BLACK GUILLEMOT INVESTIGATIONS NEAR THE NUVUK ISLANDS, N.W.T., IN 1981

a preliminary report submitted to the Canadian Wildlife Service

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Like any enterprise that takes place in a remote location, this project involved the cooperation of many people. Of those who came north with me, I am indebted to Jamie Campbell for his diligent work and soul-soothing music, Dave Noble, Margie Purdy and Steve Smith for their help at Nuvuk and for memorable parties on Digges Island, and Tony Gaston for sagacious counsel and for making the project possible. I thank Adami Mangiuk, Arnaituk Mark, Paulusi Alaku and Charlie Tarqik for helping in very many ways, and the whole village of Ivugivik for the warmth of their feelings after a tragedy was averted. I am grateful to Chantal Renaud, Colette Ruel, and especially Suzanne Dumais, of the Ivugivik Nursing Station for putting up with us with a smile.

Finally I thank Brock Fenton for giving me an academic home at Carleton University, and the Canadian Wildlife Service and Petro-Canada for financial support.

To all of the above, I offer my appreciation.

ABSTRACT

Breeding biology, distribution on the water, and diet of Black Guillemots (*Cepphus grylle*) were investigated at the Nuvuk Islands, N.W.T., in southwestern Hudson Strait. About 200 pairs of guillemots nested at Pitsulak City, the main study area, and lesser numbers bred on other nearby islands. Hatching peaked at the end of July, and chicks grew at rates near the average of those reported in the literature. Chick diet was dominated by blennies, particularly *Stichaeus punctatus* (Arctic shanny). Adults fed largely on *Boreogadus saida* (Arctic cod), but also took blennies, crustaceans, and polychaetes. Chick feeding deliveries were strongly clumped in time, but mean rates were roughly uniform throughout the day. Boat surveys recorded Black Guillemots almost solely in shallow (less than 37 m) water. Guillemots were thus clearly segregated from Thick-billed Murres (*Uria lomvia*) which favoured deeper water.

INTRODUCTION

The marine bird family Alcidae is widely distributed in the boreal and Arctic marine zones of the Northern Hemisphere. Alcids typically concentrate for breeding in a small number of very large colonies, from which they commute long distances to forage. These patterns have earned alcids great ecological success, but they unfortunately also render difficult the study of some key elements of alcid biology, most notably their foraging.

In the present report, I summarize the results of the first year of a three year investigation into the foraging ecology of the Black Guillemot (*Cepphus grylle*) in western Hudson Strait. For purposes of comparison, I also include some unpublished data from previous guillemot work in the Gulf of St. Lawrence.

In contrast to most northern seabirds, Black Guillemots breed in small colonies, and venture no more than a few kilometers from them to feed. These features greatly simplify the logistics of monitoring guillemot foraging. Nevertheless, their close relation to other Alcidae means that the findings of a foraging study on this species may clarify our understanding of the foraging ecology of other seabirds.

Previous investigations into the ecology of the Black Guillemot have been conducted in the Gulf of Finland (Bergman 1971), Denmark (Asbirk 1979), Iceland (Petersen 1981), the Bay of Fundy (Winn 1950, Preston 1968), and the estuary and the Gulf of St. Lawrence (Cairns 1980,1981). This project has operated as an adjunct to a larger investigation of the ecology of low Arctic Thick-billed Murres (*Uria lomvia*). Progress in this work has been summarized by Gaston (1980) and Gaston et al. (1981).

STUDY AREA

Physiography and vegetation

This study was conducted on islands and waters adjacent to the Nuvuk Islands, N.W.T., (62°23'N, 78°02'W), which lie at the juncture of Hudson Bay and Hudson Strait, near the northwest tip of Quebec (Fig. 1). This area is 12 km southwest of the Inuit village of Ivugivik, Quebec. Many of the geographical features of this area lack official names so the place names used in this report include many local Inuit and arbitrarily coined names.

In contrast to the rugged terrain and precipitous cliffs bordering Digges Sound, 30 km to the northeast, landforms in the Nuvuk Islands area are moderate in slope, and generally meet the water in gently sloping rocky or sandy beaches. However, some low cliffs are found in most of the island groups, including the Gingi group, the North and South Skerries, and the Nuvuk Islands.

Vegetative cover in the area is closely linked to maritime exposure. Low-lying parts of the mainland are generally covered with herbaceous vegetation, while the hilltops are vegetated with lichens. These communities also appear on the larger offshore islands, but the smaller islands are devoid of terrestrial plants, or nearly so.

Inshore waters to the south and west of West Nuvuk Island are shallow and reef-strewn. Offshore from this zone, the seafloor is fairly level, with typical depths of 60 m. North of the Nuvuk Islands lies a 300 m deep trench which extends westward from Digges Sound.

Benthic algae are abundant throughout the area. Fucoids dominate the intertidal zone, and luxuriant beds of laminarians up to 6-8 m long cover shallow sub-tidal areas.

Four islands to the south and west of West Nuvuk Island were the principal sites of this investigation, and merit further description. Pitsulak City, 300 m in length, lies 1.8 km off the southwest tip of West Nuvuk Island (Fig. 1). A raised beach of rounded boulders runs along the central two thirds of the eastern side of the island, and extensive patches of tumbled rock slabs occur to the west of this zone. The shoreline is low and gently sloping except along the island's northwest

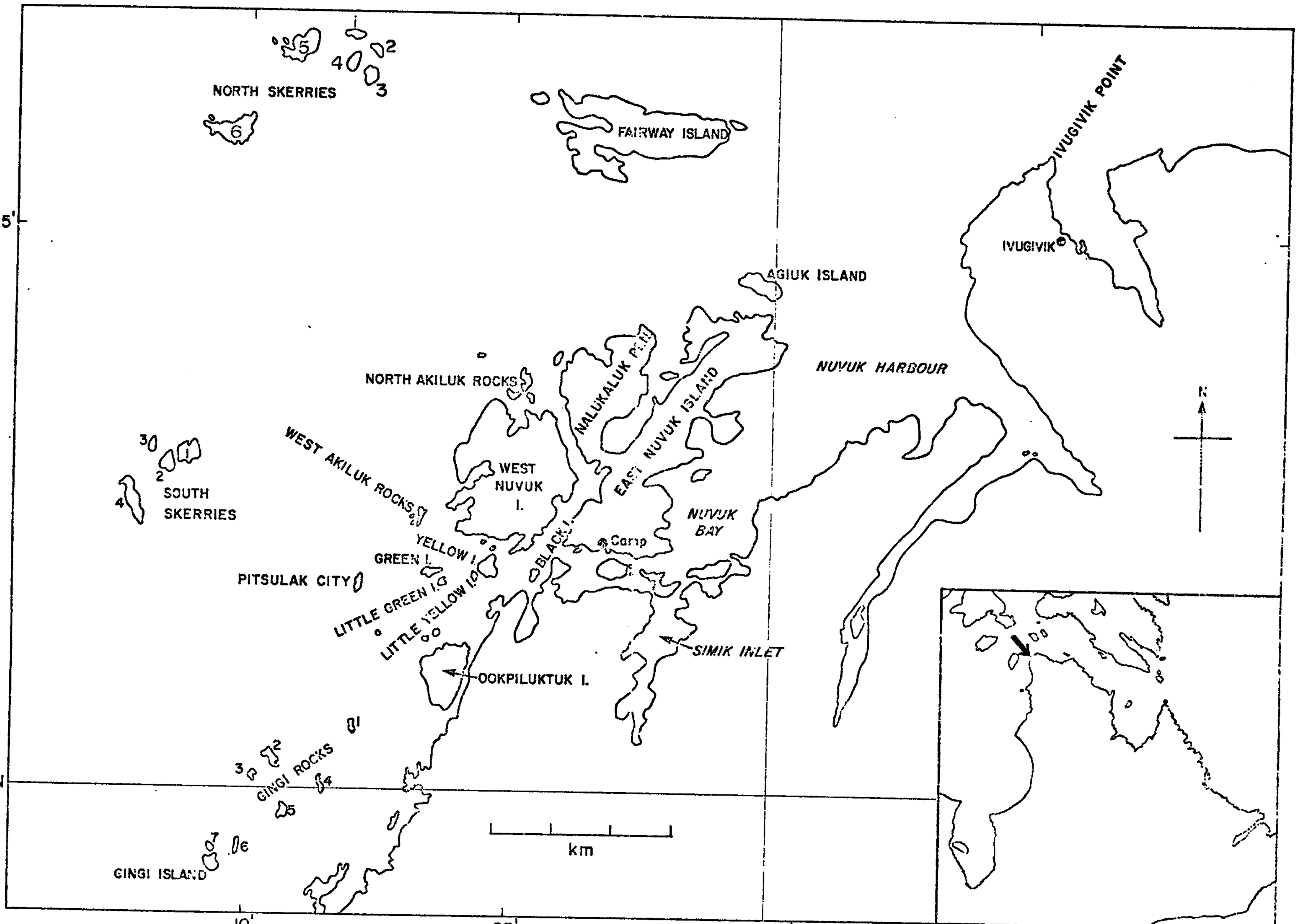

Fig. 1. Study area.

edge where there is a low cliff. The highest elevation is 5.5 m. Pitsulak City is largely unvegetated, but there are some rock lichens and a few small patches of herbaceous plants.

Green Island is located 1 km to the east of Pitsulak City, and 0.6 km to the southwest of West Nuvuk Island (Fig. 1). The island is roughly the same size as Pitsulak City, and has a maximum elevation of 6 m. Most of the surface of Green Island is smooth bedrock, with scattered rock slabs. On the north side of the island boulders are more abundant and in places form rubble piles 1-2 m deep. An adjacent island, referred to as Little Green, is low and is probably wave-washed in severe weather.

Yellow Island is the largest of the principal study islands, and is located 200 m south of West Nuvuk, and 600 m east of Green Island. The high central portion of the island supports lichen communities typical of mainland hilltops, and on the eastern slope grasses and other herbaceous plants grow in a large area of well-developed soil. Boulder rubble is found around most of the periphery of Yellow Island, except at the eastern side where there is a sandy beach. The largest concentrations of rubble are on the west side (rock slabs) and at the southeast corner (round beach boulders). Rock slab rubble is also abundant on nearby Little Yellow Island.

The smallest study island is Black Island, situated 600 m east of Yellow Island, and 150 m north of the Quebec mainland. Black Island is high, but has no real cliffs. Small patches of tumbled boulders are found around the edge of the island, and most of the terrestrial plants are rock lichens.

Nesting distribution of aquatic birds

Black Guillemots breed on most of the small islands in the Nuvuk area. The site with the largest population, and the highest nesting density, is Pitsulak City, which contains in the order of 200 pairs (Fig. 1). Most of the guillemots on Pitsulak City nest among the jumbled boulders and broken slabs of bedrock of the central part of the island. The northern portion of this habitat I have denoted Area B, and the southwestern portion, where the boulders approach the cove on the west side of the island, and the guillemot nesting density is particularly high, is Area F. The raised boulder beach on the east side of the island

(Area C) serves as nesting habitat for several dozen guillemots. Only a few guillemots breed at the northern and southern extremities of the island which are mostly smooth bedrock. Black Guillemots share Pitsulak City with several nesting Common Eiders (Somateria mollissima), several Atlantic Puffins (Fratercula arctica), as well as three pairs of Herring Gulls (Larus argentatus) which failed to hatch their clutches in 1981.

Green Island is the second most important guillemot colony in the Nuvuk area. Most of the island's approximately 100 pairs of guillemots nest in the tumbled boulders along the north side. Several dozen Common Eiders also nest on this island. Nearby Little Green Island is too low and too smooth for guillemot nesting.

Yellow and Black Islands each shelter roughly 15-20 pairs of guillemots. Most nests on Yellow Island are widely scattered although there is a clump of several pairs nesting on adjacent Little Yellow. On Black Island, guillemot nests are located in small knots of several nests each around the edge of the island. Nesting on both islands occurs in a variety of habitats, including bedrock crevices, boulder heaps, and rounded beach boulders. Both islands are also nesting sites for small numbers of Common Eiders, and one pair each of Red-breasted Mergansers (Mergus serrator).

Gingi Island, several of the Gingi Rocks, and most of the islands in the North and South Skerries shelter breeding guillemots. Since little time was spent in these areas, no valid estimation can be made of their breeding populations. However, it is unlikely that the collective breeding population of these islands exceeds 125 pairs. Eiders are also common breeders on most of these islands, with their most populous site being South Skerries 1, where we estimated 75 pairs bred.

In addition to these small islands, Black Guillemots also occupy the coastlines of large islands and the mainland, albeit in very low density. Several pairs appeared to be nesting on East Nuvuk Island between the camp and the island's southeast point, and one or more pairs may also have been nesting on the mainland adjacent to Black Island. Common Eiders are abundant breeders on the larger Nuvuk Island, but their nests are broadly dispersed except for a dense colony on an island in a pond on West Nuvuk Island. A pair of Peregrine Falcons (Falco peregrinus) nested on East Nuvuk Island on a sea-cliff directly northwest of the camp.

Weather, ice and tides

Meaned daily weather data recorded at the East Nuvuk camp each evening are presented in Table 1. The weather was cool and often damp throughout the summer, although on a few days in July the afternoon temperature struggled above 15°C. These mild temperatures were associated with southeast breezes which had been warmed as they passed over the Quebec mainland. Temperatures were noticably lower near the end of August, and several centimeters of snow fell on the night of the 27th, and two days later a hard frost put thick ice on the rock pools of Pitsulak City.

Pack-ice covered most of the water around the Nuvuk Islands when we arrived on 18 June. Heavy ice remained in the area for most of the following three weeks, although there were several relatively ice-free intervals during this period. The ice dispersed rapidly after mid-July, and was gone by the end of the month.

No tidal predictions are available for Ivugivik or the Nuvuk Islands, but Canadian Hydrographic Service (1980) predictions for Port de Laperierre on West Digges Island agreed fairly closely with tidal peaks recorded at the East Nuvuk camp. Tides at Port de Laperierre are semi-diurnal with a mean amplitude of 2 m, and the tidal regime in the study area is likely quite similar to this.

Table 1

Weather records from the camp at East Nuvuk Island. Readings taken at 1930.

date	rainfall/d (mm)	mean wind-speed (km/h)	mean cloud cover (/10)	% of days with visibility ≤ 1 km	mean temp-erature (°C)
27-30 June	1.0	28	8.3	25	7.5
1-15 July	4.8	18	6.8	11	6.6
16-31 July	2.2	20	6.4	25	5.6
1-15 August	0.3	14	3.1	0	6.8
16-31 August	1.1	18	7.4	13	5.4

METHODS

Logistics

The field party for this project (D. K. Cairns and J.A. Campbell) arrived at Ivugivik on 16 June. Transportation was by Nordair jet from Montreal to Frobisher Bay, and from Frobisher to Ivugivik by Twin Otter furnished by the Polar Continental Shelf Project. After a two day wait for weather at Ivugivik, the field team and equipment were ferried to East Nuvuk Island by an A-Star helicopter, chartered from Heli-Quebec.

Once arrived, we immediately began construction of an 8' x 12' cabin at a site on the south side of the island (Fig. 1). This cabin was constructed of 5/16" plywood sheathing backed by styrofoam insulation, and we furnished it with a propane refrigerator and stove, and sleeping accommodation for three in the form of triple-decker cots.

Water transportation was hampered at the start of the field season by sea-ice, which gradually dispersed and caused no problems after 15 July. Our boat was a 12' Achilles inflatable, which we found to be of excellent quality and quite suitable for the purpose at hand. This boat was powered variously with a 15hp and a 7.5 motor, with a 4hp carried as a spare.

On 2 August, a camp was established on Pitsulak City, which was occupied more-or-less continuously by DKC until the end of the field season. Accommodation was a backpacker's dome tent, which was found te be rather cramped for such a long period of use.

Camp was broken on 5 September, with the assistance of the Digges Island team. The following day we flew from Ivugivik to Frobisher by Twin Otter, and on the 7th returned to Montreal by Nordair jet.

Breeding biology

Timing and success of breeding were monitored in Area C of Pitsulak City during nest visits spaced four to five days apart. Chicks and adults were measured with vernier calipers and steel rulers and tapes. Chicks were weighed on Pesola balances and adults were weighed with an Ohaus triple-beam balance. The same balance was also used to weigh recovered prey samples.

A stiff wire with its ends curved into leg and neck hooks was used to extract both chicks and adults from deep crevices.

Feeding deliveries to the young were observed from wooden blinds stationed in Areas B and F.

