2	258	256	113	176	159	119	108	113	234	112	1648
Aug. 3	288	251	111	178	189	122	108	109	251	136	1743
Aug. 4	298	293	111	184	182	126	101	105	230	113	1743
Aug. 5	282	273	113	139	145	112	110	98	247	131	1650
Aug. 6	269	259	110	156	133	102	101	109	197	148	1584
Aug. 7	258	275	108	162	165	124	111	101	228	127	1659
Aug. 8	264	257	101	171	152	112	107	107	180	137	1588
Aug. 9	227	223	96	149	137	104	100	90	205	122	1453
Aug. 10	268	252	103	159	158	114	103	96	228	127	1608
Aug. 11	280	242	100	160	163	109	100	110	207	132	1603
Aug. 12	-	[weather too bad]					71	77	-	-	-
Aug. 13	320	276	118	179	160	116	112	110	232	128	1751
Aug. 14	322	277	104	191	174	119	109	113	232	131	1772
Aug. 15	314	278	113	170	153	122	110	100	216	126	1702
Aug. 16	238	231	104	163	143	122	94	103	235	133	1566
Aug. 17	251	220	103	157	145	117	100	107	218	122	1540

Appendix 5.2 Daily evening counts at plots A-J, made between
1700-1830 hrs, 1988.

DATE	A	B	C	D	E	F	G	H	I	J	TOTAL
June 13	118	146	74	91	82	65	62	73	125	33	869
June 14	183	188	68	142	117	88	84	91	194	140	1295
June 15	92	136	57	82	77	64	54	54	123	21	760
June 16	52	41	26	32	16	7	30	20	35	25	284
June 17	224	260	102	186	158	114	102	105	230	130	1611
June 18	159	203	115	134	104	79	86	84	180	108	1252
June 19	161	200	96	165	102	86	92	101	158	90	1251
June 20	216	210	90	146	132	88	98	98	182	102	1362
June 21	208	233	98	156	112	100	90	103	184	124	1408
June 22	212	196	98	177	119	99	102	108	186	122	1419
June 23	174	183	82	165	123	100	102	100	226	103	1358
June 24	137	178	76	126	90	80	70	86	158	56	1057
June 25	224	224	120	183	112	106	112	110	196	130	1517
June 26	267	248	113	191	157	121	109	132	246	136	1720
June 27	200	213	117	156	122	97	95	110	214	130	1454
June 28	236	242	110	184	147	115	105	118	218	147	1622
June 29	245	257	101	177	136	118	105	112	257	154	1662
June 30	227	220	124	162	118	106	97	101	198	117	1470
July 1	238	258	110	205	155	112	117	121	253	154	1723
July 2	237	258	103	171	141	114	101	113	238	141	1617
July 3	226	228	124	159	138	104	90	108	236	152	1565
July 4	221	245	119	162	132	102	99	108	214	153	1555
July 5	215	250	102	166	134	114	100	118	202	109	1510
July 6	258	253	121	185	170	122	105	119	217	136	1686
July 7	244	262	121	176	133	112	113	124	235	152	1672
July 8	300	275	114	187	140	114	106	115	234	149	1734
July 9	286	248	131	204	160	112	111	101	233	156	1742
July 10	251	228	105	164	124	97	108	113	231	162	1583
July 11	268	237	128	173	142	110	102	102	236	150	1648
July 12	262	238	96	162	124	87	99	104	200	124	1496
July 13	279	231	101	160	139	92	110	104	200	112	1528
July 14	236	265	114	148	118	94	88	101	228	123	1515
July 15	266	248	96	168	130	98	108	102	226	152	1594
July 16	272	259	100	164	114	104	106	100	214	135	1568
July 17	233	242	116	172	116	104	102	106	220	140	1551
July 18	230	249	93	152	110	95	94	102	242	137	1504
July 19	203	249	122	140	112	95	88	97	210	116	1432
July 20	287	250	98	183	130	110	104	99	220	122	1603
July 21	252	249	91	175	123	104	88	98	197	130	1507
July 22	255	235	130	166	120	100	92	95	214	127	1534
July 23	274	241	108	165	127	110	112	108	237	151	1633
July 24	190	248	103	171	112	94	112	106	201	131	1468
July 25	284	304	120	205	180	131	122	116	239	146	1847
July 26	290	284	144	185	111	112	113	110	245	134	1728
July 27	244	216	98	130	86	72	94	93	158	92	1283
July 28	331	264	110	214	169	126	108	102	226	132	1782
July 29	261	248	96	180	151	110	112	100	236	147	1641

