NUMBERS AND DISTRIBUTION OF MUSKOXEN IN THE QUEEN MAUD GULF AREA, JULY, 1982

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ABSTRACT

The numbers of muskoxen in the Queen Maud Gulf area, which includes muskox management units H1-1, H1-2, and part of F1-2, were estimated from a block survey along the drainages (high density stratum) and a transect survey of the areas between drainages (low density stratum). Coverage of the high density stratum was 70%; at the 95% confidence level the estimate was 2,180 - 3,066 muskoxen. The low density stratum received only 3% coverage and the resulting estimate was imprecise; at the 95% confidence level, the estimate was 3,240-8,584. The total population east of the Ellice River to the Kaleet River and south to 66°33'N was 5,857-11,275, at the 95% confidence levels. Subjectively, the lower estimate is more in accord with impressions gained during the survey. The total number of muskoxen observed on and off transect and during ferry flights was 3,751. This estimate was generated from 412 herds of a mean size of 13.2, excluding 139 solitary bulls. The numbers of muskoxen have been monitored by unsystematic aerial surveys since 1960 when only two muskoxen were observed. The population has increased since then and the distribution has spread from the Perry River east to the Kaleet River.

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INTRODUCTION

There are currently four muskox management units in the Queen Maud Gulf area (Fig. 1). Those management units were established in 1977 after completion of a reconnaissance survey in July 1976 (Spencer 1976) following requests from the hunters of Gjoa Haven to establish a muskox quota in the area (B. Hubert pers. comm. 1983). A subsequent survey in March 1979 (Boxer 1980) was made in response to requests by the Hunters' and Trappers' Associations of Cambridge Bay and Gjoa Haven which maintained that the muskoxen in the Queen Maud Gulf area were increasing. Later in 1979, R. Decker surveyed the area's wildlife for the Northern Land Use Information Series (NLUIS) mapping project. The surveys in 1976 and 1979 were unsystematic and could not be extrapolated to estimate population size. The results from those reconnaissance surveys do, however, suggest that the muskox population rapidly increased and was considerably larger than had been thought. The hunters of Gjoa Haven and Cambridge Bay requested further increases to the quotas, and hence an estimate of population size was required as the first step toward determining a suitable level of harvest. The first objective of the survey was to generate a population estimate and the second objective was to provide information to Gjoa Haven hunters on whether the muskox population was spreading east of the Simpson River. The third objective of the survey was to evaluate the use of linear transects, blocks, and unsystematic drainage surveys in estimating muskox numbers and determining distribution.

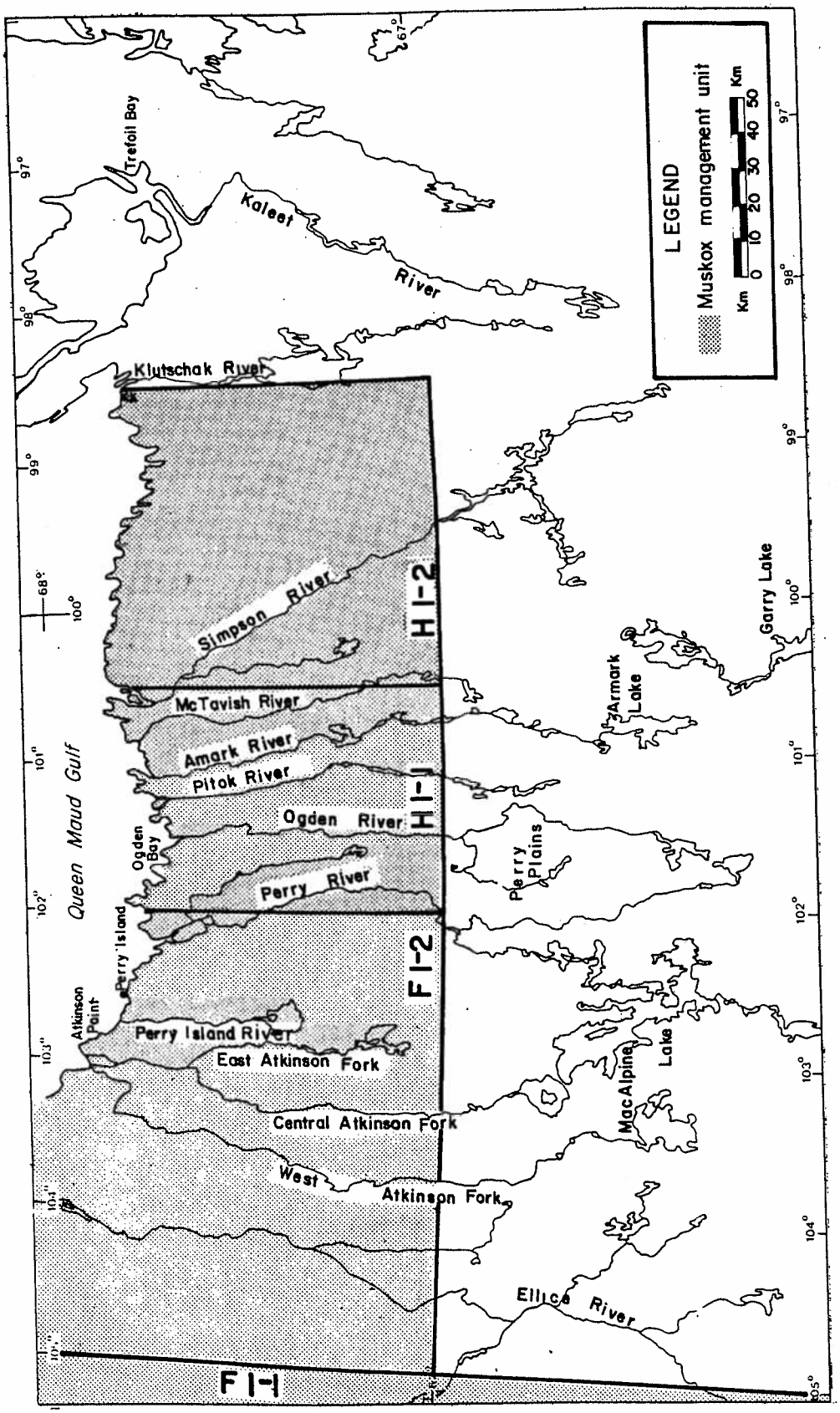

Figure 1. The study area and muskox management areas in the Queen Maud Gulf area.

STUDY AREA

The Queen Maud Gulf study area (Fig. 1) covers the central lowlands, which are delimited by the southern boundary of the limits of post-glacial marine transgression (Bird 1967). The east and west boundaries are the eastern and western uplands, respectively (Bird 1967). The central lowlands have low relief and gradually rise from the coast to a maximum of 200 m above sea level at MacAlpine Lake. The marine sediments overlie Precambrian rocks which form boulder fields or outcrops. The coastal areas tend to be rocky with long narrow valleys where tussocky sedge meadows form a continuous ground cover. Eriophorum vaginatum, Carex spp., Betula glandulosa, Ledum decumbens and Rubus chamaemorus are dominant species. On the rock outcrops and drier areas, grasses and dwarf shrub communities predominate.

The higher inland areas, 100 and 200 m agl, have a more extensive cover of marine sediments forming wide valleys and flat, poorly drained areas; outcrops, eskers and patterned ground are frequent. The eastern and western uplands are more elevated with extensive rock outcropping and boulder fields.

The climate is characterized by its dryness. The area has the lowest annual precipitation along the Canadian mainland arctic coast (Maxwell 1980). Annual mean total precipitation is approximately 150 mm increasing rapidly to the east and northeast to 200 mm east of the Back River (Fig. 2).