Adult diets

Twenty-two adult Black Guillemots were collected with a 12-guage shotgun in the Gingi Islands-Ice Harbour area, and in Digges Sound between Ivugivik and East Digges Island. The birds' digestive tracts were drenched with 70% ethanol immediately upon collection, and the stomachs were removed within several hours and stored with their contents in 70% ethanol in Whirl-packs.

Samples were sorted and identified in March-April 1982 with the help of the CWS reference collection, and Diane Laubitz of the Invertebrate Division of the National Museum of Natural History. Total lengths were estimated for *Boreogadus saida* by means of a regression relating otolith length to total length, which was derived by D. Noble from *Boreogadus* specimens recovered on Digges Island.

Distribution of birds on the water

The distribution of seabirds on the water was recorded from an inflatable boat which was run at constant throttle along a straight line between islands. The number and time to the nearest minute of birds sighted within 60° to the right or left of the line of travel of the boat were recorded on a tape recorder. Birds were not recorded until they were close enough to the boat to be identified to species; birds that passed across the bow at too great a distance to be identified were not included. This criterion was not, however, applied to gulls, since Glaucous (*Larus glaucoides*) and Iceland (*L. hyperborealis*) Gulls could only be distinguished at close distances.

The depth contour maps which supplement the plots of bird distribution were derived from Canadian Hydrographic Service nautical chart no. 5412. On the transect between Pitsulak City and Gingi Island a a bottom profile was run with a depth sounder, and the information thus obtained was used to supplement chart data for this area.

Banding and marking

In addition to standard U.S. Fish and Wildlife Service aluminum bands, a variety of marks and tags were applied to guillemot chicks and adults.

The coloured leg bands used were of 1/32" (0.78 mm) bilaminate Gravoply plastic. This material is commonly used by signmakers, who make letters by incising the upper layer to expose the contrasting colour of the lower layer. Some leg bands were marked with letters or numbers by melting the upper layer of plastic with a fine-pointed soldering iron. The iron was fitted in a Leroy pen-holder, and the characters traced from a lettering guide. The bands were then curled into spirals in boiling water, and set in 9.2 mm holes drilled in a plexiglass plate. The plate was then reimmersed into the boiling water where the bands were expanded to snugly fill the holes. This procedure gave bands of 6.0 mm inside diameter, with a height of 9.0 mm.

Patagial tags were made of 1/16" (1.56 mm) Gravoply cut into 45 x 22 mm strips. Letters on these tags were inscribed commercially. For contouring to wing shape the tags were curved around a glass bottle 8 cm in diameter, and held in place by elastic bands during immersion in boiling water. These tags were attached to birds' wings by monofilament codline of 1.5 mm diameter, which was sharpened with a knife to allow penetration of the patagium. After being fitted with the tag and small nylon washers on both sides, the ends of the line were "mushroomed" in a match or lighter flame to prevent the tag from slipping off.

Since the patagia of some birds resisted penetration by the sharpened monofilament, we developed in the course of the season a "wing needle" which made the job quick and easy. This device was made from the steel lead chamber of an Eversharp pencil, which was sawn and filed to a point at one end, and squeezed with pliers at the other to the proper diameter to receive the end of the monofilament.

The tracking radios used in this project were prepared by Fred Anderka of the Canadian Wildlife Service. The devices weighed about 21 g, and had a maximum range of roughly 6 km. They were attached to the birds' back with Tygon tubing, which was threaded through holes moulded into the transmitters, passed anteriorly and posteriorly around the wings, and tied across the belly. The most effective pattern for tying was found to be a diagonal "cross-your-heart" arrangement.

Letters and numbers were marked on the white wing patches of some birds with orange and blue airplane dope, available from hobby shops. This material did not seem to damage the birds' feathers, and dried within a few minutes. The colours were not completely fast, and began to fade after several weeks.

Some birds were also fitted with nylon or plastic leg streamers. The plastic streamers were cut from flagging tape and were abraded or bitten off within a day or two, but the nylon streamers were tougher, and no loss was recorded. The streamers were tied to the aluminum band, either directly, or by a short length of nylon monofilament.

Prey sampling

Various nets and traps were used in attempts to sample guillemot prey. Most netting was done with a monofilament gillnet of 25 mm stretch mesh, but a mist net was also used until it was found that entangled fish severely damaged the net. Both nets were weighted with rocks and set on the bottom.

Double-ended minnow traps were constructed of heavy wire covered with window screen. The traps measured 75 x 30 cm, and their entrances were 4 cm in diameter. These traps were baited with Arctic char (Salvelinus alpinus) heads.

Light traps consisted of clear acrylic capture chambers fastened to wooden light chambers. The capture chambers measured about 20 x 20 x 20 cm, and were fitted with moveable panels on two sides, which were set at right angles to each other to provide funnel-like entrances. The capture chamber was illuminated through a window from above by a waterproof flashlight fitted inside the light chamber.

BREEDING BIOLOGY

Timing of breeding

Breeding phenology was monitored in Area C of Pitsulak City, where hatching peaked at the end of July and beginning of August (Fig. 2). The median hatching date was 30 July, and the mean date was 3 August. Given a 28 d incubation period (Winn 1950), most eggs must have been laid near the beginning of July.

The hatching curve was bi-modal, with a second peak occurring about three weeks after the first (Fig. 2). The first peak rose sharply, indicating a fairly synchronous beginning of nesting. This may reflect the increase in foraging opportunities for nesting birds concomitant with ice break-up in late June and early July. Blockage of nest cavities by ice and snow could not have caused this steep first peak, because most nest sites were clear before the end of June.

The second peak presumably represents re-nesting attempts after the loss of a first clutch, although this cannot be confirmed because nest checks did not begin until late in the incubation period.

The reason for such a marked bi-modal distribution is obscure. If the second peak was indeed due to re-nesters, it is unlikely that initial clutch loss was caused by observer disturbance, because disturbance levels were low during the month of July when both first and second clutches would have been initiated.

Given a nestling period of 36.5 d (Cairns 1981), the main peak of fledging would have occurred in early September followed by a second peak late in the month. Since camp was broken in early September, our data are inadequate to plot a fledging curve.

Breeding success

Breeding success was determined for 20 nests in Area C, Pitsulak City. This sample does not include nests of the several birds in the area which were patagial tagged.

Thirty-four eggs were laid in the 20 nests, for a mean clutch size of 1.7. Of these 19 hatched, for a hatching success of 0.56 chicks per

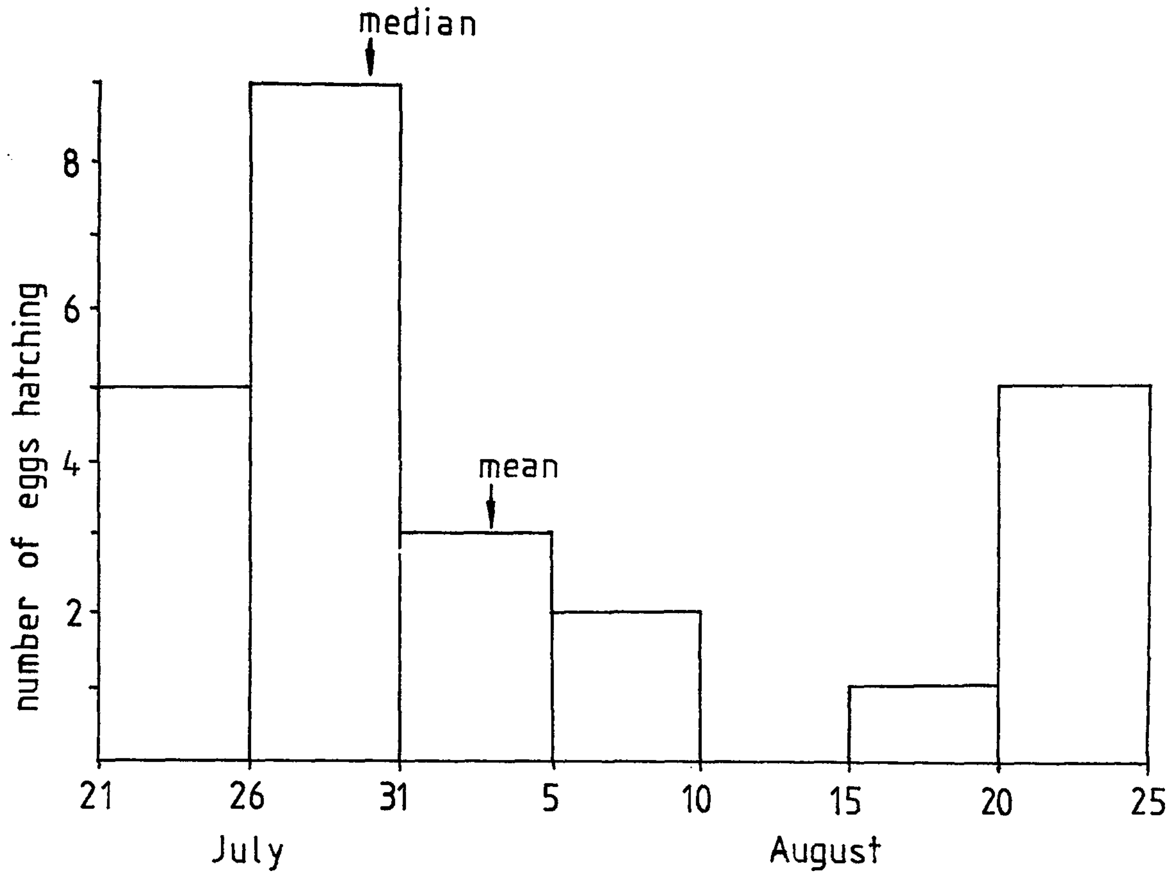

Fig. 2

Distribution of Black Guillemot hatching dates at area C, Pitsulak City.

egg, or 0.95 chichs per nest. Ten chicks fledged, for a fledging success of 0.53 fledglings per chick hatched, or 0.50 fledglings per nest.

Literature values of Black Guillemot breeding success vary widely (see Petersen 1981 for a compilation), and observer disturbance may profoundly influence success rates (Cairns 1980). However, it may be significant that this study and one conducted in the St. Lawrence estuary (Cairns 1981) were very similar in breeding success as measured at each stage of nesting, as well as in the pattern and intensity of observer disturbance.

Chick growth and adult measurements

Growth curves for chick weight, wing length, wingspan and tarsus are plotted in Figs. 3-6. These curves are derived from measurements of chicks in Area C, Pitsulak City. Since each chick was measured at four to five day intervals, the individuals represented in each day class varied from day to day. This variation in sample composition is likely responsible for much of the fluctuation in the curves.

The weight curve for Pitsulak City chicks is compared to those of other guillemot breeding areas in Fig. 7. Mean weights are highest during most of the nestling period for Icelandic chicks, and lowest for chicks raised at Prince Leopold Island in the Canadian high Arctic (see Fig. 7 for references). It is tempting to speculate that the early rapid gains of the Icelandic chicks reflect the early commencement of nesting there, which allows guillemots to forage in near continuous daylight during much of the chick-rearing season. Continuous foraging during chick-rearing at the other high-latitude colonies of Nuvuk and Prince Leopold is not possible because birds at these colonies breed later, and it is dark at night by the time their chicks hatch.

Measurements of adult Black Guillemots which were captured for banding or shot for gut analysis are presented in Table 2. Weights were similar to those found in the Gulf of St. Lawrence (Cairns 1981), and wing lengths resembled those compiled by Storer (1952) for a wide geographical area.

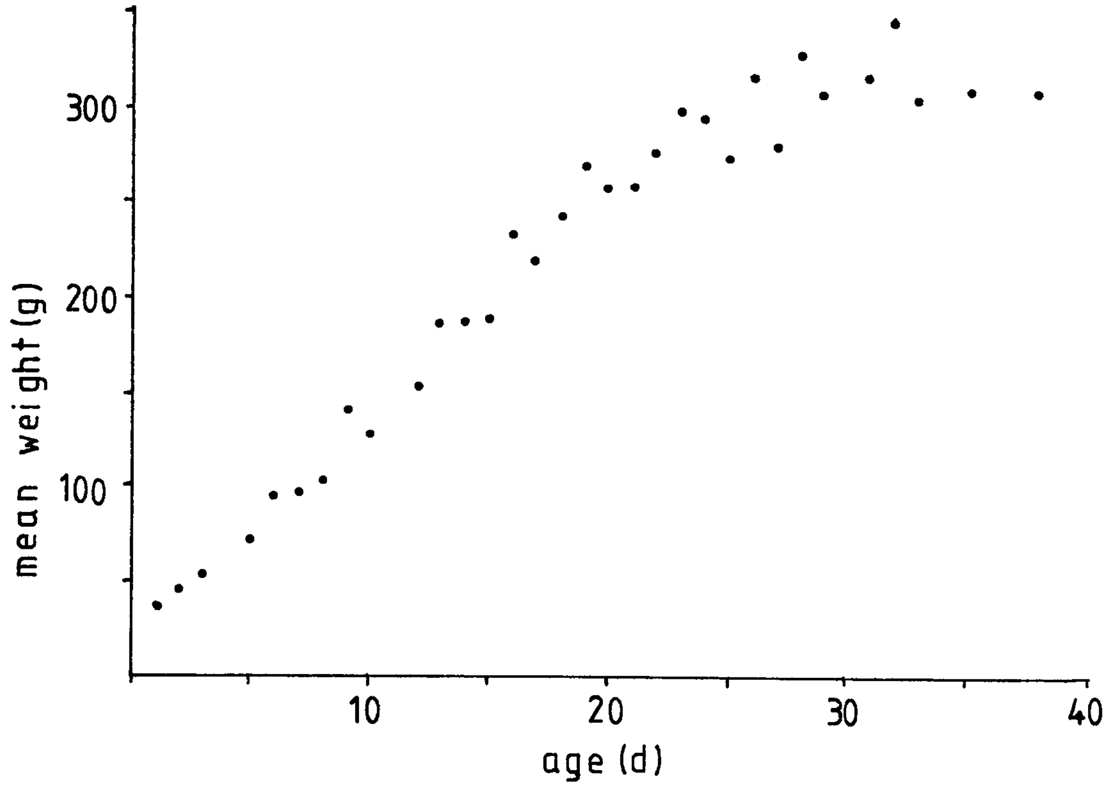

Fig. 3. Growth in weight of Black Guillemot chicks from Area C, Pitsulak City. n for each day varies from 1 to 5.

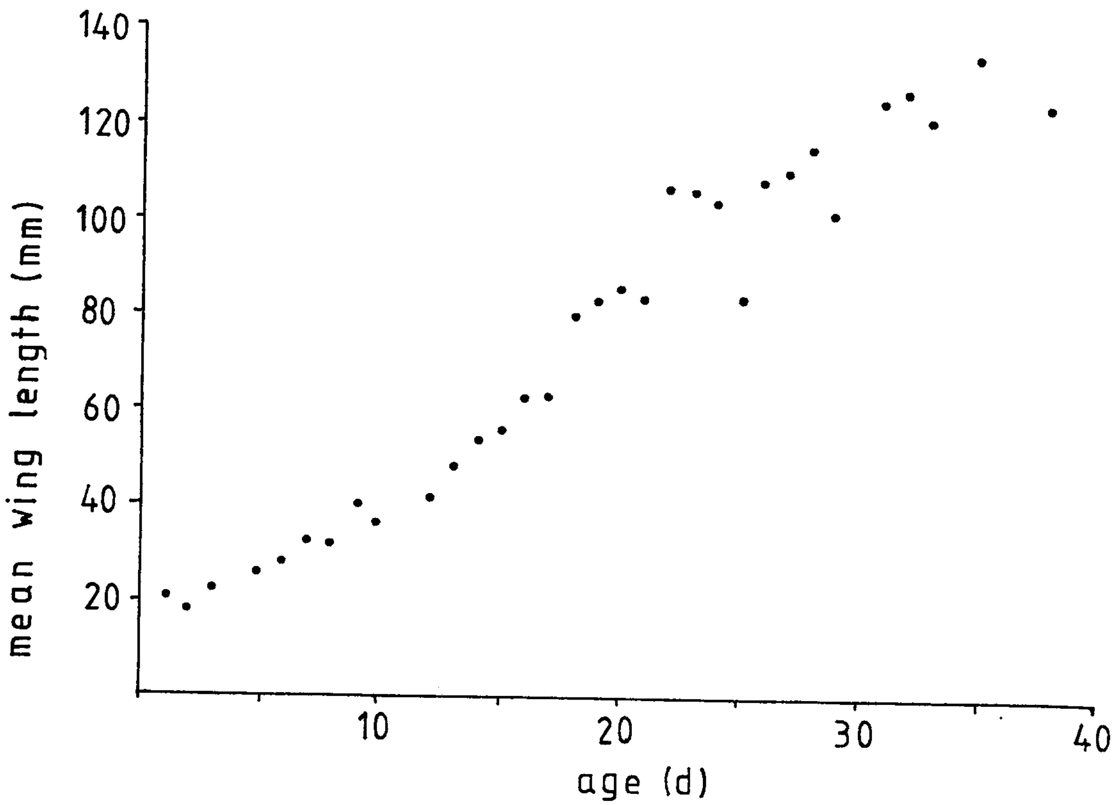

Fig. 4. Growth in wing length of Black Guillemot chicks from Area C, Pitsulak City. n for each day varies from 1 to 5.