DATE	A	B	C	D	E	F	G	H	I	J	TOTAL
July 30	289	262	134	198	178	118	116	106	220	141	1762
July 31	237	246	100	191	145	106	106	106	232	132	1601
Aug. 1	278	266	120	196	138	90	111	100	209	137	1645
Aug. 2	303	262	102	193	136	122	111	109	241	155	1734
Aug. 3	309	273	122	184	140	108	100	112	216	125	1689
Aug. 4	282	262	110	182	150	125	113	114	226	138	1702
Aug. 5	225	198	119	122	78	62	97	100	191	112	1304
Aug. 6	256	243	114	168	112	90	101	98	184	108	1474
Aug. 7	311	267	113	197	157	127	120	118	266	156	1832
Aug. 8	318	275	128	189	146	116	112	110	220	132	1746
Aug. 9	260	257	103	197	164	116	122	112	221	124	1676
Aug. 10	276	250	100	190	158	115	110	111	206	148	1664
Aug. 11	304	276	122	222	187	114	131	113	238	132	1839
Aug. 12	292	249	103	182	180	114	109	107	245	143	1724
Aug. 13	300	258	103	186	164	109	114	102	249	132	1717
Aug. 14	326	266	115	180	127	101	128	106	242	143	1734
Aug. 15	252	230	104	184	138	108	132	108	235	134	1625
Aug. 16	290	233	112	199	128	111	107	98	215	130	1623

APPENDIX 5.3 DAILY PLOT COUNTS, 1989

DATE	PLOT										TOTAL
	A	B	C	D	E	F	G	H	I	J	
29 Jul	342	313	123	195	174	122	-	130	272	135	-
30 Jul	316	258	129	175	131	108	-	145	248	125	-
31 Jul	340	275	112	214	177	101	117	137	226	143	1942
1 Aug	338	270	121	197	162	102	137	143	224	155	1849
2 Aug	316	288	112	202	173	108	145	141	214	131	1830
3 Aug	308	264	113	208	149	125	142	134	220	136	1799
4 Aug	319	243	118	214	180	120	138	148	208	123	1811
5 Aug	356	256	124	198	155	108	139	142	198	136	1812
6 Aug	321	256	110	189	167	105	147	141	220	132	1788
7 Aug	323	280	105	204	152	111	134	131	190	137	1767
8 Aug	333	246	108	196	171	119	145	148	193	147	1806
9 Aug	341	228	110	173	153	101	135	142	207	126	1716
10 Aug	335	256	114	194	157	128	129	139	240	138	1830
11 Aug	328	220	100	206	158	100	133	147	206	135	1733
12 Aug	314	254	114	196	143	100	141	144	200	135	1741
13 Aug	292	256	104	196	155	100	130	137	188	140	1698
14 Aug	310	250	101	169	131	86	131	141	173	130	1622
15 Aug	320	247	112	206	160	110	129	129	178	130	1721
16 Aug	296	212	97	161	138	86	121	124	178	130	1543
17 Aug	288	242	111	202	140	114	128	128	190	130	1673