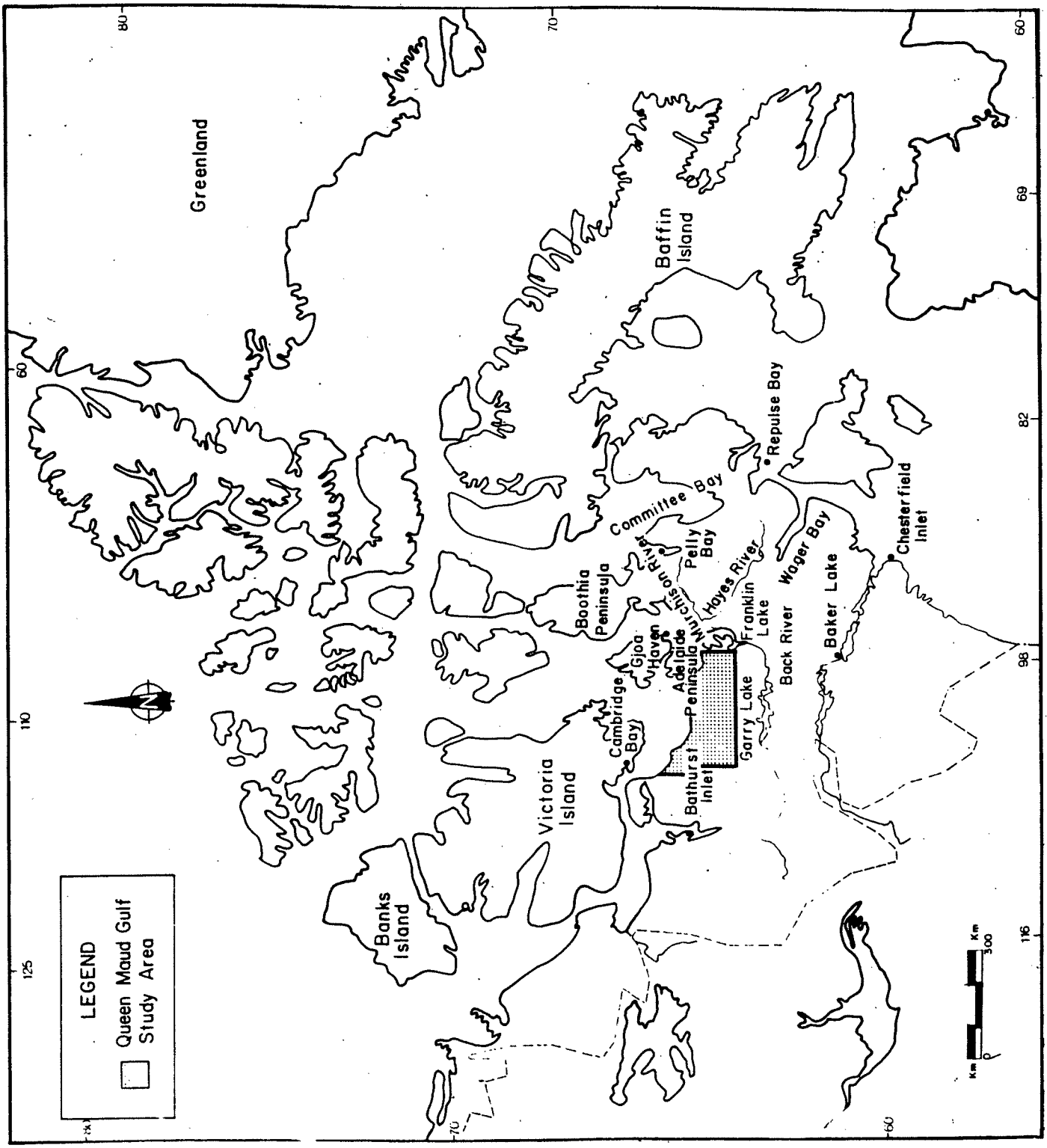

Figure 2. Northwest Territories map showing places named in the text.

Past Distribution of Muskoxen in the Study Area

The Queen Maud Gulf was one of the areas of the Canadian arctic mainland least explored by Europeans, and the lack of written accounts of the area means that evidence for the presence of muskoxen is scanty and conjectural. Simpson (1843), who sailed along the southern Queen Maud Gulf coast in July 1839, was the first European to visit the area. Simpson (1843) commented that the banks of the mouth of the Ellice River were much frequented by muskoxen. Back's accounts of the Adelaide Peninsula (Fig. 2) point to muskoxen being relatively common (In: Macpherson and Manning 1959). However, in 1855 Anderson did not see muskoxen on Adelaide Peninsula though he saw hides being used for tents near Franklin Lake (In: Macpherson and Manning 1959). Until Hanbury (1904) explored part of the area in 1902, there were no published European observations of the area as exploratory and trade activities were concentrated elsewhere.

The Hudson Bay Company (Tener 1965) recorded that during the periods 1862-1892 and 1896-1900, 3,300 muskox hides were traded at Chesterfield Inlet (Fig. 2). Possibly some of those hides originated from the Queen Maud Gulf area as well as north of Chesterfield Inlet. Comer (In: Hone 1934) wrote in 1912 that Chesterfield Inlet was the southern boundary for muskoxen and that they were quite abundant to the west and northwest of Wager Bay (Fig. 2). Comer noted that 40 muskoxen were killed near Wager Bay in 1911-1912 and sold to the Hudson Bay Company at Chesterfield Inlet (In: Hone 1934). Muskoxen may have also been traded or killed during trading trips to the east of the trading posts at

Bathurst Inlet. In 1911, for example, Eskimos traded 30 muskox hides from west of Kent Peninsula to a trading ship at the mouth of the Coppermine River (Hone 1934). The Ellice River, which was an important travel route from Baker Lake to Bathurst Inlet, was devoid of muskoxen when French (1919) travelled along it in May 1917, although Simpson (1843) had seen muskoxen there in 1839. Burwash (1931: In Hone 1935) related Eskimo reports that muskoxen could be found between Adelaide Peninsula and the head of the Perry River but that muskoxen were not found along the well-travelled routes between Chesterfield Inlet, Baker lake and the southern shore of Queen Maud Gulf. Neither Burwash (1931) nor Rasmussen (1927) saw muskoxen when they travelled along that coast. Anderson (1930: In Hone 1934) compiled sightings of muskoxen and also obtained reports of a remnant muskox population of about 50 between Adelaide Peninsula and the Perry River.

The evidence for muskoxen being in the Queen Maud Gulf area in the nineteenth century is conjectural, but can be surmised from the sightings along the Ellice River to the west and on Adelaide Peninsula and Committee Bay to the east (Rasmussen 1927). Hanbury (1904) believed many muskoxen inhabitated the Queen Maud Gulf area, but was told by Eskimos that the muskoxen had been killed or driven away. Equally, the cause of the apparent population declines, which coincided with cultural changes from contact from the activities of whalers and traders, is conjectural.

Sightings of muskoxen continued to be scarce from the Queen Maud Gulf area from at least the late 1930's to the 1970's. Gavin (1945) made journeys into the Queen Maud Gulf area from the Hudson

Bay post near the mouth of the Perry River between 1937 and 1940. Gavin noted (1945: 228) that a few muskoxen were occasionally seen during the year. The largest herds he saw were 12 and 15 muskoxen in May 1938 on the mainland of Flagstaff Island. Poncins (1941) did not see muskoxen along the Perry River or along the coast to Pelly Bay; however, he attests to the continued hunting of muskoxen in his reference on the use of muskox robes in an igloo and muskox meat. Hanson et al. (1956) did not see muskoxen when they travelled along the Perry River in 1949. Banfield (1951) saw no muskoxen during flights between Perry River and Bathurst Inlet in 1948 and 1949. Tener (1958) in his compilation of recent muskox sightings only recorded a sighting of muskoxen near Garry Lake though there were muskoxen at Bathurst Inlet and near the head of Committee Bay to the east, as well as in the country between the Hayes and Murchison Rivers.

Nevertheless, there were at least some muskoxen from the early 1900's to the 1950's in the area as Inuit now living at Baker Lake recall that their parents and grandparents hunted muskoxen with dog teams until 1956 while travelling between Garry Lakes and the coast (J. Niego pers. comm. 1983). In 1951 there were 141 Inuit living between the Ellice River and Sherman Inlet some of whom travelled as far inland as MacAlpine Lake (Hanson et al. 1956). By the 1960's all the people had moved to Cambridge Bay, Gjoa Haven or Baker Lake. Currently, there are only hunting trips to the area, and seasonal occupation of an outpost camp at the mouth of the Perry and Kaleet Rivers.

The discovery of nesting Ross' Geese (Anser rossii) (Gavin 1945) lead to studies of the geese in the 1960's and 1970's. An extensive aerial survey of geese (Table 1, Fig. 3) in August 1960 resulted in the sighting of two solitary bull muskoxen (T.W. Barry pers. comm. 1982). During aerial surveys in July 1965 (Table 1, Fig. 4), 5 muskoxen were observed in one herd, but 65 muskoxen in four herds were counted the following July (J. Ryder pers. comm. 1983). The slow increase continued and was documented furing additional geese surveys (Table 1) in 1971 and 1972 (Fig. 5) when 124 and 222 muskoxen were counted, respectively (E. Kuyt pers. comm. 1983). Two goose surveys were flown in 1975 (Table 1, Fig. 6); the number of muskoxen observed in July (342) and August (343) was almost identical.

The hunters of Cambridge Bay and Gjoa Haven were aware of the increase in the numbers of muskoxen in the Queen Maud Gulf area and were interested in obtaining a quota to hunt muskoxen. In response to their interest, an aerial survey was flown in July 1976 (Table 1, Fig. 7) and 836 muskoxen were counted (Spencer 1976). Subsequently, three muskox management areas were established (Fig. 1) with an original quota of 10 muskoxen for Gjoa Haven (units H/1-1, H/1-2) and 5 for Cambridge Bay (unit F/1-2).

The eighth summer aerial survey of the Queen Maud Gulf area was in July 1979 (Table 1, Fig. 8). The survey was part of the mapping for the Northern Land Use Information Series (Department of the Environment); 3,843 muskoxen were counted during the extensive flights over the area (R. Decker pers. comm. 1983).

Table 1. Dates, distances flown and aircraft used during surveys of Queen Maud Gulf area, 1958-1982.