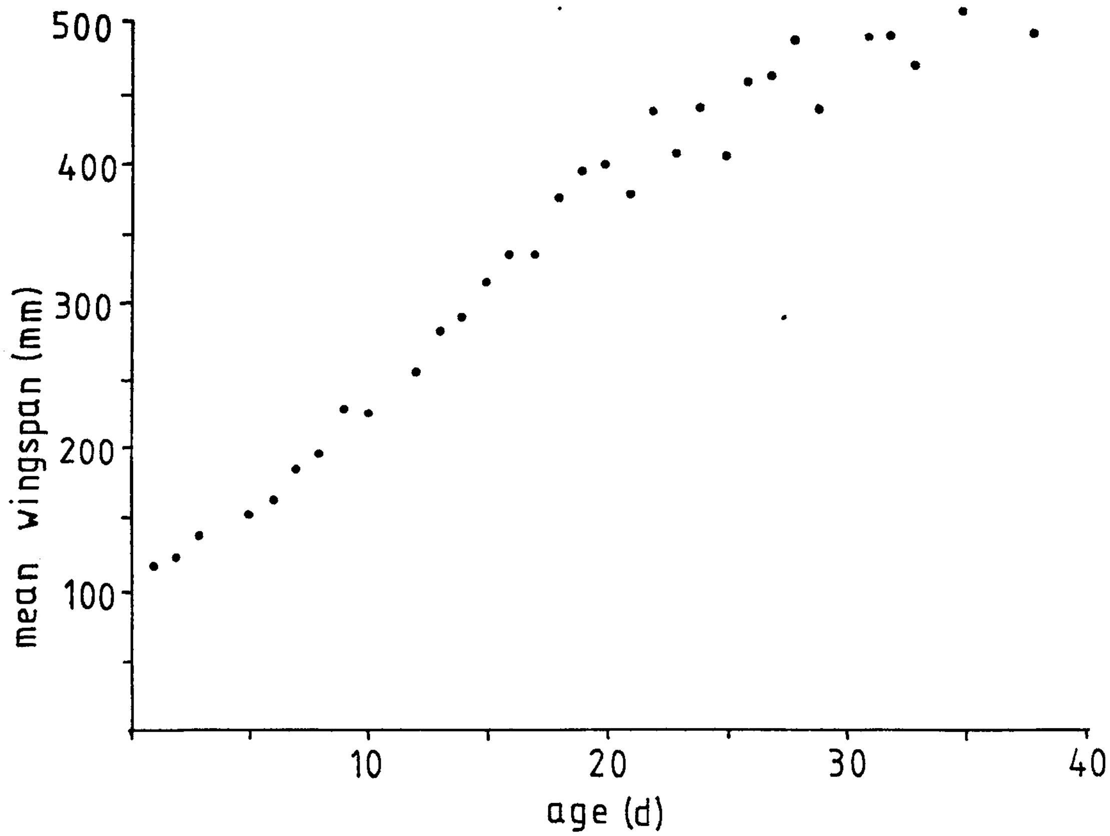

Fig. 5. Growth in wingspan of Black Guillemot chicks from Area C, Pitsulak City. n for each day varies from 1 to 5.

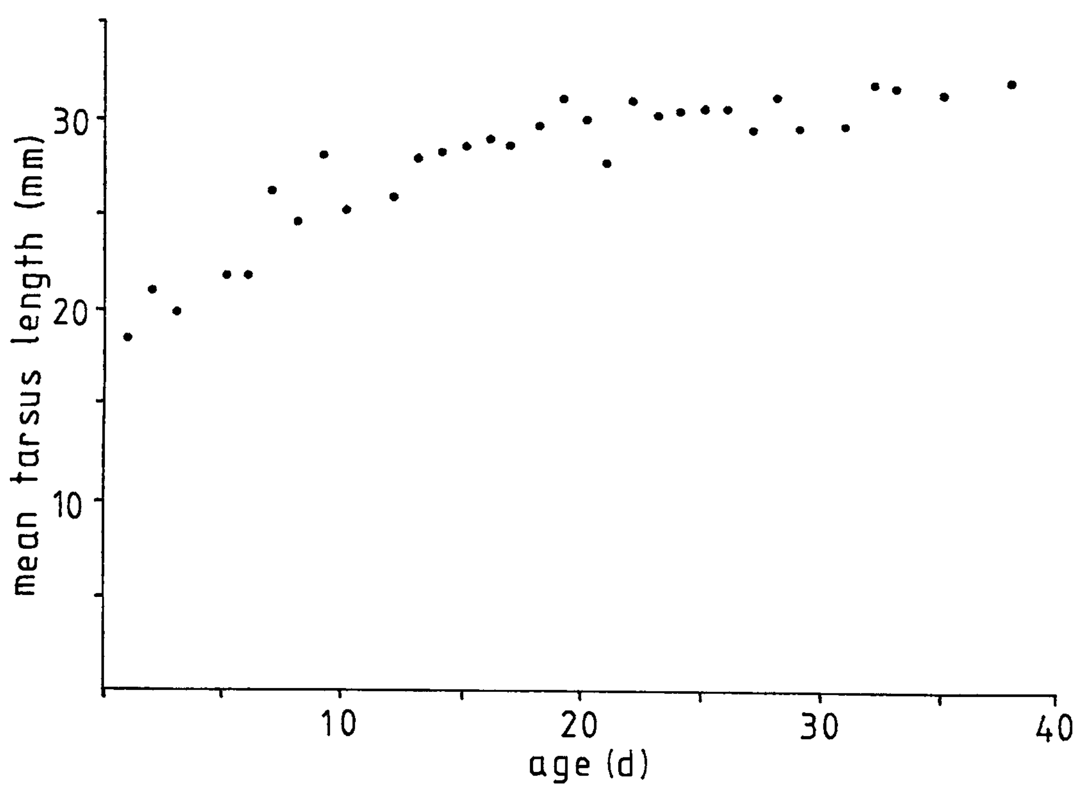

Fig. 6. Growth in tarsus length of Black Guillemot chicks from Area C, Pitsulak City. n for each day varies from 1 to 5.

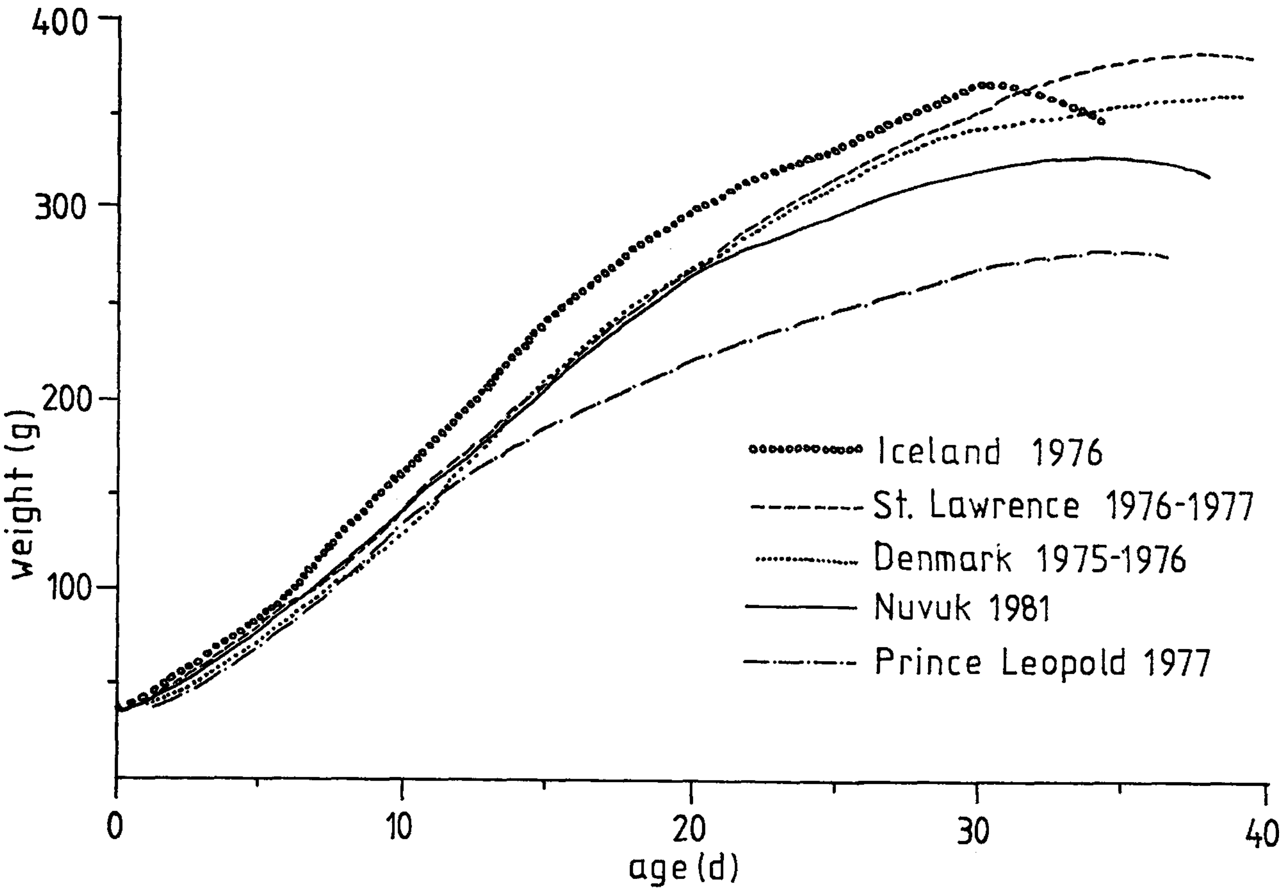

Fig. 7

Growth in weight of Black Guillemot chicks at various sites. Data for Iceland from Petersen 1981; for St. Lawrence estuary and Gulf from Cairns 1981; for Denmark from Asbirk 1979 ; for Pitsulak City, Nuvuk Islands, from present study; and for Prince Leopold Island, Lancaster Sound, from A.J. Gaston (personal communication).

Table 2

Measurements of adult Black Guillemots captured or shot in the Nuvuk Islands area, N.W.T.

	all birds			males			females		
	$\bar{x}$	SD	n	$\bar{x}$	SD	n	$\bar{x}$	SD	n
weight (g)	406	32.8	67	426	31.3	14	422	44.4	3
wing (mm)	168.7	4.2	59	166.7	3.5	14	172.0	2.0	3
culmen (mm)	26.8	1.5	53	27.1	1.2	14	26.7	0.4	3
tarsus (mm)	31.4	1.2	52	31.2	1.1	14	30.5	2.4	3

PRELIMINARY DATA
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The sex-ratio of the known-sex sample (14 males:3 females) differed significantly from equality (G with Yates' correction = 6.28, P<.025). Preponderence of males in samples of guillemots has been previously reported by Belopol'skii (1957) who considered it due to "greater activity" on the part of the males, and by Petersen (1981), who speculated that males may be more active in foraging for the young than females at the time of chick brooding. Like the above authors, I suspect that the unequal sex-ratio is the product of behavioural differences between sexes, but at the present time the nature of these differences is unclear.

Chick diets

The dietary spectrum of guillemot chicks as determined by recovering dropped items and by observing food deliveries is presented in Table 3. The dominant prey species recorded by both methods was *Stichaeus punctatus* (Arctic shanny), which comprised 53% of the recovered sample, and 38% of the identified portion of the observed sample. Other members of the Blennioidea were also important, particularly *Eumesogrammus praecisus* (fourline snakeblenny) and *Cryptacanthodes maculatus* (wrymouth). Many blennies in the obserbed sample could not be identified to species, but it is likely that the majority of these were of the species mentioned above. However, a number of observed fish were definitely blennies, but were not of the above species. As well, one blenny in the recovered sample has yet to be identified.

Minority constituents of chick diet were *Boreogadus saida* (Arctic cod) and various Cottidae. In the recovered sample the only cottid found was *Myoxocephalus scorpius* (shorthorn sculpin) but several other sculpins were seen being delivered to chicks that were not of this species. In addition two *Ammodytes americanus* (American sand lance) and one unidentified crustacean were observed being delivered to chicks.

The sample of dropped items, although small (n=32), provides an unbiased indication of prey composition, because all of the prey items were dropped by adults following their entanglement in noose carpets, or because of some other human intervention. The sample thus avoids the biases of other studies of seabird prey recoveries, which often

Table 3

Prey items brought by Black Guillemots to Pitsulak City.

prey	items recovered					items observed	
	number	mean weight (g) ±SD	mean length (mm) ±SD	% by number	% by weight	number	% of those identified
Boreogadus saida (Arctic cod)	4	5.5±3.0	94.8±13.8	13	5	16	7.7
Ammodytes americanus (American sand lance)	–					2	1.0
Blennioidea							
Cryptacanthodes maculatus (wrymouth)	2	9.5±6.1	144.5±29.0	6	4	6	2.9
Eumesogrammus praecisus (fourline snakeblenny)	6	19.8±6.4	139.2±15.4	19	25	11	5.3
Stichaeus punctatus (Arctic shanny)	17	16.7±5.3	144.9±14.7	53	60	79	38.0
unidentified Blennioidea	1	3.0	113	3	1	86	41.3
total Blennioidea	26	16.4±6.4	142.3±16.1	81	90	182	87.5
Cottidae							
Myoxocephalus scorpius (shorthorn sculpin)	2	12.7±3.5	103.5±12.0	6	5	–	
unidentified Cottidae	–					7	3.4
total Cottidae	2	12.7±3.5	103.5±12.0	6	5	7	3.4
Crustacea	–					1	0.5
unidentified prey	–					346	
total	32	14.8±6.9	133.9±23.5	100	100	554	

include prey voluntarily discarded by the parent or rejected by the chick. The observed sample, on the other hand, has the inherent bias that some species are more readily identified than others, and may consequently be over-represented. This problem is particularly acute in the present study where less than half of the delivered items were identified, and of these, over 40% could only be designated as Blennioidea sp.

The weights of items in the recovered sample permit a more meaningful assessment of the relative importance of the various dietary components, because the mean weights of the various prey species vary widely. In this analysis Stichaeus is still the most important prey, at 60% of total prey weight, and its fellow blennies account for an additional 30% of prey weight. Eumesogrammus showed the highest mean weight of any species, and composed 25% of total prey weight. Although Boreogadus composed 13% of the number of prey recovered, its representation was only 5% of total prey weight, because of its very small size.

Collections of dropped prey were made from 1 August to 1 September, but the only clear change in prey composition was the increase in Eumesogrammus in the latter part of the period (comparing frequency of occurance of Eumesogrammus for 1-16 August vs. 17 August - 1 September, $G=6.29$, $P<.025$). Indeed, four of the six Eumesogrammus in the recovered sample were collected on 30 and 31 August.

The predominance of blennies in the diets of guillemot chicks at Nuvuk confirms the species' widespread predilection for this group, which has been found to be the mainstay of chick feeding at numerous locations in Europe and North America (Petersen 1981, Cairns 1981, Preston 1968, Winn 1950, Asbirk 1979, Bergman 1971). Gadids and cottids, which were the major non-blenny prey at Nuvuk, have also been found to be important in chick feeding elsewhere (Petersen 1981, Cairns 1981).

Patterns of chick feeding

Four hundred and thirty-seven food deliveries were observed in 20 h of observation between 0700 and 2000 during 18-26 August in Area F of Pitsulak City. Because many of the birds were nesting in a single pile of tumbled boulders, I was unable to determine the exact number of nests in the area, and had to estimate the number of nests by the number of individual birds delivering food to the area. This produced an estimate of 17 nests, which means that guillemots delivered 1.29 food items/nest/h, of 16.8 items/nest during a 13 h day. This feeding rate is substantially higher than those found by other workers (0.83 items/nest/h, Petersen 1981; 0.79 items/nest/h, Cairns 1981; 0.87 items/nest/h for two-chick broods, Asbirk 1979).