APPENDIX 5.4 DAILY PLOT COUNTS, 1990

DATE	PLOT												TOTAL (A-J)
	A	B	C	D	E	F	G	H	I	J	N	P	
May 25													
May 26													
May 27													
May 28													
May 29	306	290	144	216	148	132	119	127	-	-	-	-	1798 ¹
May 30													
May 31													
Jun 1													
Jun 2													
Jun 3	334	283	136	225	145	109	119	115	219	93	-	-	1778
Jun 4													
Jun 5													
Jun 6													
Jun 7													
Jun 8	352	285	135	242	148	122	119	112	218	135	-	-	1868
Jun 9													
Jun 10													
Jun 11	204	156	93	142	83	71	57	60	112	18	-	-	996
Jun 12	209	171	105	162	102	88	90	111	203	120	-	-	1361
Jun 13													
Jun 14													
Jun 15													
Jun 16	291	185	132	264	153	122	121	133	188	143	-	-	1732
Jun 17	218	231	84	177	111	84	104	83	146	135	-	-	1373
Jun 18	71	92	43	67	40	35	44	58	70	23	-	-	543
Jun 19	208	169	101	137	96	73	63	70	123	72	-	-	1112
Jun 20	211	204	95	174	87	74	72	85	199	124	-	-	1325
Jun 21	150	175	71	125	75	57	57	64	146	90	-	-	1010
Jun 22	217	185	113	142	95	78	76	73	185	101	-	-	1265
Jun 23	134	108	77	101	67	42	70	67	102	57	-	-	825
Jun 24	159	157	84	149	89	70	-	-	-	-	-	-	-
Jun 25	247	227	114	178	118	95	82	90	191	120	-	-	1355
Jun 26	157	142	84	111	65	59	59	68	129	65	-	-	939
Jun 27	267	228	113	170	127	91	98	94	196	130	-	-	1514
Jun 28	225	187	120	208	125	93	99	96	192	122	-	-	1467
Jun 29	187	200	95	166	89	78	79	90	157	82	-	-	1223
Jun 30	212	201	84	143	89	75	77	89	164	87	-	-	1221
Jul 1	285	226	111	191	134	92	100	98	198	124	-	-	1559
Jul 2	137	139	66	95	60	62	59	75	118	62	-	-	873
Jul 3	-	-	-	-	-	-	-	-	-	-	-	-	-
Jul 4	271	235	121	232	140	113	108	108	120	131	-	-	1579
Jul 5	222	176	78	155	103	76	80	96	163	109	-	-	1258
Jul 6	284	211	101	180	114	91	93	92	181	103	-	-	1450
Jul 7	300	256	116	201	132	97	94	89	199	108	-	-	1592

DATE	PLOT												TOTAL (A-J)
	A	B	C	D	E	F	G	H	I	J	N	P	
Jul 8	253	197	193	156	109	79	74	85	188	114	-	-	144
Jul 9	288	223	115	199	115	85	93	101	201	113	-	-	153
Jul 10	284	237	120	196	129	83	96	103	214	130	-	-	159
Jul 11	225	209	96	166	114	92	80	96	194	111	-	-	138
Jul 12	254	173	98	166	115	74	81	96	190	101	-	-	134
Jul 13	268	217	103	200	119	93	100	89	207	93	-	-	148
Jul 14	204	189	109	184	120	85	88	105	190	109	-	-	138
Jul 15	230	216	103	173	120	95	91	99	179	109	-	-	140
Jul 16	306	204	104	171	112	79	85	93	179	103	-	-	152
Jul 17	265	176	92	181	112	74	88	98	191	120	-	-	139
Jul 18	-	-	[winds >100 km/h, rain]					-	-	-	-	-	-
Jul 19	262	201	110	198	119	86	93	88	178	93	-	-	142
Jul 20	220	205	100	162	118	95	81	93	196	111	-	-	138
Jul 21	278	205	99	187	113	87	94	105	199	110	-	-	147
Jul 22	291	241	107	174	142	88	85	101	194	117	-	-	154
Jul 23	211	182	80	144	95	72	76	87	179	105	-	-	123
Jul 24	244	218	101	134	98	78	88	76	200	115	-	-	135
Jul 25	321	231	99	195	167	100	98	93	210	116	-	-	163
Jul 26	-	-	[winds >100 km/h, rain]					-	-	-	-	-	-
Jul 27	360	229	107	202	153	101	109	105	222	129	-	-	171
Jul 28	110	126	86	126	59	60	75	96	-[wind gusting >90 km/h]			-	118
Jul 29	318	217	110	161	117	74	86	104	-	-	[fog]		-
Jul 30	247	214	99	214	155	103	105	86	191	126	-	-	154
Jul 31	-	-	-	-	-	-	-	-	-	-	-	-	-
Aug 1	276	228	121	214	178	102	91	102	186	107	121	140	160
Aug 2	291	227	106	170	127	106	81	101	194	108	115	130	151
Aug 3	324	233	124	199	181	101	88	118	203	126	118	142	169
Aug 4	254	252	109	190	173	96	98	102	200	123	137	162	159
Aug 5	289	259	113	172	144	85	92	99	193	111	129	119	155
Aug 6	266	235	115	204	157	97	100	96	199	128	123	127	159
Aug 7	317	228	114	209	164	101	93	111	205	132	138	134	157
Aug 8	356	224	107	224	216	110	99	101	202	122	130	158	175
Aug 9	320	253	123	234	184	104	98	100	209	152	128	153	177
Aug 10	255	241	104	189	172	100	103	86	192	125	122	154	157
Aug 11	279	229	109	189	168	99	106	100	185	130	124	167	159
Aug 12	270	232	116	219	163	98	98	88	186	123	123	159	159
Aug 13	314	230	121	209	157	91	107	97	192	133	127	186	165
Aug 14	70	98	67	78	58	49	54	52	83	54	61	75	76
Aug 15	238	[176]	100	173	108	72	92	83	164	106	104	141	[131]
Aug 16	283	218	102	201	146	102	103	94	194	120	125	155	156
Aug 17	293	218	103	193	141	84	100	100	198	123	123	157	155
Aug 18	261	222	108	187	151	101	93	79	168	115	116	150	148
Aug 19	260	218	116	184	127	95	87	83	174	126	111	144	147