Date Year	Month	Aircraft type	Flight distance (km)	Source
1958		Beaver		T.W. Barry unpubl.
1960		Beaver		T.W. Barry unpubl.
1965	July	Cessna 185	2,815	J. Ryder (1967)
1966	July	Cessna 185	3,260	J. Ryder (1967)
1971	August	Cessna 185	--	E. Kuyt pers. comm.
1972	July	Cessna 185	--	E. Kuyt pers. comm.
1975	July	Cessna 185		T.W. Barry unpubl.
1975	August	Bell 206B		T.W. Barry unpubl.
1976	July	Cessna 337	1,340	W. Spencer (1976)
1979	March	Turbo-Beaver	1,478	D. Boxer (1979)
1979	July	Cessna 185		R. Decker unpubl.
1982	July	Cessna 185		A. Gunn and R. Case (1984)

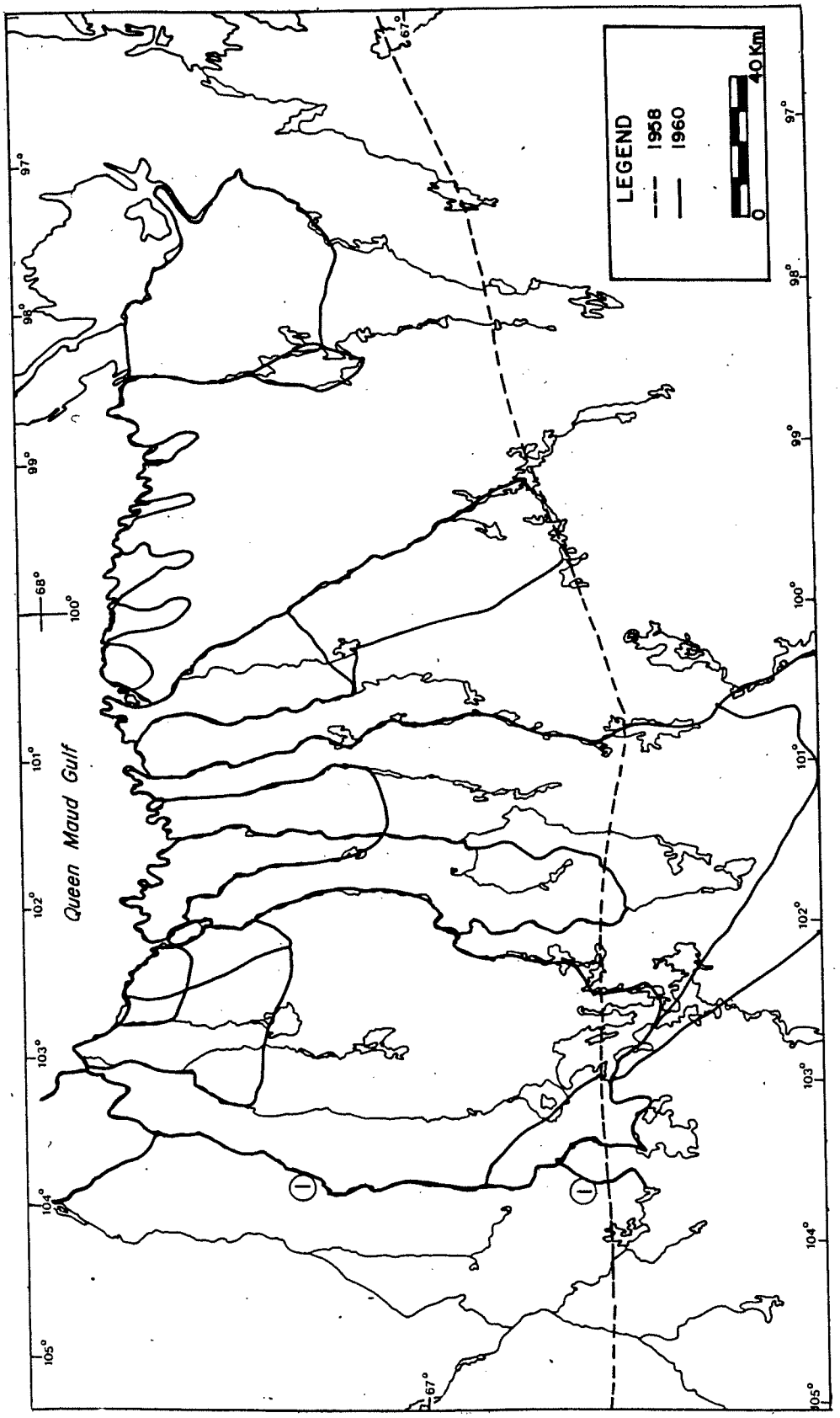

Figure 3. Locations of muskox herds counted during aerial surveys of geese in August 1960, Queen Maud Gulf area.

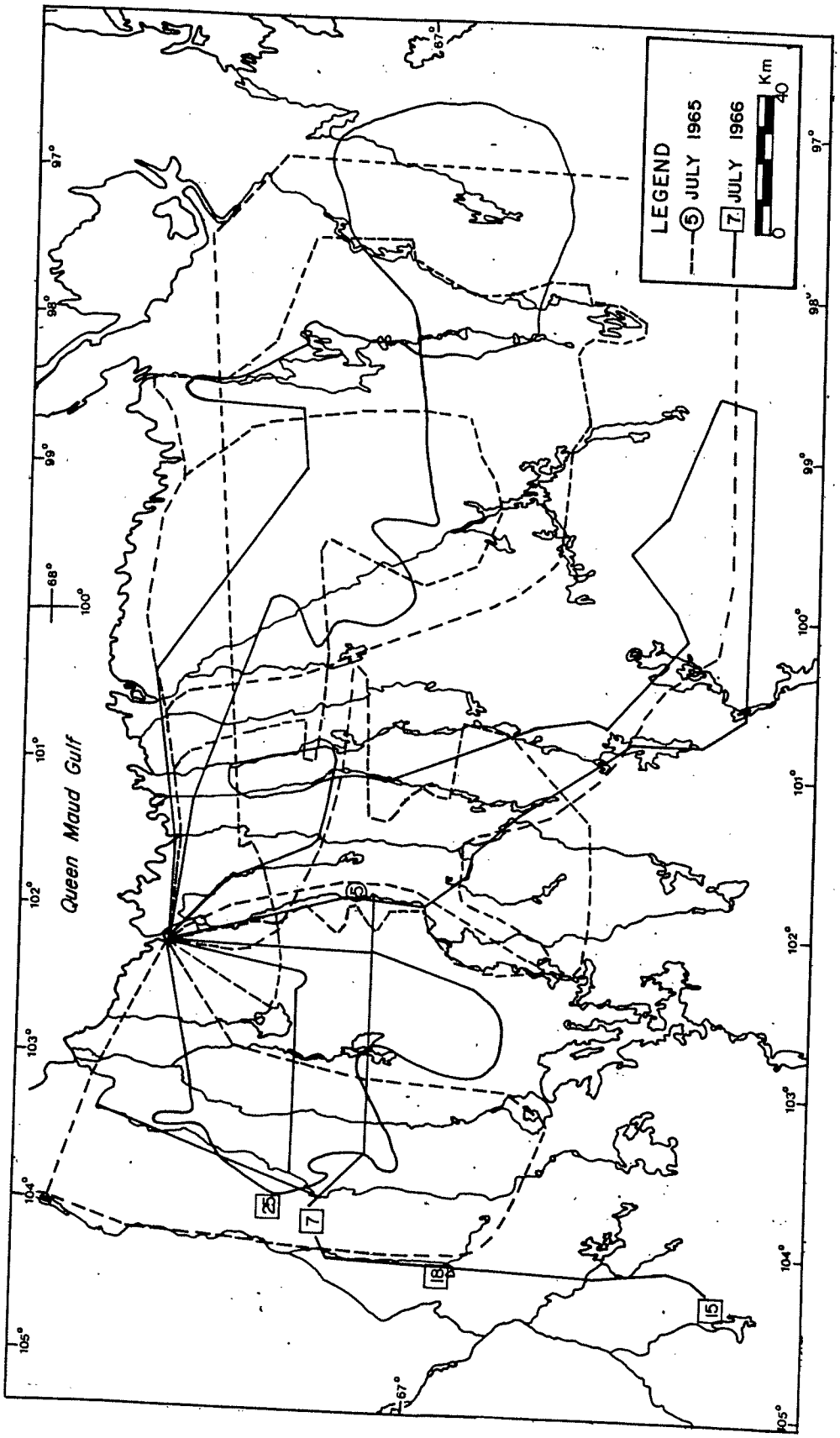

Figure 4. Locations of muskox herds counted during aerial surveys of geese in July 1965 and 1966, Queen Maud Gulf area.