The overall frequency of feeding deliveries was roughly uniform during daylight hours (Fig. 8). This pattern was similar to that found by Asbirk (1979), but differed from the bi-modal curves with strong morning peaks reported by Petersen (1981) and Cairns (1981).

The overall uniformity in feeding rate masked great short-term variation in feeding rate, which becomes apparent when delivery rates are broken into five minute periods for each of the observation days (Fig. 9). In four of six observation sessions, the temporal distribution of feeding deliveries was significantly clumped, as compared to a Poisson distribution which would be expected if deliveries were randomly distributed (Table 4). Feeding deliveries were not found to be clumped in Area B (coefficient of dispersion=1.07, possibly because the nests in this area were spread over a much wider area than those of Area F, where the other observations were made. Deliveries were not significantly clumped during one session in Area F, but this may have been due to the short sampling period (n=16 observation periods).

Guillemot feeding events at St. Mary's Island in the northwestern Gulf of St. Lawrence (Cairns unpubl.) show a dispersion pattern similar to that found at Area F of Pitsulak City (Fig. 10). At St. Mary's the rate of chick feeding drops by roughly one half at about 1000 each day, but feeding deliveries are significantly clumped both before and after this time (Table 4).

Clumping tendencies in Black Guillemot food deliveries have previously been documented by Bergman (1971) and Slater and Slater (1972). Delivery clumping is related to the guillemots' habit of loafing on the water below the colony after returning from the foraging grounds, and then flying in concert with other birds to the nesting area. If all loafing birds that were carrying food participated in such a mass delivery, one

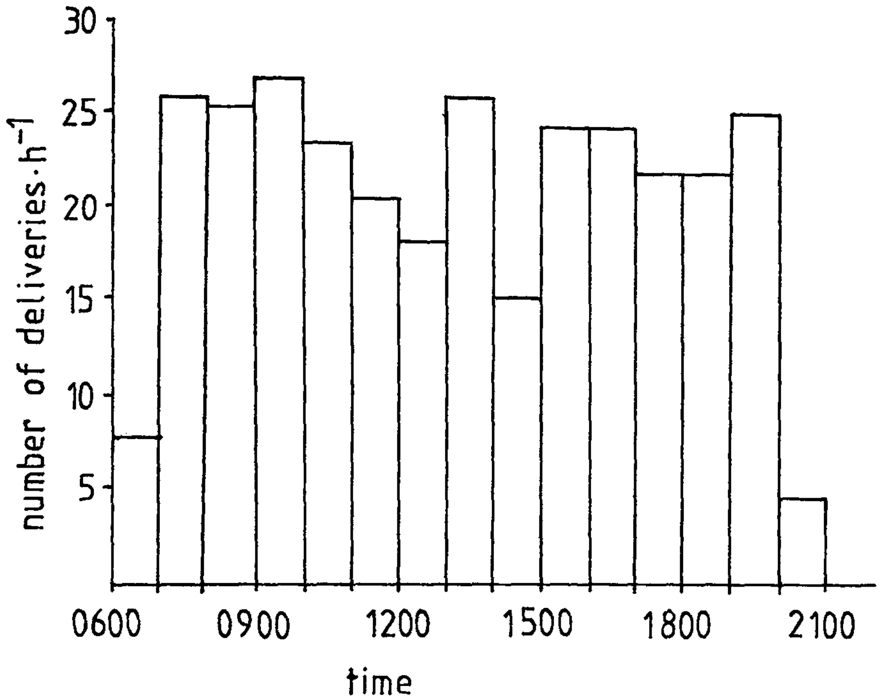

Fig. 8
Frequency distribution of food deliveries to Black Guillemot chicks at Subcolony F, Pitsulak City, based on 452 deliveries in 20.75 h of observation between 18 and 26 August.

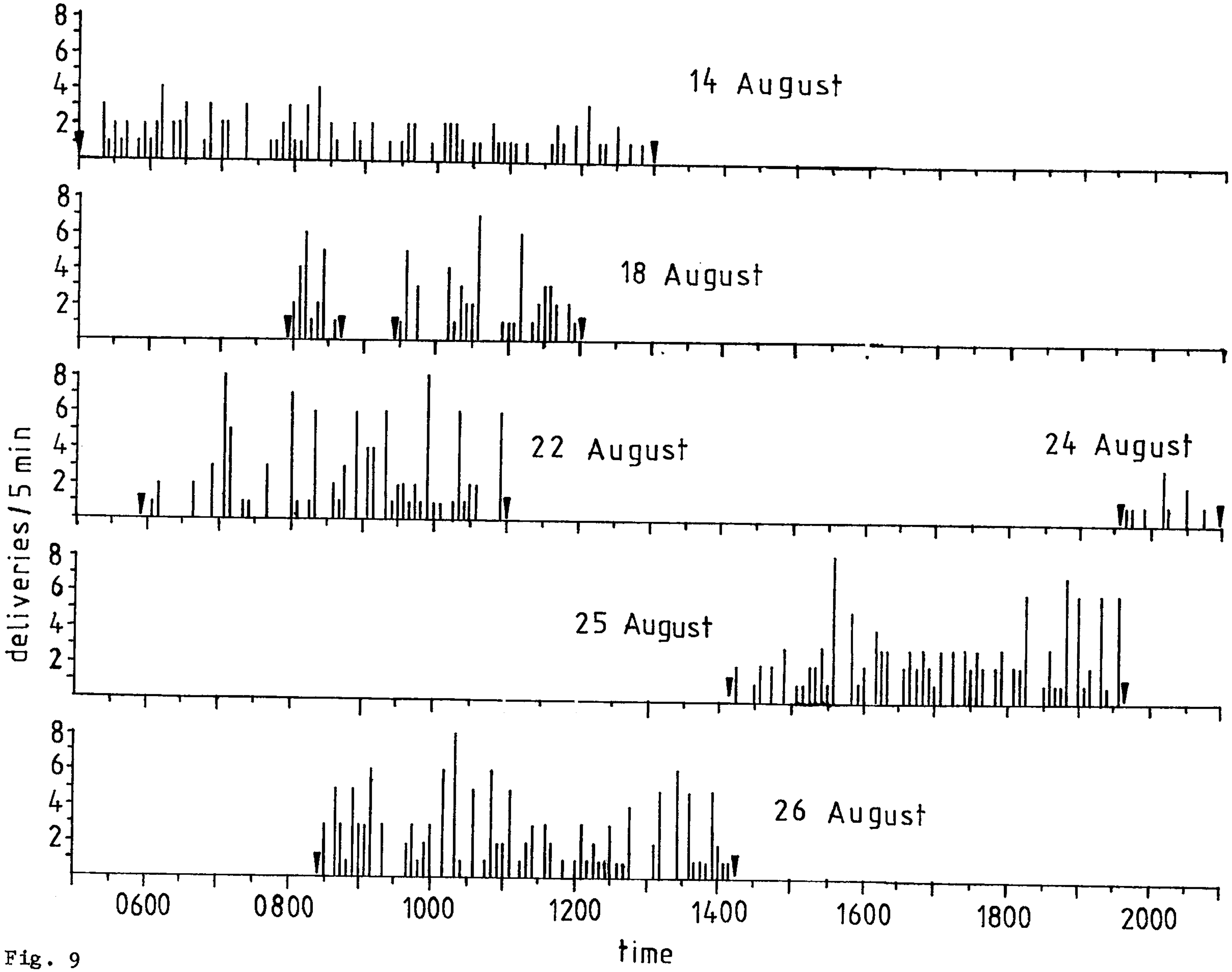

Fig. 9

Number of food deliveries to Black Guillemot chicks on Pitsulak City per five minute period. Data for 14 August from area B, subsequent data from area F. Triangles indicate beginning and end of observation periods.

Table 4

Dispersion of number of food deliveries to Black Guillemot chicks per five minute period at Pitsulak City and at St. Mary's Island, Gulf of St. Lawrence.

area	date	number of 5 min periods	coefficient of dispersion[a]	P[b]
Pitsulak City - Area B	14 Aug. 1981	96	1.07	>.1
" " Area F	18 Aug. 1981	39	2.04	<.005
" " "	22 Aug. 1981	60	2.90	<.005
" " "	24 Aug. 1981	16	1.25	>.1
" " "	25 Aug. 1981	65	1.88	<.005
" " "	26 Aug. 1981	69	1.98	<.005
St. Mary's - 0500-1000[c]	8-17 Aug. 1977	193	1.75	<.001
" 1000-2000[c]	6-17 Aug. 1977	157	1.41	<.001

[a] $C.D.=s^2/\bar{x}$

[b] Probability that the dispersion pattern differs from the Poisson distribution. P determined by comparing index of dispersion $(s^2(n-1)/\bar{x})$ to X^2 function (see Pielou 1977:125).

[c] Coefficients of dispersion calculated separately for 5 min periods occurring before and after 1000, because overall feeding rates were high before this time, and low after it.

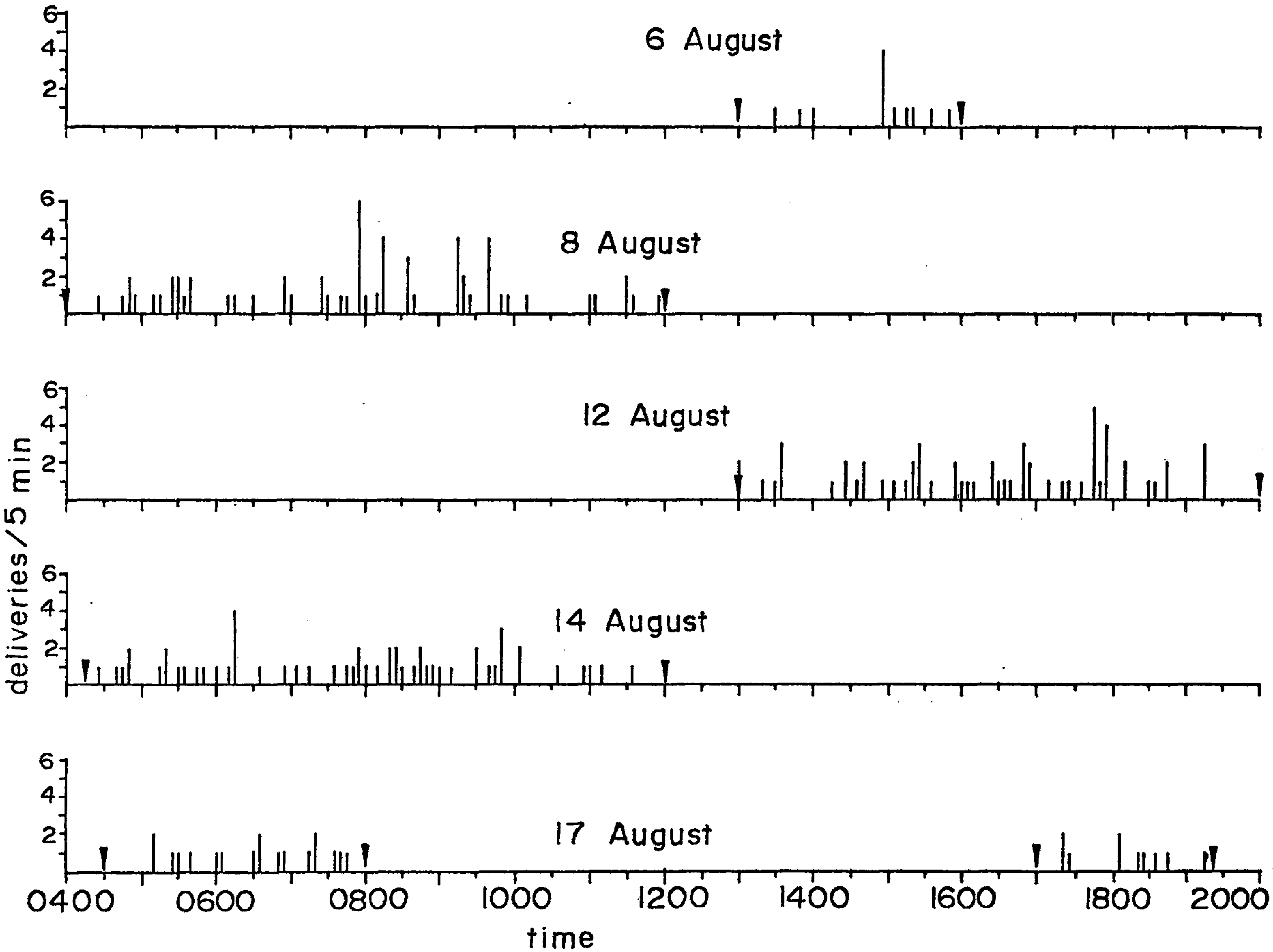

Fig. 10

Number of food deliveries to Black Guillemot chicks on St. Mary's Island, Gulf of St. Lawrence, per five minute period. Triangles indicate beginning and end of observation periods. Data collected in 1977.

would expect a subsequent period in which no deliveries were made. This appears to be the case at least some of the time, as several of the spikes of food delivery in Fig. 9 are followed by periods without deliveries. The fact that other periods of intense activity were followed by periods containing deliveries tells us little about the extent of this effect, because the subsequent deliveries could have been made by either additional loafers on the water, or by freshly incoming birds. It is unfortunate that I was unable to monitor the loafing grounds during these sessions, because of the necessity of maintaining constant watch on the colony.

One factor that ought to increase clumping of food deliveries is the presence of a kleptoparasite. Although one or more Parasitic Jaegers (Stercorarius parasiticus) were present and harrassing guillemots near the colony on 26 August, the coefficient of dispersion on that day was not higher than on other days. Thus guillemots do not appear to synchronize nest visits when confronted with jaegers as Atlantic Puffins seem to do (Grant 1971).

In order to discover whether some guillemots might be more prone than others to deliver their food in groups, I have plotted the feeding events of the five guillemots most often identified when delivering food (Fig. 11). Since no conspicuous tendency could be discerned from these plots, I further calculated the mean number of feeding deliveries occurring within one minute of each feeding delivery by these birds (Table 5). The means were similar and provide no evidence for inter-individual differences in the tendency to deliver in groups. This, however, is not a final conclusion, because the data were biased by the fact that some of the five birds undoubtedly delivered food without being identified, and the portion of unidentified deliveries increased in periods of frequent deliveries.

The individual food delivery patterns of four of the five birds tended to a regularly spaced dispersion rather than a random or clumped distribution, as suggested by their coefficients of dispersion of less than one (Table 5). This is what one would expect if birds made regular to-and-from journeys between the foraging grounds and their nests. However, there were several bouts of rapidly repeated deliveries, notably

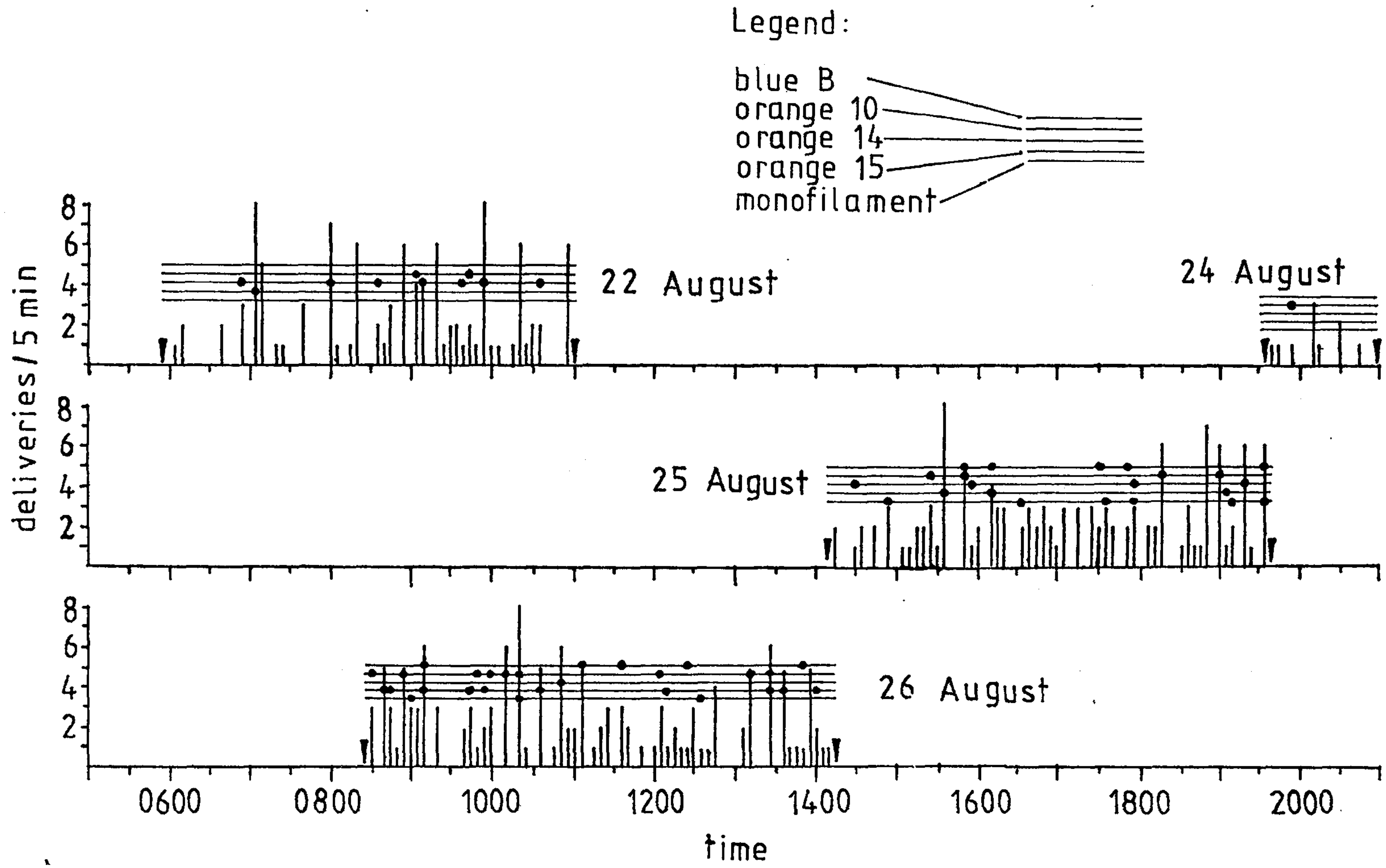

Fig. 11

Food deliveries by five Black Guillemots to nests in Area F, Pitsulak City, in relation to overall frequency of food deliveries. Triangles mark begining and end of observation periods.