DATE	PLOT												TOTAL (A-J)
	A	B	C	D	E	F	G	H	I	J	N	P	
Aug 20	284	210	98	190	142	98	91	82	181	116	109	155	1492
Aug 21	249	222	100	208	145	100	85	91	182	118	110	147	1500
Aug 22	209	194	92	124	99	85	82	83	176	113	105	140	1257
Aug 23	213	165	88	153	109	78	84	61	146	114	-	-	1211

Figures in square brackets are interpolated

APPENDIX 6.1 Food items delivered to chicks in 1987.

TAXON	COLLECTED	MASS			NUMB. %	WT. %
		MEAN	SD	N		
FISHES						
<u>Boreogadus</u>	32	15.3	8.9	32	58.2	66.7
<u>Mallotus</u>	1	9.7	-	1	1.8	1.3
<u>Ammodytes</u>	3	3.7	1.0	3	5.4	1.5
<u>Gymnelus</u>	1	7.2	-	1	1.8	1.0
<u>Stichaeus</u>	2	11.5	2.5	2	3.6	3.1
<u>Eumesogrammus</u>	2	15.8	3.9	2	3.6	4.3
<u>Leptoclinus</u>	3	3.7	1.1	3	5.4	1.5
<u>Triglops</u>	11	13.7	6.7	11	20.0	20.5

APPENDIX 6.2 Food items delivered to chicks in 1988.

TAXON	COLLECTED	SEEN	TOTAL	MASS			NUMB. %	WT. %
				MEAN	SD	N		
FISHES								
<u>Boreogadus</u>	60	33	93	14.4	8.8	39	62.8	70.0
<u>Mallotus</u>	7	6	13	6.8	3.2	6	8.8	4.6
<u>Ammodytes</u>	2	0	2	4.2	0.1	2	1.4	0.4
<u>Gymnelus</u>	1	1	2	6.3	-	1	1.4	0.7
<u>Stichaeus</u>	1	1	2	12.9	-	1	1.4	1.3
<u>Eumesogrammus</u>	3	0	3	13.9	6.9	3	2.0	2.2
<u>Leptoclinus</u>	4	4	8	4.9	0.5	4	5.4	2.1
<u>Eumicrotremus</u>	1	0	1	5.0	-	1	0.7	0.3
<u>Triglops</u>	12	9	21	16.0	6.9	12	14.2	17.5
<u>Gymnocanthus</u>	2	0	2	9.3	0.7	2	1.3	1.0
INVERTEBRATES								
Decapod spp.	1	0	1	8.1	-	1	0.7	0.4

APPENDIX 6.3 Food items delivered to chicks in 1989.