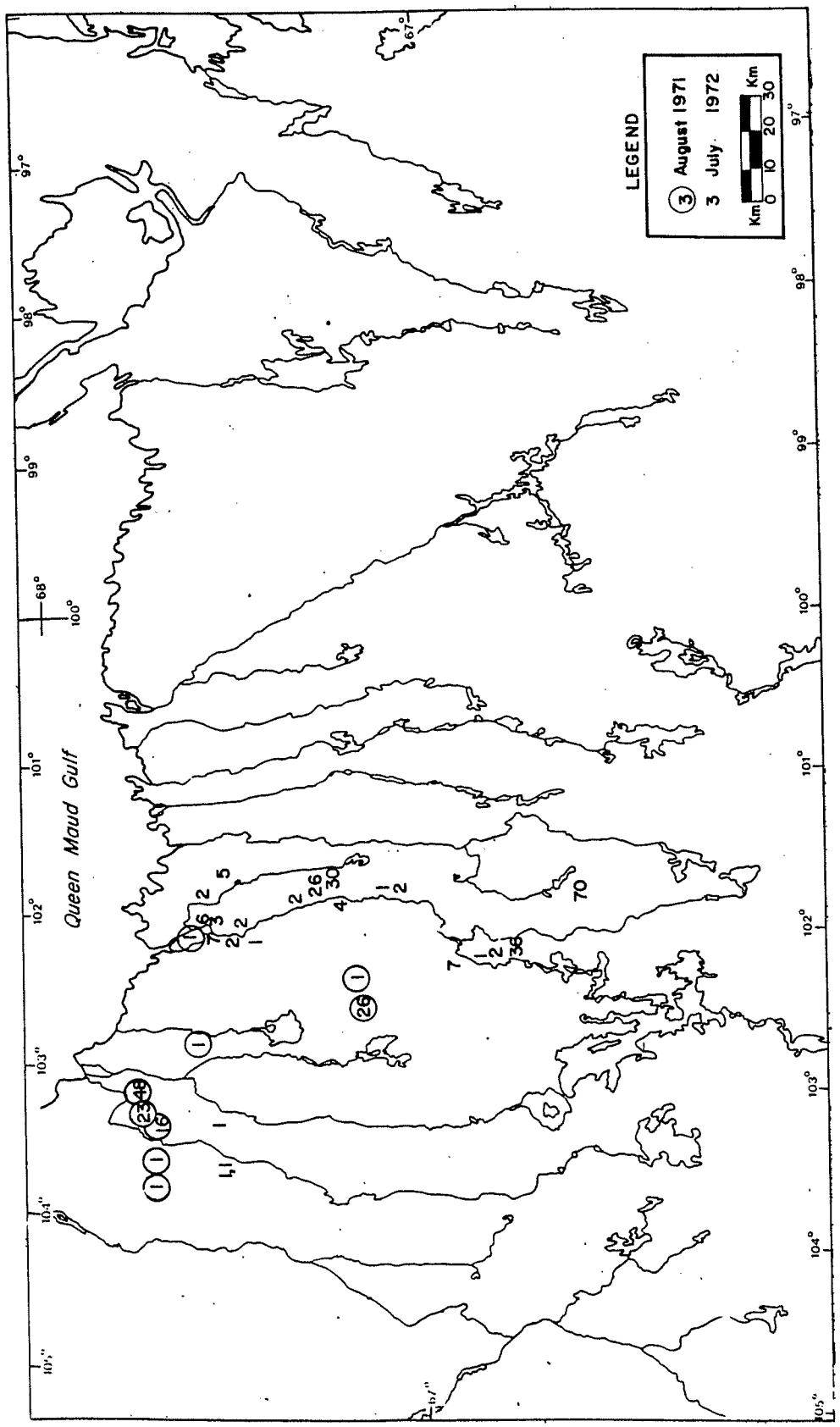

Figure 5. Locations of muskox herds counted during aerial surveys of geese in August 1971 and 1972, Queen Maud Gulf area.

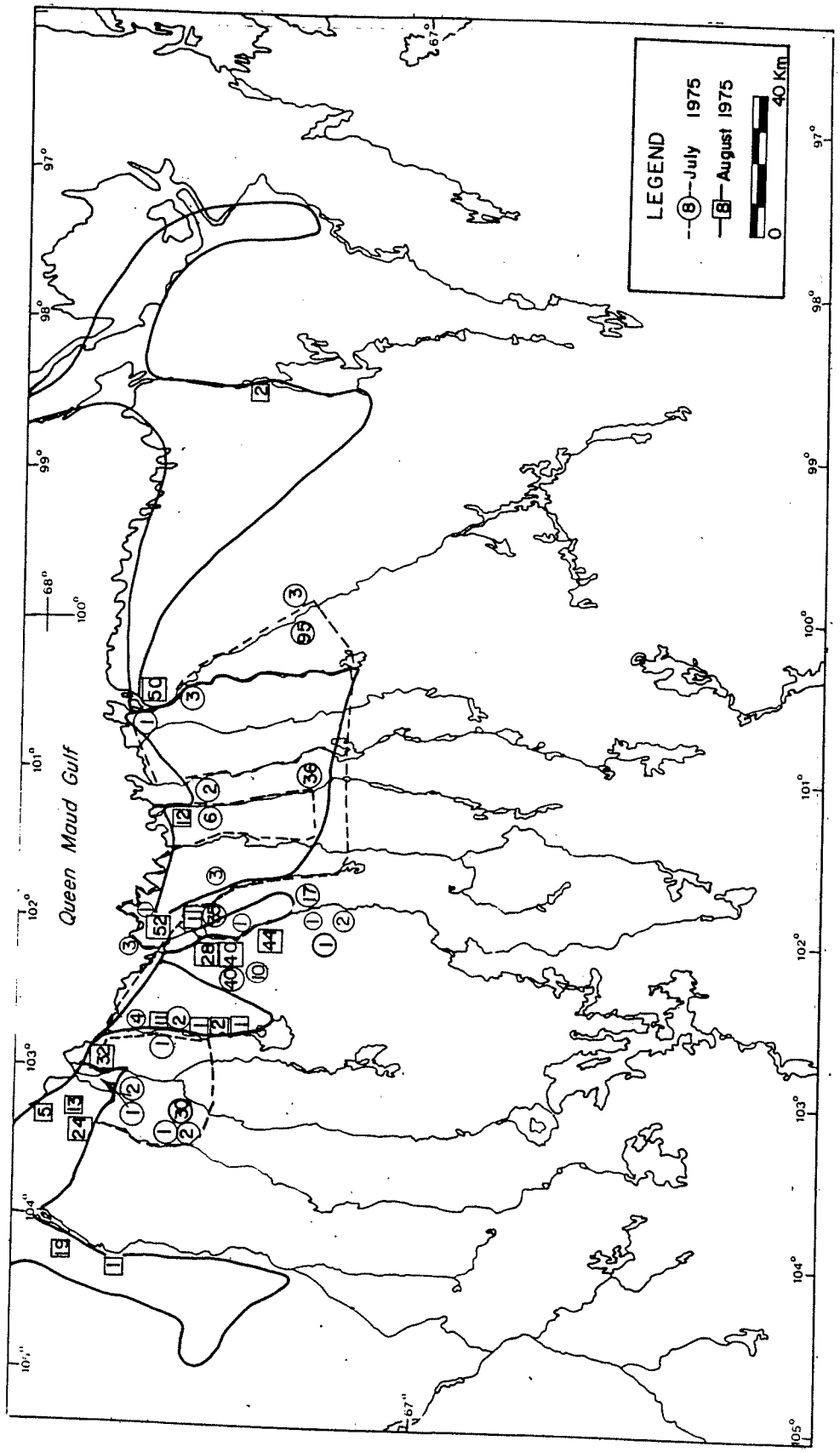

Figure 6. Locations of muskox herds counted during aerial surveys of geese in July and August 1975, Queen Maud Gulf area.

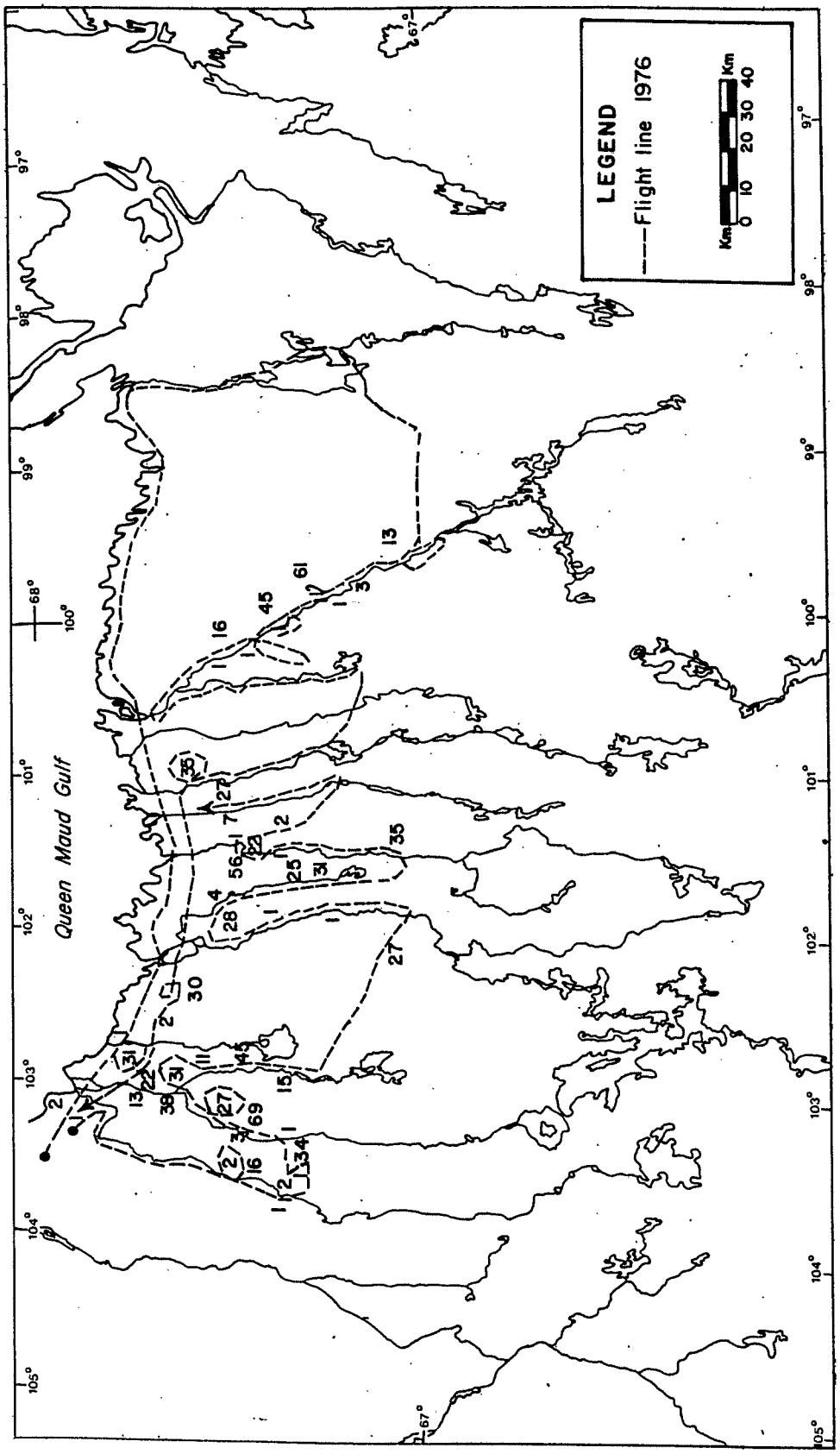

Figure 7. Locations of muskox herds counted during aerial surveys in July 1976, Queen Maud Gulf area.