Table 5

Temporal patterns of food deliveries by five marked Black Guillemots in Area F, Pitsulak City.

bird	number of food deliveries per 30 min period[a]			number of food deliveries by other birds within 1 min of food delivery		
	$\bar{x}$	coefficient of dispersion[b]	number of 30 min periods	$\bar{x}$[c]	SD	n
blue B	0.43	0.83	21	2.5	1.9	10
orange 10	0.52	1.19	29	2.5	1.8	14
orange 14	0.43	0.91	30	2.3	2.2	12
orange 15	0.49	0.89	29	2.1	1.9	14
monofilament	0.38	0.91	21	1.3	0.7	9

[a] Data derived only from observation sessions in which one or more feeding was observed.

[b] $C.D. = s^2/\bar{x}$

[c] $F \approx 0.68$, P .05

by Orange 10, which delivered four fish within 32 min on 26 August, and Orange 15, which delivered two prey items within 3 min on the same date.

Although guillemots did not show variation in their temporal patterns of prey delivery, there was significant inter-individual variation in the spectrum of prey brought to chicks (Table 6). The most aberrant individual in prey composition was Orange 15. This bird shunned the conventional Stichaeus, and instead brought exotic prey not seen to be delivered by any other bird, including two Ammodytes, a blenny which was neither Stichaeus nor Cryptacanthodes nor Eumesogrammus, at least two species of sculpins which were not Myoxocephalus scorpius, and a crustacean. The only clearly seen prey delivered by this bird which had also been observed to have been delivered by other birds was a single Eumesogrammus.

Individual variation in prey selection has also been documented by Slater and Slater (1972) and Cairns (1981) for Black Guillemots, and by Drent (1965) for the congeneric Pigeon Guillemot (C. columba).

Kleptoparasitism

Parasitic Jaegers were seen on or near Pitsulak City on eight days in August and early September. Most of the time the birds appeared alone, but on two occasions two were seen together.

The jaegers typically hunted by making aerial patrols over the guillemot loafing grounds near the colony. The only guillemots that were pursued were those that were carrying fish in flight. The intended victim would react by plunging straight into the water. If this manoeuver was not performed quickly enough, the jaeger would overtake the guillemot and the latter would drop its fish before diving. Two of the six attacks of this nature which I witnessed were successful.

Occasionally a jaeger would fly low over a fish-carrying guillemot on the water, but the guillemot always had time to dive before the jaeger reached it. On one occasion a jaeger was observed to fly past a group of guillemots sitting on a rock near the water's edge. Although the jaeger was about 20 m from the group, all the guillemots flew directly to the water.

On only one occasion was a jaeger seen to pursue a guillemot

Table 6

Identified food deliveries by marked Black Guillemots at Subcolony F, Pitsulak City, 22-26 August[a].

adult	number of deliveries of					
	Boreogadus saida	*Ammodytes americanus*	*Cryptacanthodes maculatus*	*Eumesogrammus praecisus*	*Stichaeus punctatus*	Cottidae
blue D	-	-	2	2	-	-
orange 9	-	-	-	-	4	-
orange 10	2			1	1	-
orange 15	-	2	-	1	-	5

[a] species composition of prey differs among individuals (G=40.0, $P<.005$).

flying over land. In this case the guillemot continued to fly directly to its nest, which it reached just as the jaeger was catching up with it.

On 3 August, an incident was witnessed in which the tables were turned between the two species. I first noticed a jaeger and a guillemot flying abnormally high (ca. 40 m). The guillemot seemed to be able to stay above the jaeger, and made diving passes at it. I was unable to follow events to their conclusion because both birds disappeared into the fog.

Herring Gulls occasionally perched on rocks at Pitsulak City during the chick-rearing season, which made guillemots noticably reluctant to visit nearby nest sites. I saw only one attempt by a Herring Gull to take a guillemot's fish. This incident occurred over the water, and was successful from the gull's point of view.

No jaegers were seen at Pitsulak City before 3 August, but this does not prove that this was their arrival date, since comparitively little time was spent on the island before this date.

ADULT DIETS

The stomaches of all 22 Black Guillemots collected contained prey remains. Contents of each gut are listed in Appendix 1, and results are summarized in Table 7.

All but one of the samples contained fish bones, otoliths, or soft tissues. Boreogadus saida otoliths were present in 13 stomachs, and comprised 77% of fish food items as indicated by otolith counts (although this ratio may be upwardly biased by the larger size, and presumably longer stay in the gut, of Boreogadus otoliths). Eumesogrammus praecisus and Stichaeus punctatus comprised the remainder of the identified sample, and were found in four and six stomachs, respectively. These species were also less numerous in stomachs that contained them than was Boreogadus (1.0 and 1.2 vs. 4.6 items per stomach for Eumesogrammus, Stichaeus, and Boreogadus, respectively; G=21.8, $P<.005$). Eleven small otoliths were not identified, but might have come from juvenile members of the species mentioned above.

Eight of the stomachs contained crustacean remains, but the bulk of these came from two stomachs containing 49 and 124 mysids. Amphipods and decapods were present in small numbers in three and two stomachs, respectively.

Eight stomachs contained polychaete jaws, but no other parts of this group were found. The jaws were concentrated in two samples, which contained 31 of the 54 items recorded.

The prey spectrum of the Black Guillemots collected during this study differs markedly from that recorded by Smith and Hammill (1980) for 30 guillemot stomachs from southeastern Baffin Island. There, guillemots took liparid and cottid fish larvae, Parathemisto, Mysis, and cephalopods. The difference between these results and my own may be due in part to the timing of collection; Smith and Hammill's (1980) field work ran between March and October, although they did not specify the dates on which they collected guillemots.

Stomachs of Black Guillemots collected by Bradstreet (1980) in Barrow Strait during spring contained a majority of Boreogadus saida. At coastal ice edges, diet was almost exclusively Boreogadus, but at

Table 7

Stomach contents of 22 Black Guillemots shot near Ivugivik, Quebec

prey taxon	number (and %) of stomachs containing given numbers of items[a]					number (and %) of stomachs containing taxon	mean number items/ stomach	
	0	1-4	5-9	10-49	50		for stomachs containing taxon	for all stomachs
<u>Fish</u>								
Boreogadus saida	9 (41)	6 (27)	5 (23)	2 (9)	0	13 (59)	4.6	2.7
Eumesogrammus praecisus	18 (82)	4 (18)	0	0	0	4 (18)	1.0	0.2
Stichaeus punctatus	16(73)	6 (27)	0	0	0	6 (27)	1.2	0.3
unidentified	2 (9)	20 (91)	0	0	0	20 (91)		
total fish	1 (5)	13 (59)	5 (23)	3 (14)	0	21 (95)	4.9[b]	3.5[b]
<u>Crustacea</u>								
Mysidae	17 (77)	3 (14)	0	1 (5)	1 (5)	5 (23)	36.0	8.2
Amphipoda	19 (86)	3 (14)	0	0	0	3 (14)	2.0	0.3
Decapoda	20 (91)	2 (9)	0	0	0	2 (9)	2.5	0.2
total Crustacea	14 (64)	5 (23)	1 (5)	1 (5)	1 (5)	8 (36)	23.9	8.7
<u>Polychaeta</u>	14 (64)	6 (27)	2 (9)	0	0	8 (36)	3.5	1.3

[a] number of fish or polychate items = number of otoliths or jaws/2, rounded up to the nearest individual

[b] includes unidentified otoliths, but not bones and soft tissue

offshore ice edges the amphipods Onisimus and Apherusa comprised 40% of the diet. The dominant position of Boreogadus in spring diets of Barrow Strait guillemots seems to be repeated for the summer diets of the guillemots of the Nuvuk area. However, the major invertebrate taxa found in the Barrow Strait stomachs were not recorded in the present study.

That Black Guillemots feed their young on fish, but take both fish and invertebrates for their own use, has been confirmed by many studies (Petersen 1981, Belopol'skii 1957, Hartley and Fisher 1936, Cairns 1981, Winn 1950, Preston 1968). The reason for this appears to be that most invertebrate prey available to guillemots is too small to be economically transported from the feeding ground to the colony. The near exclusivity of fish in the diet may also be related to the greater proportion of digestible material in fish than in most invertebrates.

In the present study adult and chick diets were found to differ not only in invertebrate content, but in the species composition of fish prey as well. Although over three quarters of the fish prey items found in adult stomachs were Boreogadus, this species comprised only 13% of chick diet by number, and 5% by weight (Table 3). The paucity of Boreogadus in chick diets is related to its small size; the mean weight from samples collected whole was only 5.5 g, and weights of fish from the stomachs must have been of the same order given the similarity of the lengths of fish collected whole to lengths estimated from otolith measurements (Table 3, Appendix 1). Thus guillemots find it advantageous to ferry the larger (15-20 g) blennies to their young rather than eating them themselves, and conversely, the small Boreogadus are used for their own sustenance, rather than being transported to the young.

DISTRIBUTION OF BIRDS ON THE WATER

Distributions of seabirds in the waters of the Nuvuk area were recorded in 12 transects between 15 and 23 August (Figs. 12-18). Most guillemots were recorded on transects connecting Pitsulak City, Gingi Island and the South Skerries, but their distribution patterns within this area were not consistent among the three sampling days. Most of the guillemots seen in flight along these transects were headed towards or away from Pitsulak City, suggesting that they were members of that colony.

Guillemots leaving Area F on Pitsulak City after feeding their young almost invariably headed southwest, and some were seen splashing down on the water at the limit of binocular resolution, to the northwest of Gingi Rock 2. I suspect that the two shoals in this area (6 and 11 m deep, Fig. 19) may have been the destination of many of these birds, but unfortunately the transects did not cross these shoals.

Transects among the South Skerries, North Skerries, and Fairway Island were nearly devoid of guillemots, except in the immediate vicinity of Fairway Island. Consistent small concentrations of guillemots on the water were also noted in Nuvuk Bay during the transects and in casual observations.

Thick-billed Murres were recorded on all transects, but the greatest concentrations were found on transects to and from Fairway Island. This area is a major flyway for murres of the Digges Sound colonies as indicated by the large number of birds flying northeast and southwest. At least some of the time many of these birds continue beyond this area; on 8 August between 1542 and 1552 I counted by telescope 1030 murres moving south between Pitsulak City and the South Skerries. Between 1554 and 1604 on the same day I counted 3460 murres flying north. Many birds were also found on the water in the area, but utilization varied between days. For example the extreme concentrations (up to 700 sightings/min) found on 15 August northeast of the South Skerries (Fig. 15) were absent on 20 August, when only a handful of murres were seen on the water in the area.

Bottom contours of the areas in which transects were run are presented in Figs. 19-21. Sighting frequencies of Black Guillemots

Fig. 12

Seabird transects in the Pitsulak City area, 15 August. Stacked symbols indicate the number of sightings per minute. Species code in the legend is as follows: BG - Black Guillemot, TBM - Thick-billed Murre, AP - Atlantic Puffin, NF - Northern Fulmar, CE - Common Eider, JR - jaeger, GU - gull, AT - Arctic Tern. Time and date of the beginning of each transect are given near the transect start point. Arrows on transect line indicate direction in which transect was run.

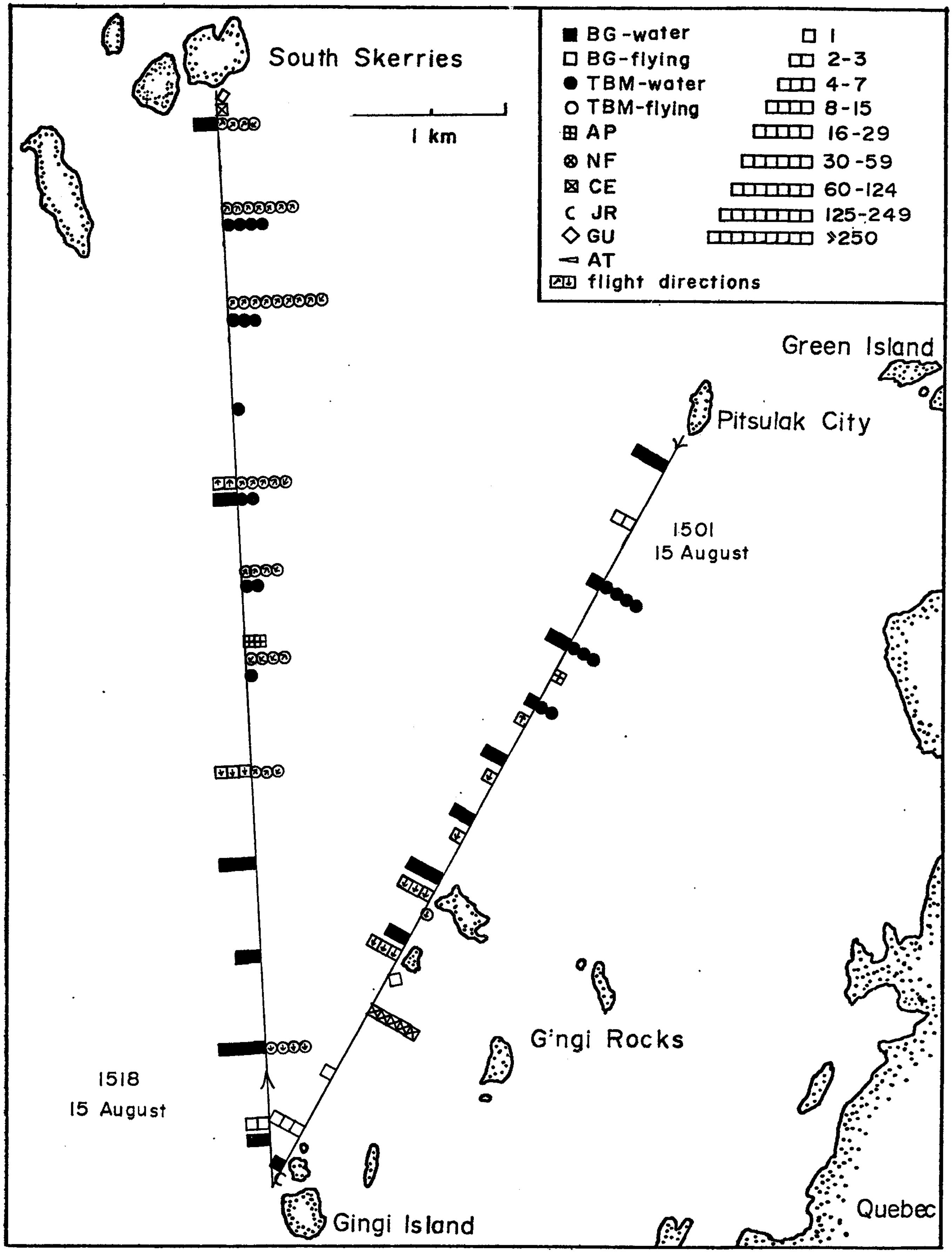
South Skerries
1 km
BG-water
BG-flying
TBM-water
TBM-flying
AP
NF
CE
JR
GU
AT
flight directions
1
2-3
4-7
8-15
16-29
30-59
60-124
125-249
>250
Green Island
Pitsulak City
1501
15 August
G'ngi Rocks
1518
15 August
Gingi Island
Quebec