TAXON	COLLECTED	SEEN	TOTAL	MASS		N	NUMB. %	WT. %
				MEAN	SD			
FISHES								
<u>Boreogadus</u>	12	79	91	19.8	9.4	10	46.0	75.7
<u>Mallotus</u>	7	32	39	3.8	2.5	7	19.7	6.2
<u>Ammodytes</u>	1	6	7	9.4 ¹	-	1	3.5	0.8
<u>Gymnelus</u>	6	11	17	8.1	3.5	6	8.6	5.8
<u>Stichaeus</u>	1	0	1	20.6	-	1	0.5	0.9
<u>Eumesogrammus</u>	1	2	3	19.9	-	1	1.5	2.5
<u>Leptoclinus</u>	2	5	7	4.3	0.6	2	3.5	1.3
<u>Triglops</u>	4	16	20	9.1	3.1	4	10.1	7.6
<u>Gymnocanthus</u>	1	0 ²	1	11.4	-	1	0.5	0.5
INVERTEBRATES								
<u>Nereis</u>	1	0	1	1.3	-	1	0.5	<0.1
<u>Gonatus</u>	0	6	6	(2) ³	-	-	3.0	0.5
<u>Parathemisto</u>	2	3	5	0.8	-	1	2.5	0.2

¹ This specimen was much larger than those seen delivered, hence a value of 3g was used in estimating % by weight

² Any Gymnocanthus seen delivered would probably not have been distinguished from Triglops, hence their presence may have been underestimated

³ Mean weight of 2 g estimated by eye

N.B. A partially dried specimen of the blenny Pholis fasciatus measuring about 300 mm in length was also picked up from the ledges. It must have been delivered to a chick, but was presumably much too large for it to handle. This is the longest fish recorded delivered to a Thick-billed Murre chick.

APPENDIX 6.4 Food items delivered to chicks in 1990.

TAXON	COLLECTED	SEEN	TOTAL	MASS			NUMB. %	WT. %
				MEAN	SD	N		
FISHES								
<u>Boreogadus</u>	10	90	100	18.5	10.4	10	46.9	73.2
<u>Mallotus</u>	1	28	29	5.5	-	1	15.1	6.3
<u>Ammodytes</u>	0	3	3	[5.3] ¹	-	-	1.6	0.6
<u>Gymnelus</u>	2	11	13	12.1	9.1	2	6.8	6.2
<u>Stichaeus</u>	0	0	0	-	-	-	-	-
<u>Eumesogrammus</u>	0	2	2	[16.5]	-	-	1.0	1.3
<u>Leptoclinus</u>	4	9	13	3.7	0.8	4	6.2	1.9
<u>Triglops</u>	1	16	17	11.9	-	1	8.9	8.0
<u>Gymnocanthus</u>	1	0 ²	1	9.8	-	1	0.5	0.4
<u>Eumicrotremus</u>	0	1	1	[6.5]	-	-	0.5	0.3
INVERTEBRATES								
<u>Nereis</u>	0	0	0	-	-	-	-	-
<u>Gonatus</u>	0	1	1	[3.7]	-	-	0.5	0.1
<u>Parathemisto</u>	1	6	7	0.5	-	1	3.6	0.1
"shrimp"	3	3	6	6.2	2.8	3	3.1	1.5

¹ Figures in brackets are the means of previous years

² Any Gymnocanthus seen delivered would probably not have been distinguished from Triglops, hence their presence may have been underestimated

Appendix 7. Wing length in relation to age, used for age determinations (based on measurements made in 1986)

WING LENGTH (mm)	AGE
24-25	1
26-27	2
28	3
29	4
30	5
31	6
32	7
33	8
34-35	9
36-37	10
38-40	11
41-43	12
44-46	13
47-49	14
50-52	15
53-55	16
56-58	17
59-61	18
62-64	19
65-66	20
67-68	21

Appendix 8.1 Summary of chick growth parameters, 1988

BAND NO.	HATCH (1 Jul=1)	MASS (g)			WING LEN (mm)		AGE AT DEPART.
		14DAY	MAX	DEPART.	14DAY	DEPART	
08083	18	209	245	245	52	72	21
08084	23	226	260	260	53	76	20
08085	25	227	233	228	56	74	20
08086	20	216	243	240	53	80	23
08087	23	208	235	235	55	72	20
08088	21	224	234	214	53	83	25
08089	23	226	237	229	58	74	20
08090	23	251	268	232	63	79	20
08091	23	216	227	227	60	74	20
08092	23	203	214	214	61	76	20
08093	20	236	270	270	55	84	23
08095	23	195	240	229	57	90	26
08096	21	212	221	221	60	79	22
08097	23	242	266	266	67	80	20
08098	20	233	244	241	54	79	23
08099	23	269	278	278	62	82	23
08100	20	210	270	270	53	85	26
08101	23	227	267	248	51	77	23
08103	20	188	219	219	53	72	23
08104	20	211	248	248	51	75	23
08105	20	215	252	236	52	78	23
08106	23	252	272	272	61	80	23
08107	23	225	244	244	51	79	23
08108	23	239	266	266	57	79	23
08109	20	194	208	203	51	77	23
08110	20	214	238	222	55	76	23
08111	20	184	234	234	47	73	23
08112	20	231	251	251	58	82	23
08113	20	200	237	237	60	85	23
08114	20	220	232	209	55	79	23
08115	23	209	236	214	55	82	26
08118	24	202	246	234	54	84	25
08121	24	186	228	228	51	74	22
08124	27	226	260	260	54	77	22
08132	23	206	241	241	50	70	20