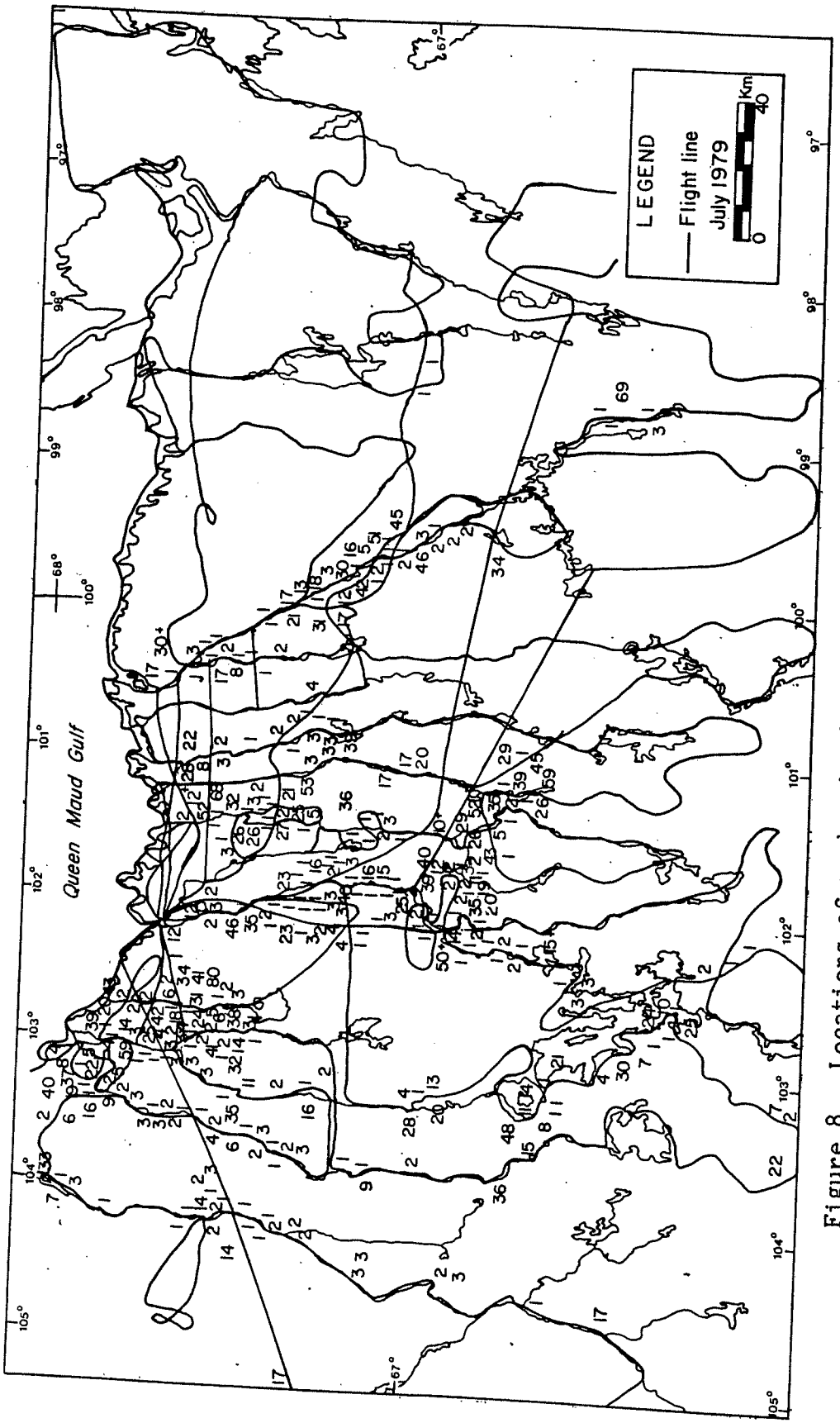

Figure 8. Locations of muskox herds counted during aerial surveys in July 1979, Queen Maud Gulf area.

The only winter survey of muskoxen in the Queen Maud Gulf area was completed in March 1979 (Table 1, Fig. 9). The survey was completed in response to requests by the hunters of Cambridge Bay and Gjoa Haven; 373 muskoxen were counted (Boxer 1980).

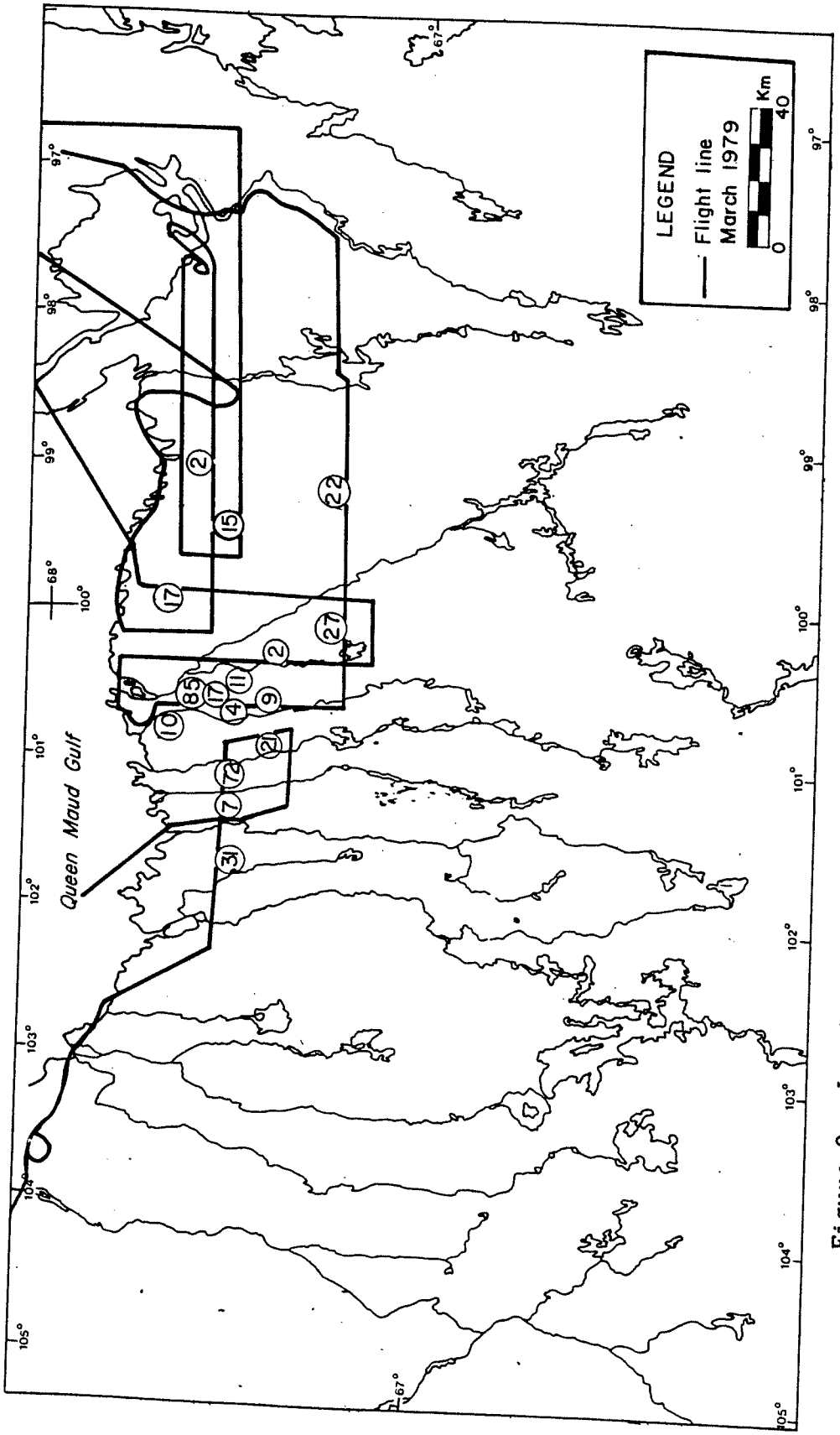

Figure 9. Locations of muskox herds counted during aerial surveys in March 1979, Queen Maud Gulf area.

METHODS

Empirical knowledge of muskox distribution and the results of the August 1979 reconnaissance survey (R. Decker pers. comm.) were used to stratify the study area prior to the survey. The major drainages were designated high density areas and the intervening watersheds as low density areas. The latter was covered by a transect survey using east-west transects 1.6 km wide on either side of the aircraft. The transects were perpendicular to the trend of the topographic features and 42 km apart.

The high density areas were flown using a block survey technique. The blocks were 8 km wide, centered on the river and 16 km long. Each block was surveyed by flying two lines, one on each side of and parallel to the river. The inner strip (aircraft to river) was (2.4 km) wider than the outer strip (1.6 km wide) because the river formed an effective visual boundary as determining the width of strips is difficult in relatively flat areas. The boundary was delimited by a tape marker on the wing strut of the aircraft. If blocks centered on neighbouring rivers or tributaries overlapped, the river or tributary in the middle was not surveyed. There were 79 blocks, 39 of which were selected using a random number table to give 50% coverage.