Fig. 12

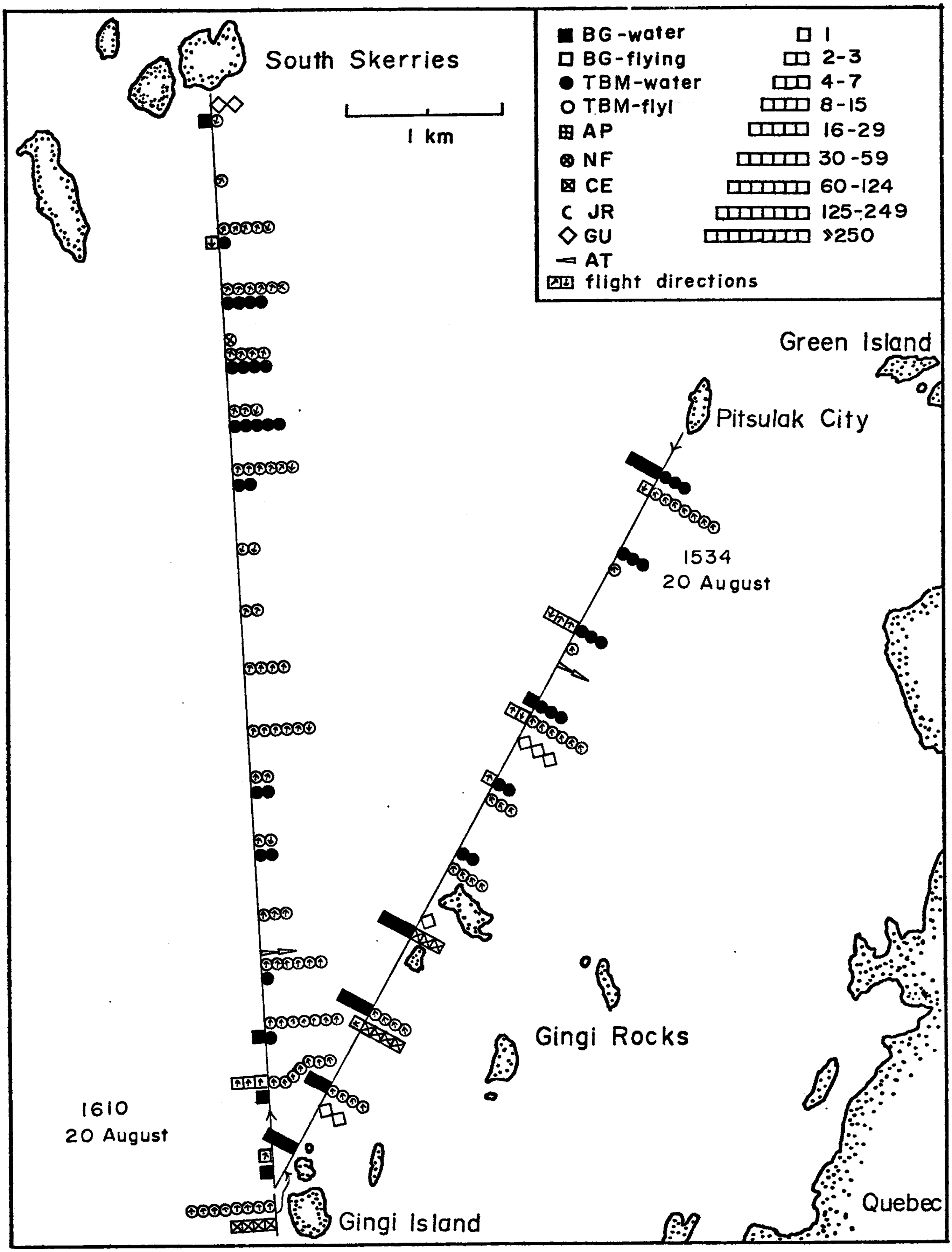

Fig. 13

Seabird transects in the Pitsulak City area, 20 August. See notes in caption of Fig. 12.

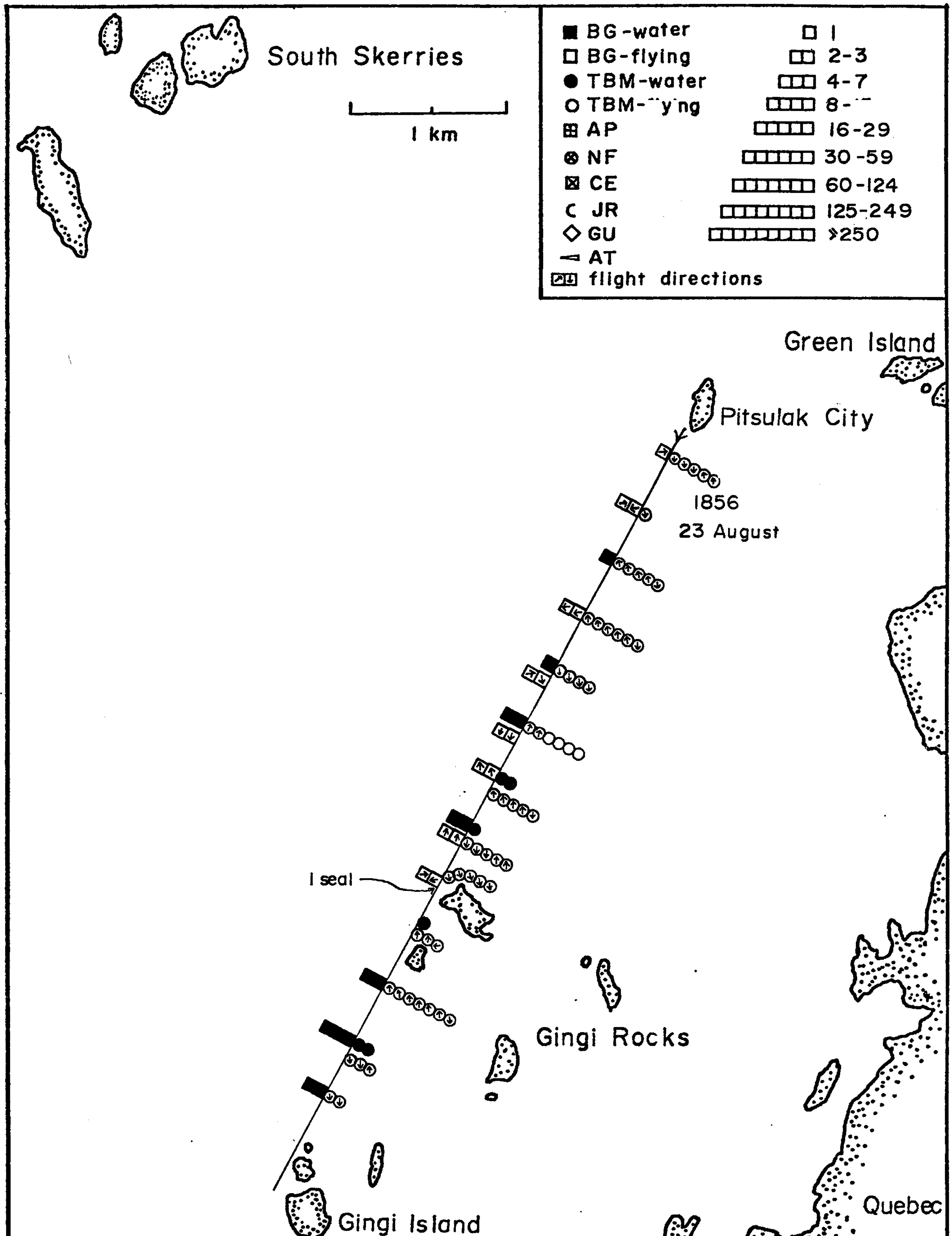

Fig. 14
Seabird transect in the Pitsulak City area, 23 August. See notes in caption of Fig. 12.

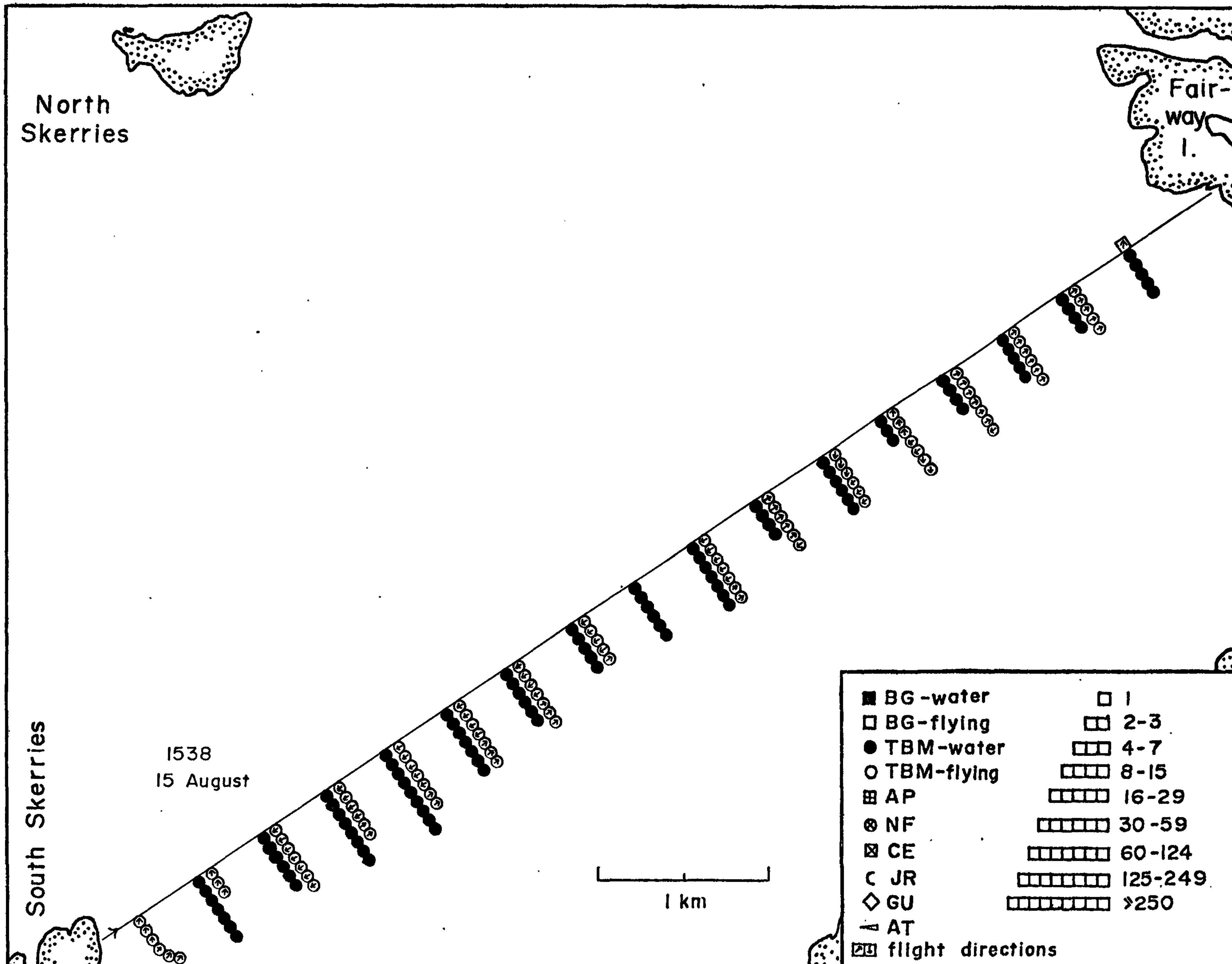

Fig. 15
Seabird transect in the Skerries area, 15 August. See notes in the caption of Fig. 12.

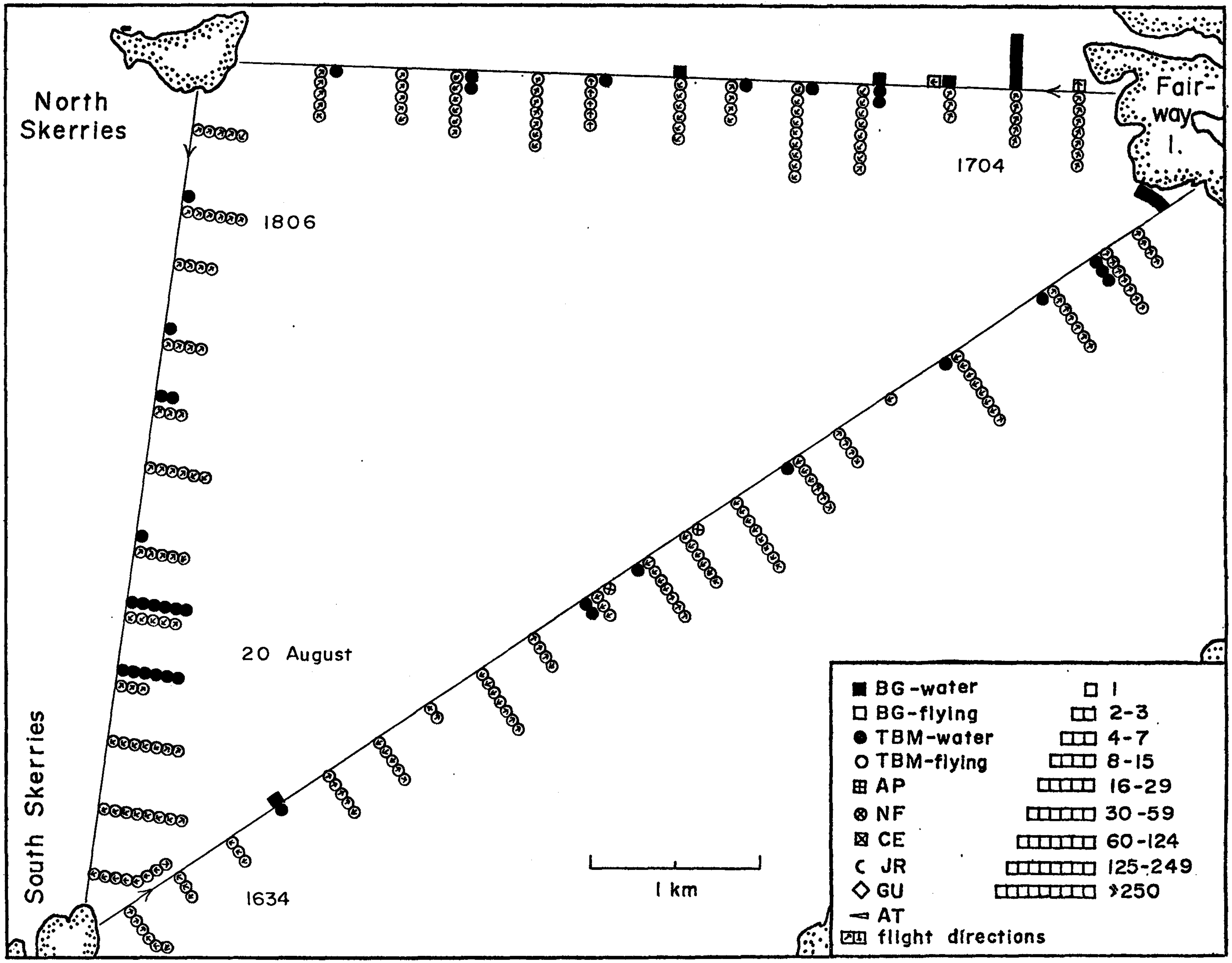

Fig. 16
Seabird transects in the Skerries area, 20 August. See notes in caption of Fig. 12.