Appendix 8.2 Summary of chick growth parameters, 1989

BAND NO.	HATCH (1 Jul=1)	MASS (g)			WING LEN (mm)		AGE AT DEPART.
		14DAY	MAX	DEPART.	14DAY	DEPART	
07502	30	196	284		49		
07503	28	184	223	223	52	70	20
07504	28	176	219		55		
07505	26	196	238		41		
07507	28	196	214		46		
07508	28	190	239		50		
07509	26	164	205		46		
07510	27	190	207		45		
07511	30	183	205		56		
07513	26	210	254	254	55	79	22
07514	28	174	217	217	49	62	20
07516	30	227	251		52		
07517	30	216	234		58		
07521	30	203	213		56		
07523	29	228	228		50		
07524	28	255	261	245	59	77	20
07525	26	203	209	186	55	64	19
07527	25	232	279	279	52	77	23
07528	25	253	253	241	58	80	23
07529	25	234	234	230	51	76	23
07530	25	219	252	252	52	73	23
07434	26	183	248		46		
07535	26	253	263	263	58	78	22
07536	26	192	216	216	52	71	22
07537	23	191	233	233	45	64	22
07540	27	251	279		53		
07542	26	194	245	245	47	69	21
07543	26	234	242	225	54	73	21
07546	29	253	271		54		
07547	28	176	185		49		
07549	28	201	217	217	53	66	20
07551	30	169	197		53		
07552	30	193	222		43		
07555*	32	153	182		42		
07560	26	186	256		46		
07564	36	155			52		
07565	36	179			49		

* One parent was a 4-year-old

Appendix 8.3 Summary of chick growth parameters, 1990.

BAND NO.	HATCH (1 Jul=1)	MASS (g)			WING LEN (mm)		AGE AT DEPART.
		14DAY	MAX	DEPART.	14DAY	DEPART	
52551	28	244	253	251	-	-	23
52552	28	235	295	295	-	-	27
52553	30	212	241	241	50	65	20
52554	28	221	241	241	-	76	23
52555	23	205	228	227	50	85	27
52556	27	197	240	240	-	79	23
52557	23	196	239	239	51	81	27
52558	23	193	213	213	51	-	25
52559	26	230	246	246	-	-	22
52560	28	213	222	222	-	77	23
52564	27	236	248	215	-	80	24
52566	30	211	234	234	53	69	24
52567	28	184	191	191	-	73	23
52568	26	237	249	249	-	-	22
52569	29	179	203	203	-	77	25
52571	30	197	212	212	-	68	21
52572	28	196	203	198	-	77	23
52573	30	217	231	231	-	72	21
52574	27	253	264	264	-	86	24
52575	31	202	202	200	53	64	20
52578	31	180	217	217	49	72	23
52579	30	169	211	211	53	76	26
52580	29	243	243	243	-	76	22
52581	29	210	210	203	-	80	22
52582	31	181	192	187	-	73	23
52583	31	206	210	197	-	68	20
52584	32	209	233	233	-	71	22
52585	31	199	204	186	-	74	23
53951	34	217	-	-	50	-	-
53952	36	169	-	-	50	-	-
53953	32	178	206	206	52	61	19
53954	31	208	213	213	50	64	20
53955	33	195	-	-	50	-	-
53956	37	195	-	-	56	-	-
53661	38	153	-	-	46	-	-
53662*	38	162	-	-	50	-	-
53663	37	127	-	-	39	-	-
53665	41	163	-	-	43	-	-
53666	42	179	-	-	50	-	-
53667	42	218	-	-	48	-	-

* One parent was a 6-year-old