The tape markers on the struts for the 0.8 km and 1.6 km strip widths were established using as a guide to strip width a truck parked 0.8 km then 1.6 km from a small shed along a straight stretch of road (at Cambridge Bay). The aircraft, a Cessna 185 on floats, was flown at 330 m agl and at 175 km/h. The two observers (D. Williams and D. Amigainik) called out their sightings over a

4-way intercom system; the sightings were recorded on 1:250,000 topographic maps and on a check sheet by the pilot and the navigator, respectively. Both the navigator and the pilot assisted with sighting muskoxen. The navigator took black and white 35 mm photographs (Kodak Plus-X pan film ASA 125) using a 75-300 mm zoom lens of some large groups.

The transect survey was based out of Cambridge Bay but the block survey was flown out of an abandoned drilling camp ($67^{\circ}04'N$, $102^{\circ}25'W$) where 10 fuel drums had been cached in June.

RESULTS

We flew 980 km on transect during the survey of the low density areas (Fig. 10). We counted 199 muskoxen with 29 calves on transect and 270 muskoxen with 24 calves off transect (Appendix A). The coverage represented only 3.4% of the study area and the corresponding estimate of population size was relatively imprecise as the Coefficient of Variation (CV) was 22.9%. The estimate was 5,912 + 2,672 (95% confidence limits) (Table 2).

We flew 1,733 km on the block survey. In addition, we counted muskoxen in non-selected blocks while ferrying to survey blocks (Fig. 11). The total of 55 blocks were surveyed (Table 2), which increased survey coverage to 70%. The number of muskoxen estimated (Table 3) from the 1,826 adult and 258 calves seen in the blocks (Table 3) was 2.623 ± 443 (95% confidence interval) (Table 2). The increase in coverage from 50% to 70% changed the estimate from 2,791 to 2,623 and increased the precision of the estimate as the CV was 0.129 at 50% coverage and 0.086 at 70% coverage.

The density of muskoxen in the low density "watershed" stratum was 15 muskoxen/100 km^2 and the density in the blocks was 27 muskoxen/100 km^2. The density varied between the drainages (Table 3) with the Ellice River and the Klutshak Rivers having the lowest densities of 8 muskoxen/100 km^2 and 1 muskox/100 km^2, respectively. The areas of highest density were located from the coast inland for about 50 km to the lower reaches of three forks of the river draining to Atkinson Point (56 muskoxen/100 km^2) and the "Perry Island" River (98 muskoxen/100 km^2). Two other areas

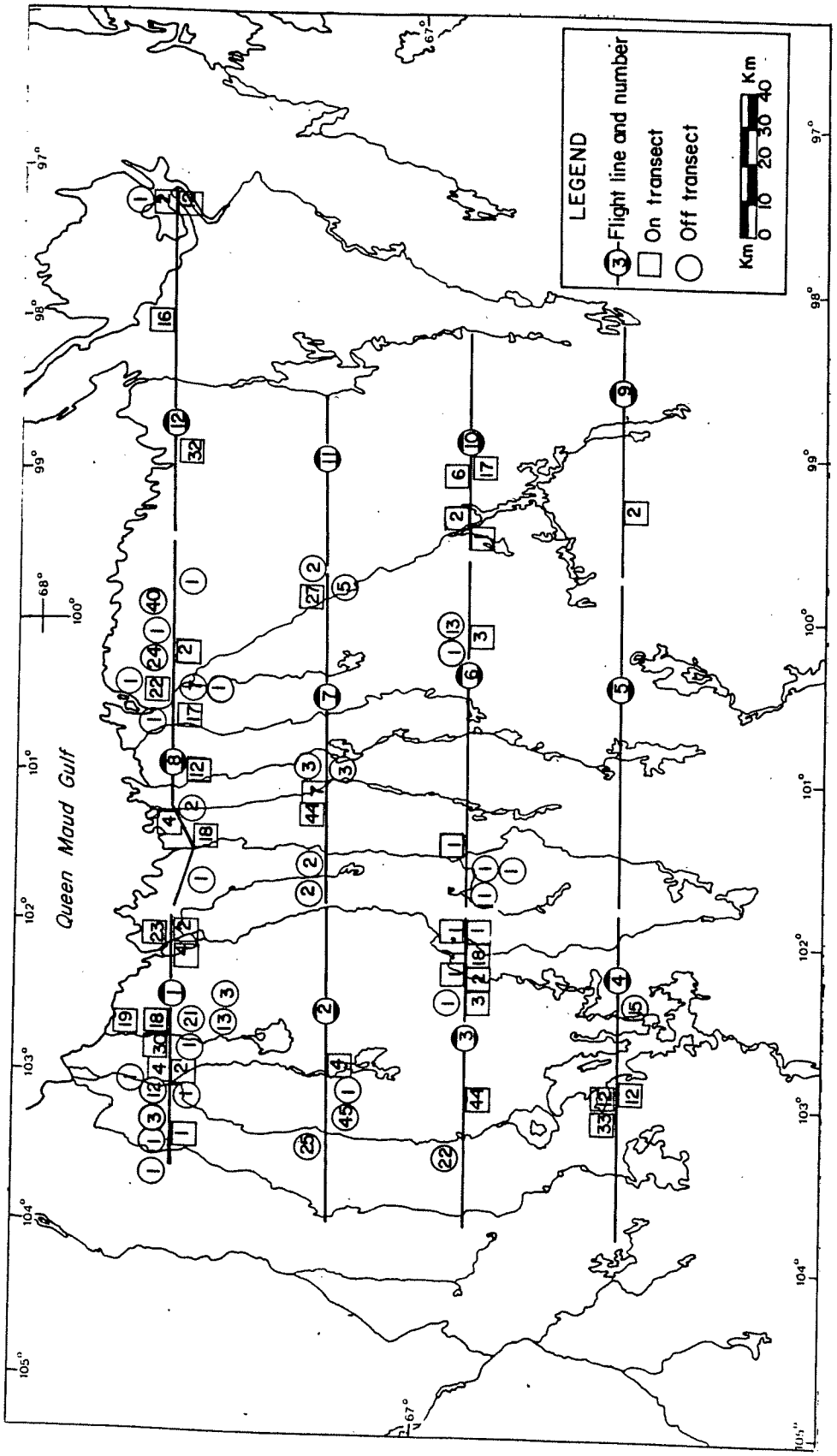

Figure 10. Locations of muskox herds counted during transect and ferry flights in July 1982, Queen Maud Gulf area.

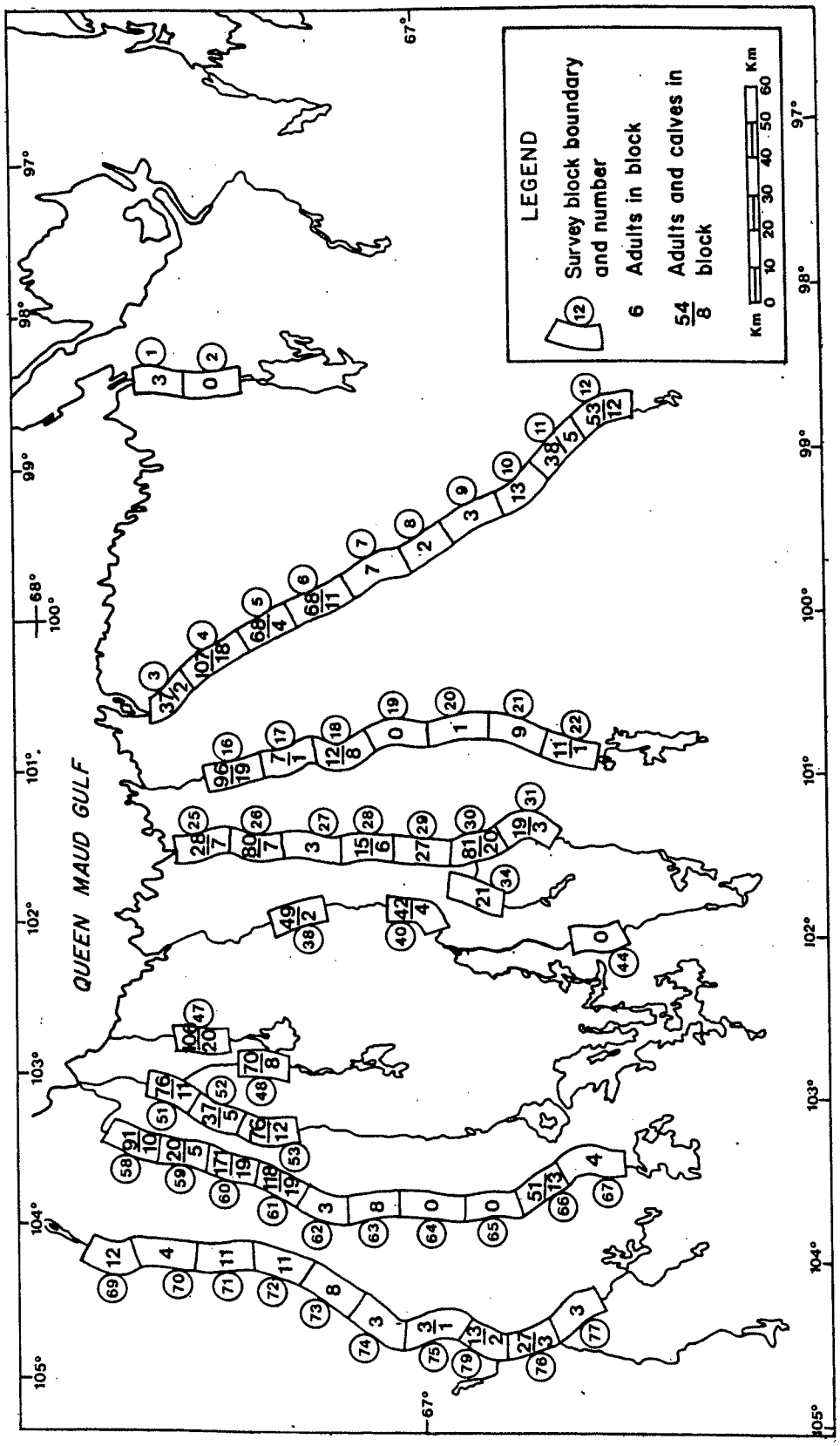

Figure 11. Flight lines and locations of muskox herds counted during block surveys of river drainages in July 1982, Queen Maud Gulf area

Table 2. Data from the transect and block survey of muskoxen used to calculate a total population estimate for the Queen Maud Gulf area, 1982.