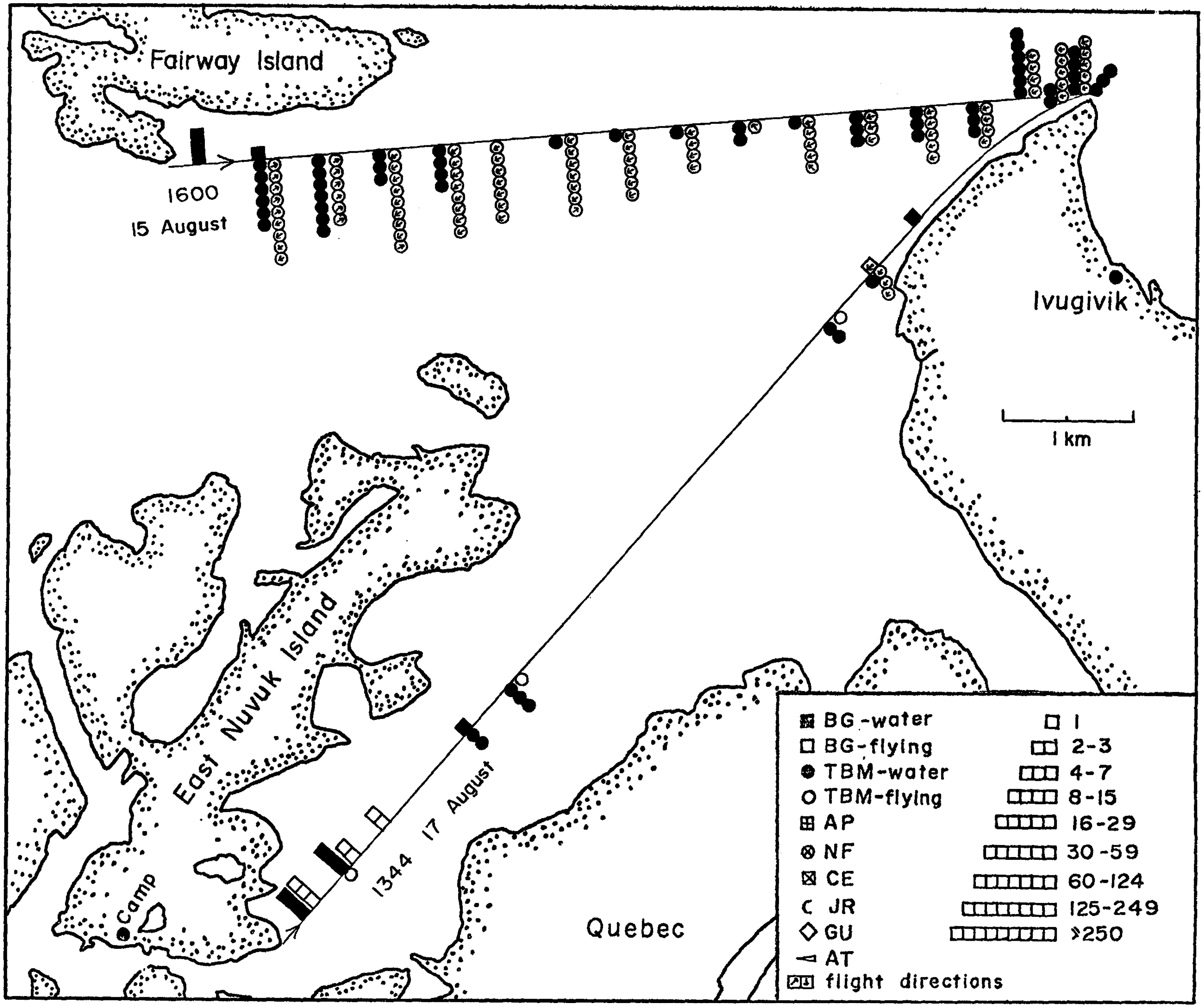

Fig. 17
Seabird transects in the Nuvuk Harbour area, 15 and 17 August. See notes in caption of Fig. 12.

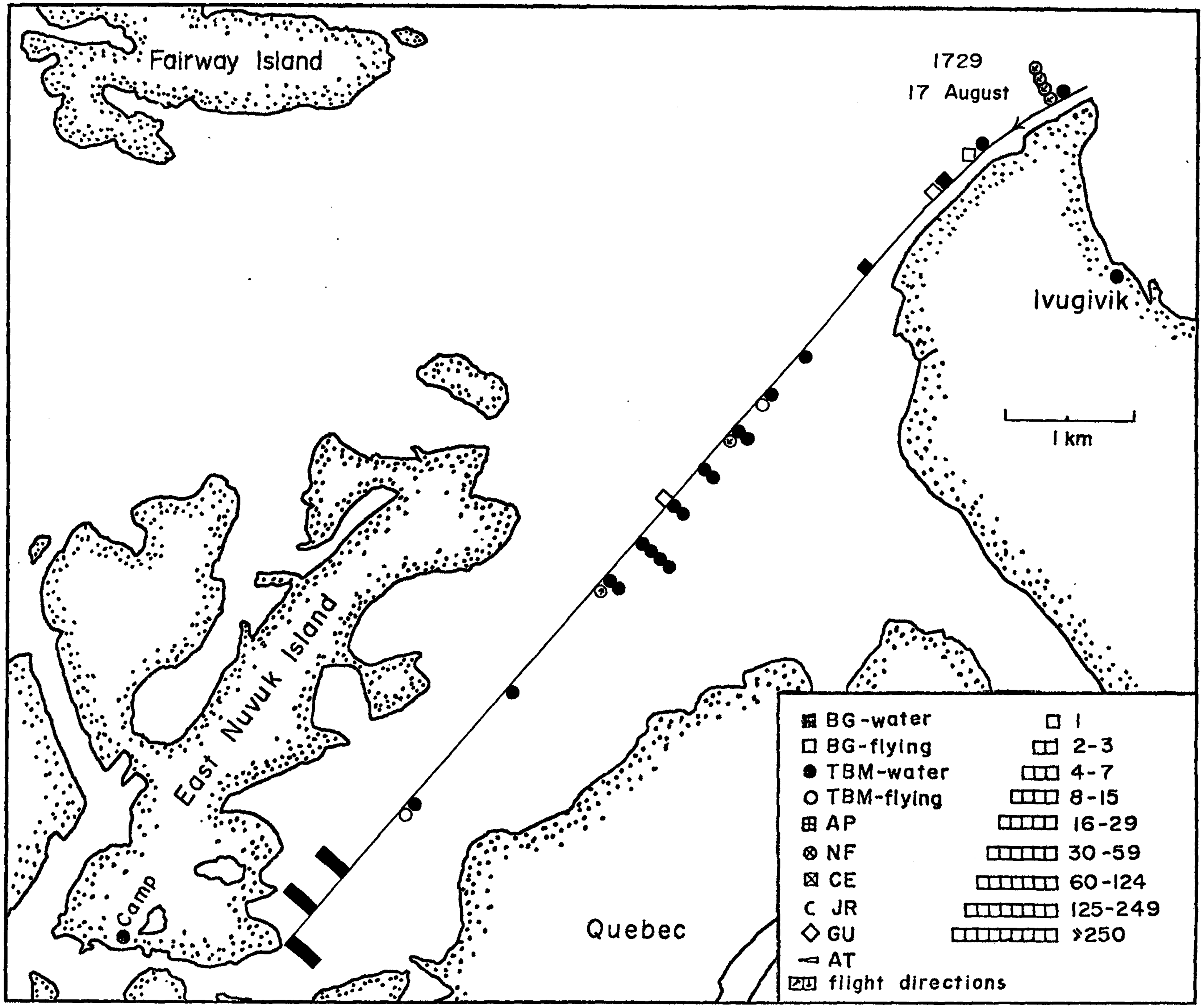

Fig. 18.

Seabird transects in Nuvuk Harbour, 17 August. See notes in caption of Fig. 12.

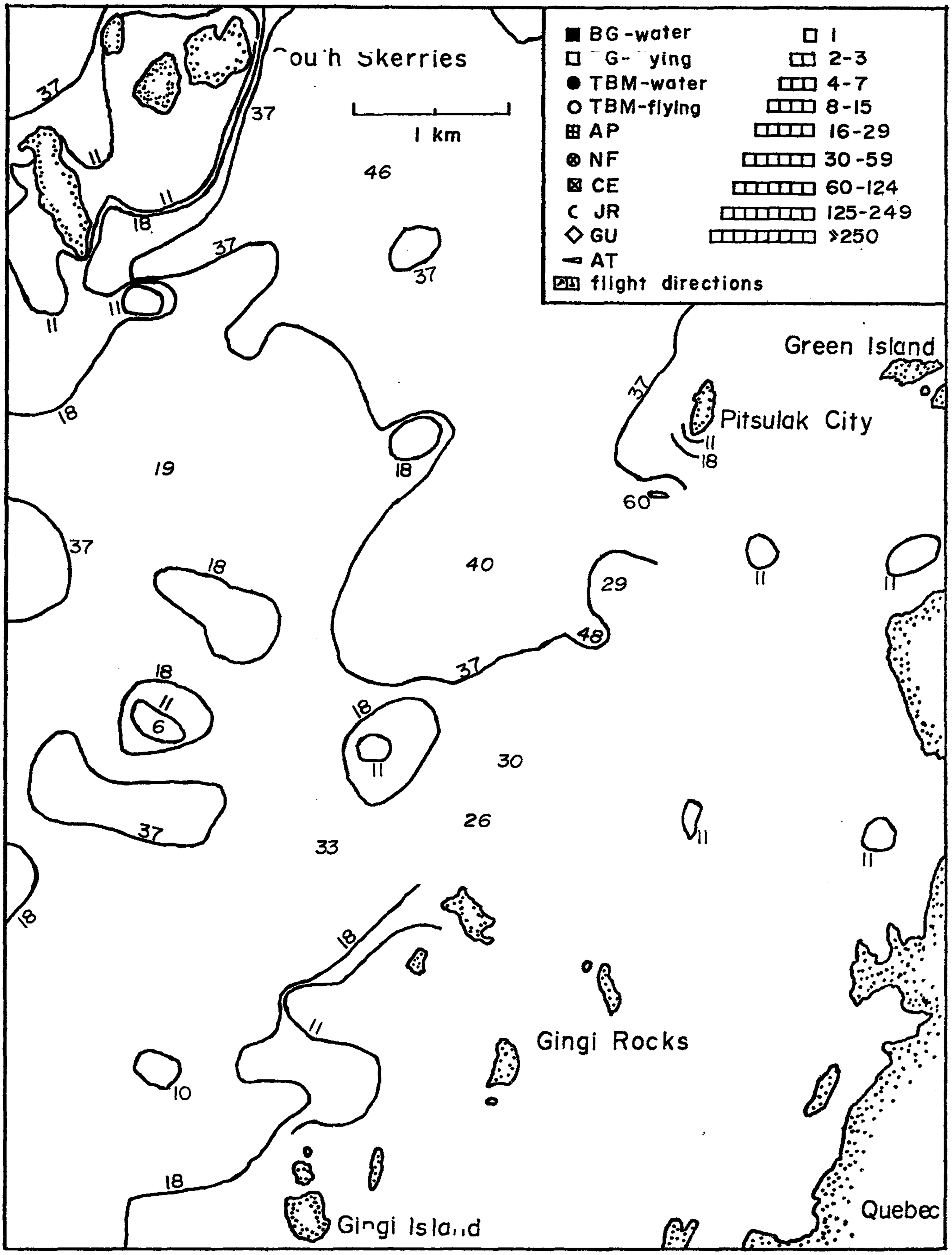

Fig. 19
Bottom contours in the Pitsulak City area. Depths in meters. Spot soundings italicized.

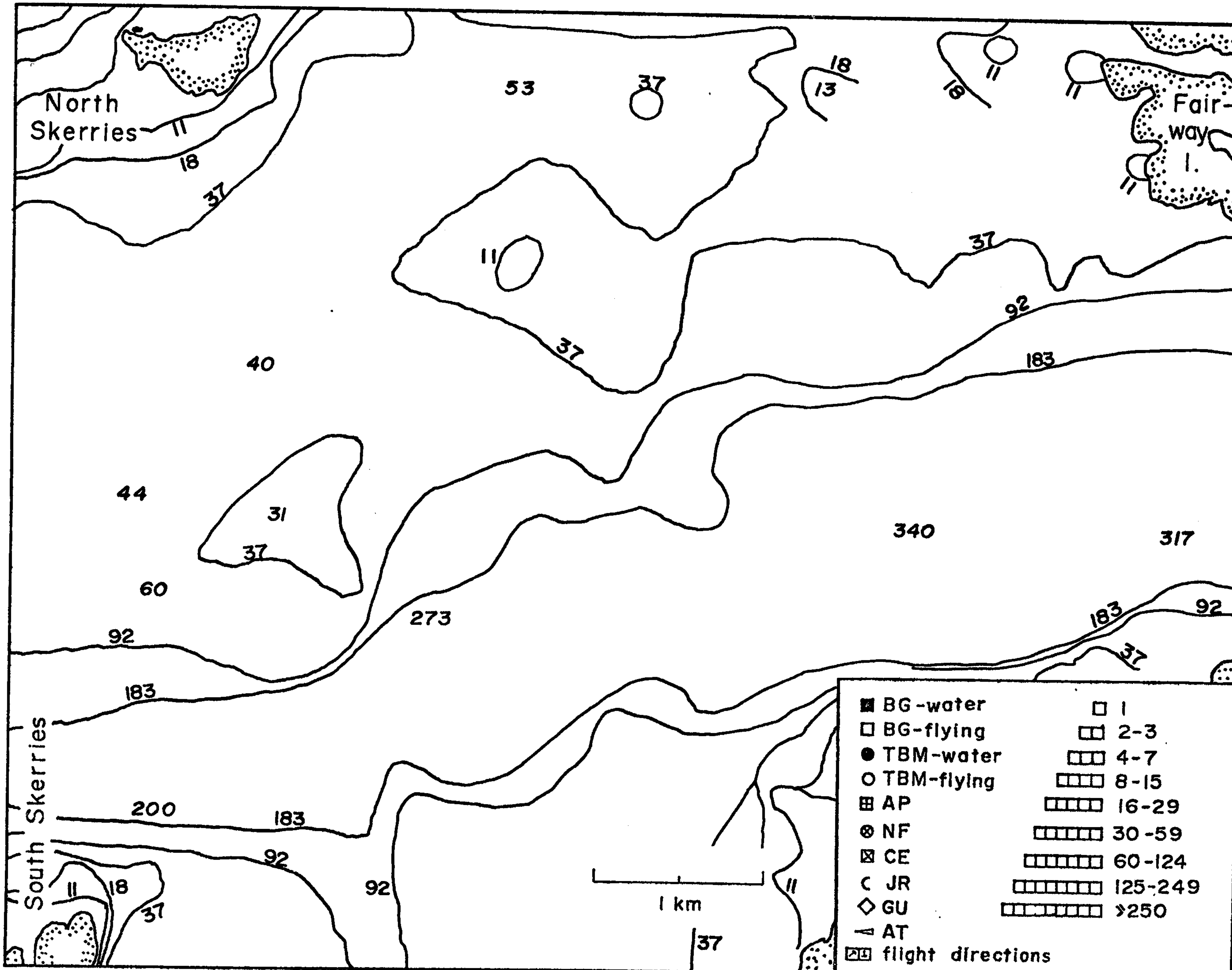

Fig. 20

Bottom contours in the Skerries area. Depths in meters. Spot soundings italicized.