		Transect survey	Block survey	Total
Maximum no. transects	(N)	108	79	
No. transects surveyed	(n)	4	55	
Stratum area, km^2	(Z)	39,000	10,112	
Area counted, km^2	(z)	1,329	7,040	
Muskoxen counted[1]	(y)	199	1,826	
Muskoxen density, km^2	(R)	0.15	0.26	
Population estimate	(Y)	5,912	2,623	8.535
Population variance	(VAR, Y)	1,856,372	51,203	1,907,575
Standard error	(SE, Y)	1,362	226	1,381
Coefficient of variance	(CV)	0.229	0.086	0.162

1 Excluding calves.

Table 3. A summary of muskoxen counted in and outside of blocks along drainages in the Queen Maud Gulf muskox management units, July, 1982.

Area	No. possible blocks	No. counted	% cover	No. adults and calves in blocks	No. adults and calves outside blocks
Ellice River	12	10	83.3	95/6	27
West Atkinson Fork	10	10	100.0	466/66	26/2
Central Atkinson Fork	8	3	37.5	189/28	15/9
East Atkinson Fork	2	1	50.0	70/8	0/0
Perry Island River	2	1	50.0	106/20	3/0
Perry River	10	3	40.0	91/6	33/3
Ogden River	9	7	77.7	253/43	35/0
Armark River	8	7	87.5	136/29	26/3
Pitok River	2	0	0	-	-
McTavish River	2	0	0	-	-
Simpson River	10	10	100.0	396/52	135/20
Klutshak River	2	2	100.0	3/0	
Perry Plains	2	1	50.0	21/0	38/8
Total	79	55	69.6	1826/258	338/45

of high density (Figs. 10 and 11) were located on the plains of the upper reaches of the Simpson and Perry Rivers.

Visibility during the surveys was generally good; muskoxen were conspicuous (Table 4) except during the survey of the two blocks on the Klutschak River, which were flown under fading and poor light conditions. Turbulence was more of a problem while flying the blocks as the winds were 15-40 km/h; while flying the transects the weather was warm and there was moderate convectional turbulence. The comparison of visual with photographic counts of the herds was invalidated by a faulty light meter on the camera and blurred images as the film speed was too slow to allow high shutter speeds.

We counted 338 muskoxen and 45 calves outside the blocks during the block survey and 270 muskoxen with 24 calves outside the transects during the transect survey. We counted a further 363 muskoxen with 78 calves during ferry flights (Fig. 12). The mean herd size of the total sample of 3,751 muskoxen, excluding 139 single bulls, was 13.2 ± 1.01 (S.E.) (Table 5). The largest herd was 62 muskoxen. This herd was comprised of three groups that galloped together and coalesced to form a herd of 54 adults and 8 calves as the aircraft approached. The number of calves counted in each herd, particularly the larger herds, was probably low as it is difficult to see calves once the herd has closed together in a defence formation. Therefore, the mean proportion of calves observed was likely an underestimate (Table 6).

Table 4. Survey dates and conditions during aerial surveys of muskoxen in July 1982, Queen Maud Gulf area.

Day	Cloud cover	Wind (km/h)	Light conditions	Coverage	Hours flown survey	Hours flown ferry
21	Broken	< 8	Bright	Transects 1,2,3,4	2.0	4.9
22	Scattered	< 8	Bright	Transects 5,6,7,8	2.1	5.1
23	Scattered	8-15	Bright	Transects 9,10,11,12	1.5	4.8
24	No surveying due to wind > 50.					1.4
25	Broken	15-20	Bright-Dull	Blocks 58-79	3.7	1.7
26	Overcast/broken	30-40	Dull	Blocks 25-53	2.9	3.7
27	Return trip to Cambridge Bay					4.5
28-29	No flying due to winds > 90					
30	Overcast/broken	20-35	Dull to poor	Blocks 1-24	3.3	4.7
Total					15.5	30.8

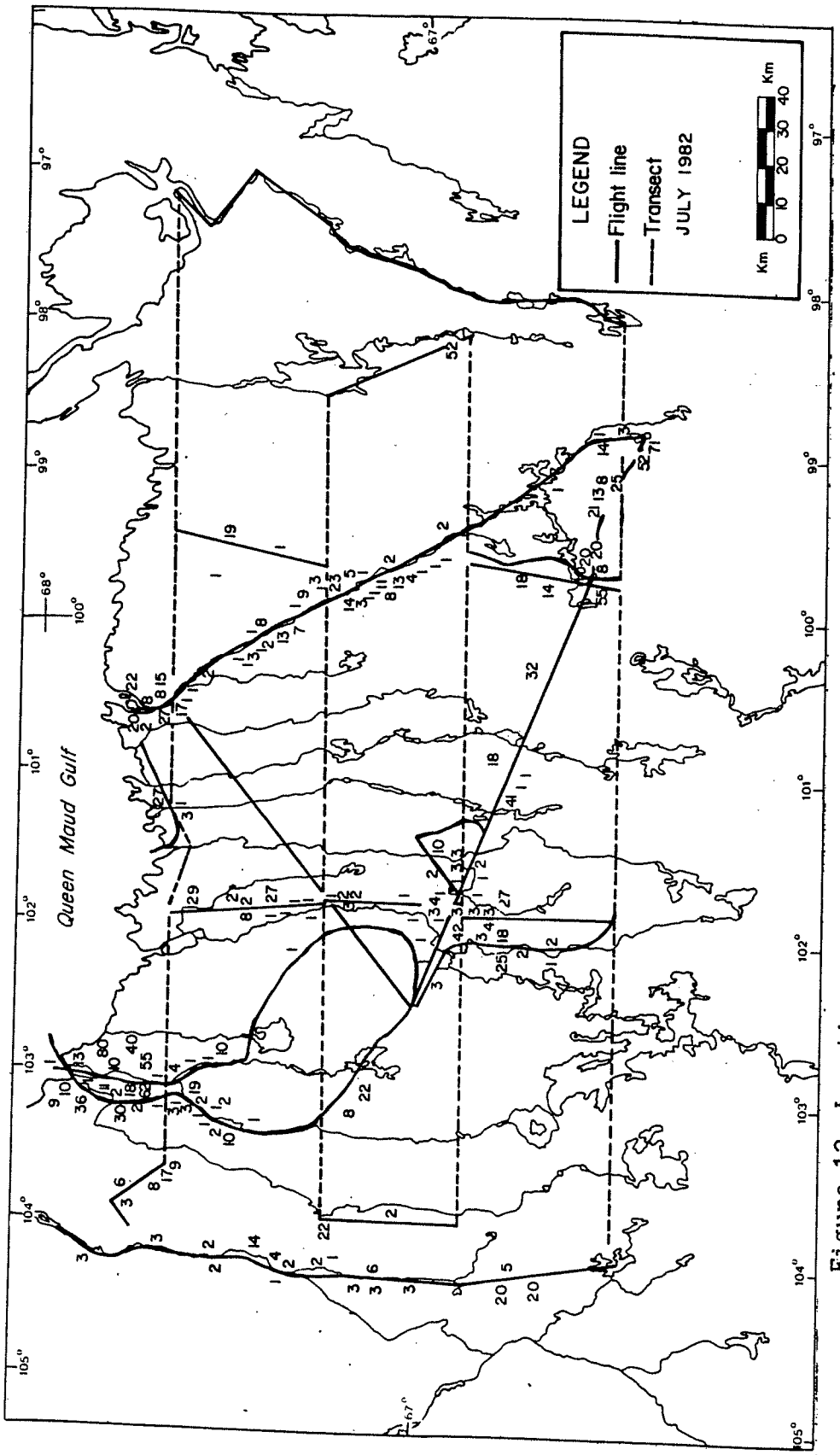

Figure 12. Locations of muskox herds counted during ferry flights in July 1982, Queen Maud Gulf area.

Table 5. Herd size and related statistics for muskox herds (including calves) observed during aerial surveys in the Queen Maud Gulf area 1966 to 1982.