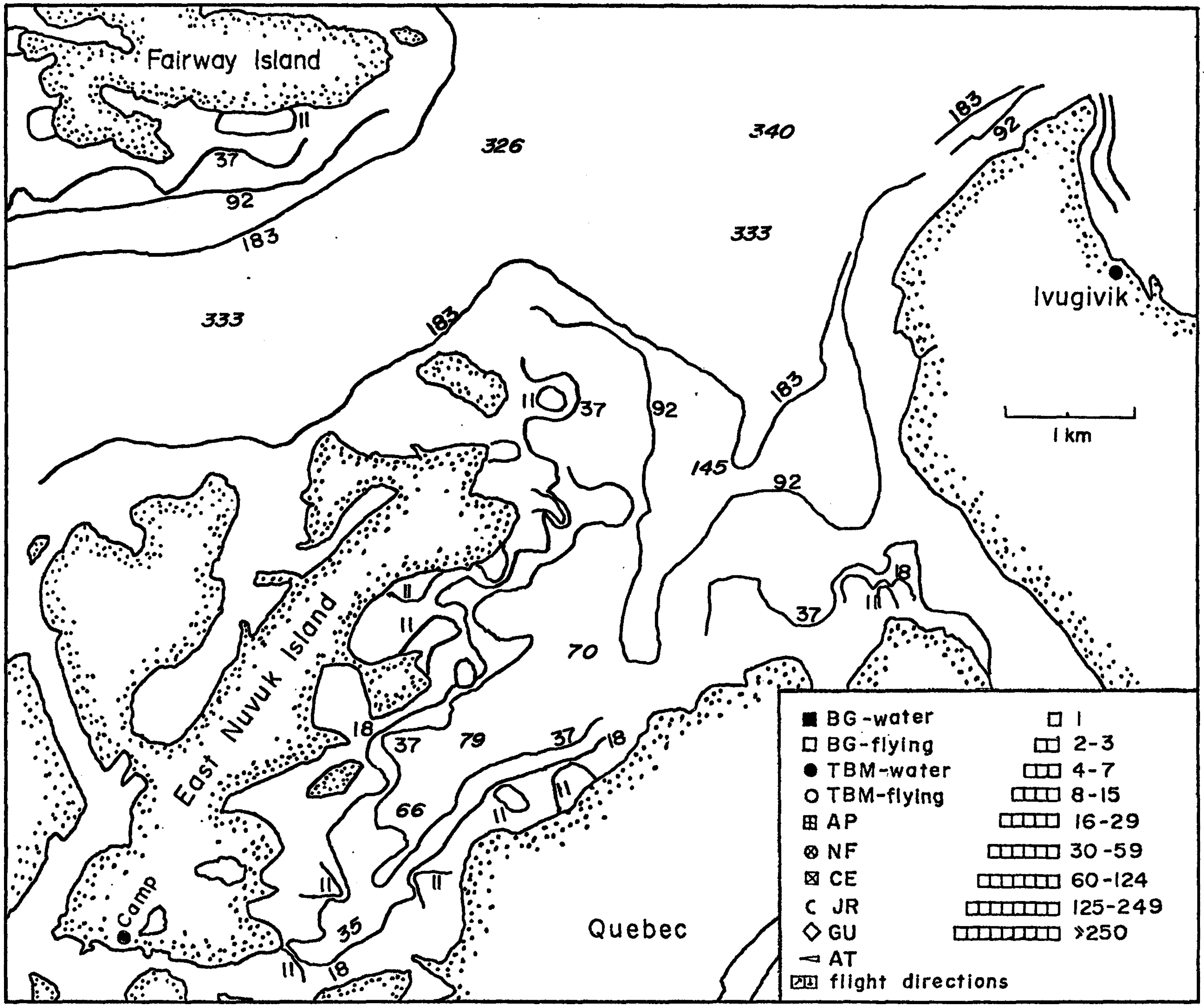

Fig. 21

Bottom contours in the Nuvuk Harbour area. Depths in meters. Spot soundings italicized.

and Thick-billed Murres on the water are compared for various water depths in Fig. 22. Guillemots were found most often in shallow areas, and virtually all sightings were made in water less than 37 m deep. The frequencies of murres, on the other hand, increased with depth, and were highest in waters deeper than 183 m.

It may be argued that the habitat segregation apparent in Fig. 22 is artifactual, and due to the fact that the deeper waters of the study area are closer to the Digges Sound murre colony, and the shallow waters are closer to the guillemot colonies of Pitsulak City and Green Island. But this is unlikely to be an important cause of the separation because the shallow areas near Pitsulak City are only slightly farther from the murre colonies than is the deep trench south of Fairway, and because guillemots were found in several areas (e.g. Nuvuk Bay, Figs. 17 and 18; Fairway Island, Fig. 16) at the edge of deep water, but not in it.

Guillemots probably choose shallow habitats because their benthic prey is more abundant or more easily obtained there. If birds sighted on the water during transects can be assumed to be foraging, then Fig. 22 suggests that most feeding takes place in water shallower than 18 m, and the remainder occurs between 18 and 37 m. Murres do not share the benthic specialization of guillemots, but it is uncertain at what depth the murres encountered on these transects are taking their prey.

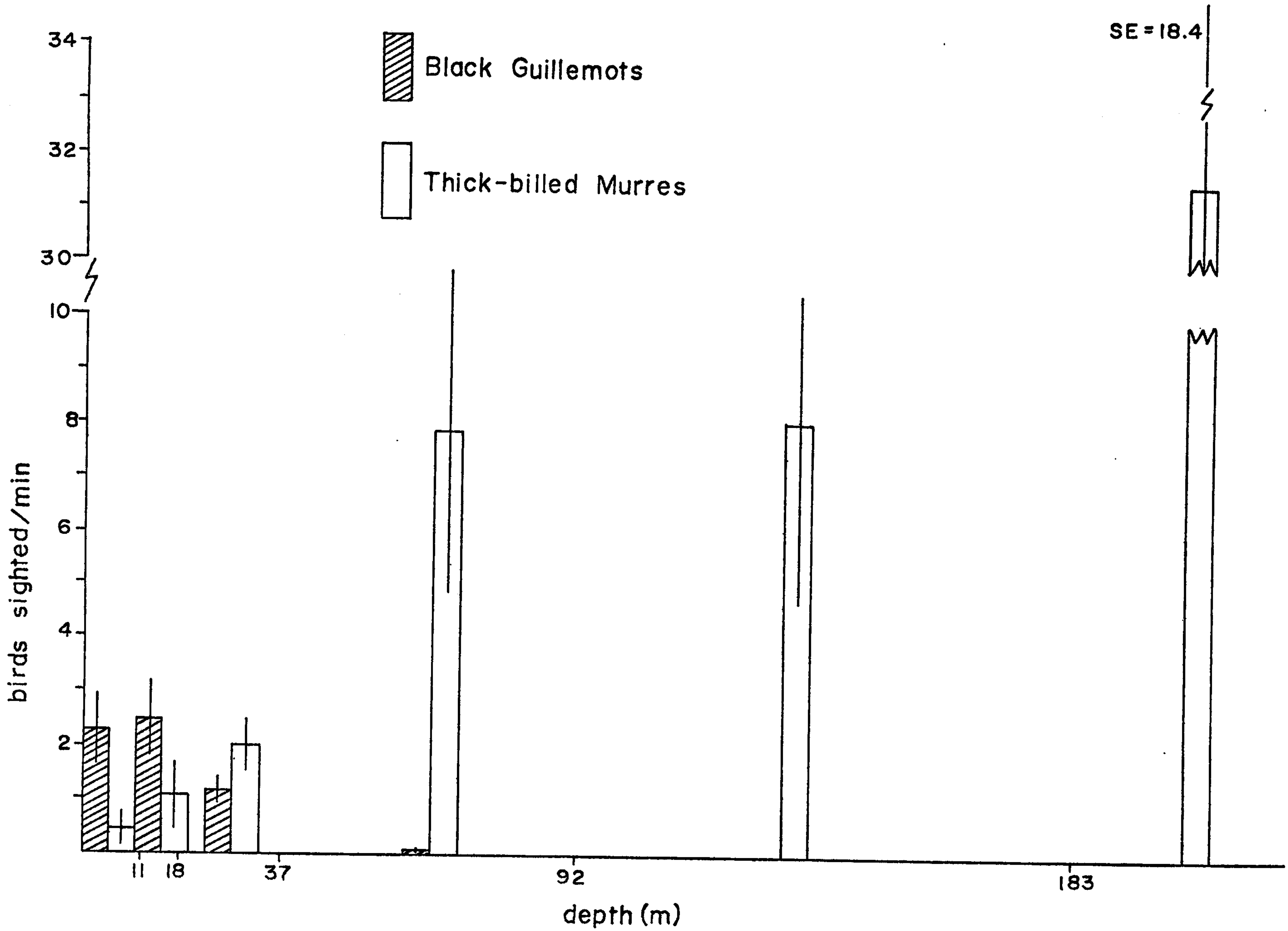

Fig. 22

Number of Black Guillemots and Thick-billed Murres sighted on the water in relation to water depth. Vertical bars indicate ± one Standard Error.

BANDING AND MARKING

One hundred adult and 168 young Black Guillemots were caught and banded. Chicks were fitted with an aluminum band on the right leg and a blue year-class band on the left leg, but adults received a variety of leg bands, wing tags, painted wing marks, streamers, and radio transmitters. The devices and marks applied to each adult are listed in Appendix 2.

Thirty-seven guillemots were marked with patagial tags, mostly on Green Island and Pitsulak City. The majority of these birds were caught in mist nets as they flew toward their nests, but some were caught in noose carpets set on club rocks near the water's edge, or near their nest entrances. Although all but one of these birds were in breeding condition when caught, as indicated by well-developed brood patches, none was subsequently seen atteding a nest. In Area C, the nests of all five birds that received patagial tags were abandonned after tagging. On several occasions untagged birds were seen incubating these nests after their partners had been tagged, but they were evidently unable to maintain their clutches alone.

Most tagged birds were never re-sighted, and must have left the area completely. A few sightings of birds tagged on Pitsulak City were recorded at Simik Inlet and Nuvuk Bay, and we made scattered observations of tagged birds around Pitsulak City. Tagged birds were only seen on land in the company of large groups of socializing, non-fish-carrying birds, which were presumably non-breeders or failed breeders.

We encountered some difficulty in securing the tags on the birds' wings, especially early in the season, but the trauma of the operation cannot be the reason that tagged birds deserted the colony, because many birds which were tagged very rapidly, and without apparent discomfort, were also never re-sighted. The possibility that the paucity of re-sightings was due to tag loss can also be discounted, because no birds were ever seen bearing only one tag, and because tagged birds also carried leg bands which would have been seen if they had come on land.

Six Black Guillemots were also fitted with radio transmitters. These birds left the immediate vicinity of the colony after release, but usually stayed within the 6 km range of the transmitters for several days before radio contact was lost. It is possible that some of these birds may have lost their radios because of improper attachment, but if they had returned to the colony without them, they would have been identified by their other marks.

The wing patches of 59 guillemots were marked with orange or blue airplane dope. This technique did not induce automatic nest desertion, since 13 of 15 known breeders which were wing marked in Area F before 26 August were subsequently seen delivering fish to nests there.

Nylon or plastic streamers were attached to the legs of 17 guillemots in Areas C and F of Pitsulak City. Because most of the streamers were lost shortly after attachment, and because their use did not begin until late in the season, their effect on guillemot behaviour is uncertain. Guillemots bearing streamers were not seen delivering fish to nests in Area F, but this is because most of the plastic streamers were lost shortly after attachment. Several guillemots which were fitted with nylon streamers stopped food deliveries after the streamers were attached, but this is not clear-cut evidence that the streamers induced desertion, since the nylon streamers were only used at the end of the season when many chicks were fledging.

One result of leg streamers was the lowering of flight speed. On several occasions guillemots without streamers were seen to overtake birds with long (20 or 30 cm) streamers. Birds carrying short streamers would likely suffer a smaller loss of flight speed.

Clearly patagial tags and tracking transmitters are unsuitable for monitoring the movements of Nuvuk Islands guillemots. The case against the radios is less clear-cut than that against the tags, because most of the radioed birds also carried tags. However, the disappearance of the two radioed birds which had not been tagged supports the notion that radios induce desertion.

PREY SAMPLING

In an attempt to learn something of the distribution of guillemot prey, nets and traps were set at various locations in Nuvuk Bay and Simik Inlet, between Black and Yellow Island, near the West and North Akiluk Rocks, between Green Island and Pitsulak City, and near Gingi Rock 2.

Despite their small mesh sizes the gillnet and the mist net were unsuccessful in catching small fish, and instead procured Greenland cod (Gadus ogac), Arctic char, and shorthorn sculpin, most of which were in the 30 - 50 cm size range. One hundred twenty of these fish were caught in 11 net days.

The minnow traps were set on the bottom, where they attracted large quantities of zooplankton, mostly amphipods, but no fish. The light traps set at various depths also caught amphipods, but no fish.

It is not clear why sampling the fish prey of the Black Guillemot has proven so difficult. The blennies that constitute much of this prey almost certainly occupy the kelp beds where the nets and traps were set. But this group seems to elude capture by conventional gear, and the only effective sampling technique appears to be direct capture by divers (Farwell et al. 1976).

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Appendix 1

Gut contents of Black Guillemots shot near Ivugivik, Quebec

spec-men no., brood patch?	time & date shot	where shot	% full	fish: *Boreogadus saida* whole speci-mens	*Boreogadus saida* no. otos.[a]	*Boreogadus saida* mean oto. length (mm) ±SD(n)	*Boreogadus saida* mean est. fish length (cm)[b]	*Eumesogrammus praecisus* no. otos.	*Eumesogrammus praecisus* mean oto. length (mm) ±SD(n)	*Stichaeus punctatus* no. otos.	*Stichaeus punctatus* mean oto. length (mm) ±SD(n)	unidentified no. otos.	unidentified mean oto. length (mm) ±SD(n)	unidentified other remains	crustaceans: Mysidae	Amphipoda	Decapoda	poly-chaetes no. jaws	other
BG-1 no	1645 11 Jul	500 m NW Gingi I. among ice	75		10	5.6± 1.0(4)	13.6							bones & flesh					2 rosettiform red algae 1 worm
BG-2 no	1700 11 Jul	100 m N Gingi I. among ice			15	5.3± 1.3(5)	13.0							well digested					
BG-3 yes	1700 11 Jul	100 m N Gingi I. among ice			2	2.4± 0.4(2)	6.9					1	2.6						1 piece red algae, 1 pebble
BG-4 yes	1715 11 Jul	ENE GR6 SSW GR5 among ice	100	4	21	4.0± 0.7(14)	10.3					2	(very worn)	bones & flesh					1 pebble
BG-5 yes	20 Jul	between Ivugivik & Digges	0		2														2 pebbles
BG-6 yes	20 Jul	between Ivugivik & Digges		1	17	4.5± 1.0(11)	11.4	1 (prob.)	2.9	2	4.3± 0(2)			very soupy					
BG-7 no	30 Jul	near Midway			19	4.6± 1.1(11)	11.4			2	6.9± 0(2)			well digested		1 *Gammarus wilkitzkii*			
BG-8 yes	30 Jul	near Midway	100		2	3.9± 0.1(2)	10.0			3	1.5± 0(3)			a few bones	124, prob. all *Mysis oculata*		1 *Lebbeus polaris*, 2 *Lebbeus* sp.		small piece red algae
BG-9 yes	30 Jul	near Midway	50	1	10	5.3± 1.6(7)	13.1	1 (prob.)	2.4					many bones	1, prob. *Mysis*			2	
BG-10 yes	30 Jul	near Midway	100							2	4.3± 0(2)			bones, flesh				18	
BG-11 no	30 Jul	near Midway	5											a few bones				4	
Bg-12 yes	30 Jul	near Midway	20		9	4.0± 1.1(3)	10.4							some bones	2 *Mysis*				1 worm

specimen no.	time & date shot	where shot	% full	fish: *Boreogadus saida* whole specimens	*Boreogadus saida* no. otos.	*Boreogadus saida* mean oto. length (mm) ±SD(n)	*Boreogadus saida* mean est. fish length (cm)	*Eumesogrammus praecisus* no. otos.	*Eumesogrammus praecisus* mean oto. length (mm) ±SD(n)	*Stichaeus punctatus* no. otos.	*Stichaeus punctatus* mean oto. length (mm) ±SD(n)	unidentified no. otos.	unidentified mean oto. length (mm) ±SD(n)	unidentified other remains	crustaceans: Mysidae	Amphipoda	Decapoda	polychaetes no. jaws	other
JAC-1 yes	1600 13 Aug	Ice Hbr.	40		2			1	2.4	2	2.2 (1)			part of fish body		3 *Gammarus* sp., 1 *Ampelisca macrocephala*			
JAC-2 yes	1600 13 Aug	Ice Hbr.	10											some bones				2	
JAC-3 no	1600 13 Aug	Ice Hbr.	100		2	7.6 (1)								mushy tissue, bones					3 pebbles
JAC-4 yes	1600 13 Aug	Ice Hbr.	0															6	
JAC-5 yes	1600 13 Aug	Ice Hbr.	15											bones, little flesh					
BG-13 no	1500 28 Aug	near Midway	5		4	3.5± 0.2(4)	9.3			1 (prob.)	3.1 (1)	4	0.5± 0.2(4)	some bones					
BG-14 no	1500 28 Aug	near Midway	2											a few bones					1 pebble
BG-15 no	1500 28 Aug	near Midway	25									3	0.3± 0(3)	bones			1 pos. decapod, 1 *Eualus fabricii*	3	
BG-16 yes	1500 28 Aug	near Midway	75											a few bones	49; at least 1 is *M. oculata*	(unidentified crustacean remains fill remainder of gut)		6	
BG-17 yes	1500 28 Aug	near Midway	25					1	2.9			1	0.6	75% of contents is fish	2, plus 2 prob.	1 prob.		13	

[a] number of whole otoliths, plus the minimum number of otoliths from which the fragments present could have been derived

[b] from the equation fish length (cm)=2.08(otolith length (mm))-1.955