Date		No. muskoxen	No. herds including singles	No. singles	Herd size excluding singles		
					Mean	S.E.	Range
Summer							
1960	August[1]	2	2	2	-	-	-
1965	July[1]	5	1	0	-	-	-
1966	July[2]	65	4	0	16.25	3.73	7-25
1971	August[3]	124	9	5	29.75	6.91	16-48
1972	July[3]	222	22	6	13.50	5.07	2-76
1975	July[1]	342	28	9	17.53	5.45	2-95
1975	August[1]	343	21	6	22.47	4.61	2-52
1976	July[4]	836	42	13	22.24	3.97	2-61
1979	July[5]	3,843	393	142	14.75	1.01	2-80
1982	July[6]	3,751	412	139	13.17	0.78	2-62
Winter							
1979	March[7]	373	17	0	21.94	4.12	2-85

1 T.W. Barry pers. comm.
2 J. Ryder (1971)
3 E. Kuyt pers. comm.
4 W. Spencer (1976)
5 R. Decker pers. comm.
6 This report
7 D. Boxer (1979)

Table 6. Numbers of calves in the herds of muskoxen in which calves were segregated and percentages of calves to total muskoxen seen in the Queen Maud Gulf area. 1966-1982.

Date[1]	No. calves	No. muskoxen segregated	Percentage calves
1960	0	2	--
1965	0	5	--
1966	12	65	18.46
1971	6	124	4.84
1972	--	0	--
1975	39	342	11.40
1975	35	343	10.20
1976	125	836	14.95
1979	501	3.731	13.43
1982	505	3.751	13.46

1 References are presented in Table 5

DISCUSSION

The scanty and sometimes circumstantial historical evidence does not clearly establish that there was a large muskox population in the Queen Maud Gulf area. However, the lack of any evidence to suggest a change in range conditions since historic times and the current presence of high densities of muskoxen can be construed as evidence that muskoxen could have, and likely did, inhabit the area. We can be reasonably sure that there were relatively few muskoxen in the area in July 1960 (Fig. 3). The differences in the intensity of coverage of the unsystematic surveys from 1960 to 1979 prevent a quantitative measure of the rate of increase. Those surveys did, however, cover similar locations especially the coast and larger drainages which are the most suitable summer habitat for muskoxen. The numbers counted were similar in July 1979 and 1982 but the 1979 survey was more intensive so it is difficult to determine if the numbers have stopped increasing. The average annual rate of increase in numbers of muskoxen observed is high (21%) (Gunn 1983); however, this increase is within the range recorded elsewhere. Jingfors and Klein (1982) reported apparent exponential rates of increase of 17% to 24% for three muskox populations introduced in Alaska. Vincent and Gunn (1981) described an average annual increase of 20-25% in the numbers of muskoxen on Banks Island between 1972 and 1980.

The sightings of muskoxen in the 1960's and early 1970's were west of Ellice and Perry Rivers and since 1975 when T.W. Barry recorded seven herds east of the Perry River, the numbers of

muskoxen seen east of the Perry River have increased (Table 7). The spread of muskoxen to the east averaged 13 km/year based on the location of the most easterly muskox herd or solitary bull during each survey between 1960 and 1982. The recolonization of the area likely originated from either the Bathurst Inlet area or possibly southwest from the Thelon Game Sanctuary. Both these areas were described by Tener (1958) as being the only two mainland areas that had concentrations of muskoxen in the 1950's.

Immigration from either Bathurst Inlet or the Thelon Game Sanctuary likely continued at an unknown rate during the 1960's and 1970's. Neither the numbers of muskoxen in the Thelon Game Sanctuary or at Bathurst Inlet are known to have shown any marked increases which could be construed as circumstantial evidence for continued immigration to other areas. Besides immigration to explain the average annual rate of increase in the numbers of muskoxen in the Queen Maud Gulf area, a further explanation concurrent with immigration would be that the unsystematic aerial surveys consistantly missed relatively large numbers of muskoxen. A third contributing factor to the increase may have been exceptional survival rates as calf production does not appear to have been especially high. Wolf sightings were rare during the aerial surveys, which suggests that wolves were uncommon even though they are often difficult to see from an aircraft. In the 1960's and 1970's, wolves were hunted in the area whenever possible (D. Amagainik pers. comm. 1982).

The block survey of the high density stratum (the drainages) lead to a precise estimate of numbers of muskoxen in the drainages

Table 7. The spread to the east of muskoxen in the Queen Maud Gulf area 1965 to 1982.

Year	Longitude zone					
	99°-100°W		98°-99°W		97°-98°W	
	Herds	Muskoxen	Herds	Muskoxen	Herds	Muskoxen
1965	0	0	0	0	0	0
1966	0	0	0	0	0	0
1975	1	3	1	2	0	0
1976	5	123	0	0	-[1]	-
1979	25	339	7	77	0	0
1982	37	409	9	244	3	14

1 No flight lines in the 97°-98° longitudinal zone.

because at the 95% confidence level the estimate is 2,180 - 3,066. The use of blocks with 100% coverage is a flexible approach for estimating muskox numbers because the size of the blocks can be adjusted to fit topographic features which mark habitat changes (and therefore muskox densities) and facilitate accurate navigation. Muskoxen do not concentrate in lowland areas in winter (they forage along slopes), which would increase the size of blocks. The small size of the blocks in one survey meant that sampling efficiency was relatively high as the block was searched with only two passes.

The low coverage and the clumped distribution of muskox herds during the linear transect survey resulted in a low level of precision as the estimated population at the 95% confidence level is 3,240-8,584. The lack of precision seems to be less an effect of the muskoxen clumped into herds and more an effect of the clumped distribution of the herds in patches of sedge tussock meadows along small drainages and poorly drained areas. An estimate of the numbers of herds (rather than individual muskoxen) in the low and high density strata resulted in similar levels of precision to the estimates based on the numbers of individual muskoxen (Table 8). Norton-Griffith (1978) notes that transects are an ineffective method when the vegetation (habitat) is patchy.

The subjective impression from flying over the low density stratum was that the numbers estimated from the linear transects were high. The possibility that linear transect surveys over-estimate the numbers of muskoxen was suggested by comparing a non-systematic survey of suitable habitat with a transect survey

Table 8. Numbers of muskox herds and single bulls estimated in the high and low density strata in Queen Maud Gulf area, July 1982.

Stratum	Estimated no. herds	SE[1]	CV[2]
Muskox herds (excluding solitary bulls)			
Low density	535	126	0.236
High density	263	27	0.103
Solitary bulls			
Low density	89	53	0.591
High density	156	22	0.141

1 Standard error
2 Coefficient of variation

on Prince of Wales Island (Gunn and Decker 1984). The comparison was not standardized and further comparisons are necessary if linear transect surveys are to be continued to be used to estimate the size of muskox populations.

The muskox were conspicuous against their background and we believe that using the pilot and navigator to support the observers in spotting muskoxen helped to reduce visibility bias. The clumping of most of the herds reduced the accuracy of counts of the larger herds. Turbulence causing the aircraft to yaw will cause errors in the observer's estimation of transect width, and the wider the transect, the greater the potential error. We encountered moderate turbulence while flying the transects and blocks. Only the outer transect for each block is subject to the error as the inner strip was demarked by the river. Although survey coverage can be increased for the same cost of flying (thus increasing the efficiency of the survey by increasing transect width), attention has to be paid to the likelihood of turbulence and strong winds causing errors in strip width, which are increased when strip width is increased.

The densities of muskoxen along the drainages averaged less than those recorded elsewhere for favourable muskox habitat. Thomas et al. (1981: 35) suggested that, "... best muskox habitat below 200 m asl can support 1-2 muskoxen/km^2 on a year-round basis if winters are not too severe." Thomas et al's. (1981) data to substantiate that statement were restricted to the Arctic Islands. The mean annual snowfall in the Queen Maud Gulf area is less (< 50 cm) compared with, for example, Banks Island (50-75 cm) and the

mean annual growing degree-days is greater; 200-300 days in the Queen Maud Gulf compared to 50-100 for northern Banks Island (Maxwell 1980). The longer growing season and shallower snow cover suggests that the Queen Maud Gulf area could support higher densities than have been reported for the most favourable habitats on the Arctic Islands.

There are however, two unknown factors that complicate any prediction that the Queen Maud Gulf area could support high densities of muskoxen. Firstly, any comparison of year-round densities between geographically distinct areas is difficult to make without knowing the actual proportion of habitat available. Secondly, three other herbivore species graze the sedge-tussock meadows in the Queen Maud Gulf area. Caribou (Rangifer tarandus groenlandicus) graze on the greening sedges in July and Ross' Geese and the Lesser Snow Geese (Anser caerulescens) graze along rivers and lake edges. The populations of geese have increased from about 2,000 in the late 1950's to 198,000 in 1982 (R. Kerbes pers. comm. 1983). There is also a possibility that the number of caribou using the area are increasing; during earlier surveys relatively few caribou were observed, but in 1979 R. Decker (pers. comm. 1982) estimated that he saw about 10,000 caribou.

The transition from the central lowland to the eastern upland plateau which is part of the Wager Plateau is located east of the Kaleet River (Bird 1967). The eastern uplands are characterized by rock outcrops and extensive boulder fields, but there are also extensive sedge-moss meadows dominated by cottongrass (Eriophorum vaginatum) (Russell et al. 1978). Those sedge-moss meadows would

be suitable summer range for muskoxen, but the lichen dominance of vegetation along slopes and the rarity of dwarf shrub communities (Russell et al. 1978) suggests a scarcity of suitable winter habitat. Snow depths would likely prevent foraging on the sedge meadows as east of the Kaleet River, the average annual snow depths increase (Maxwell 1980).

Recorded muskox range exists from the Queen Maud Gulf area east to Committee Bay (Rasmussen 1927, Hone 1934). The Inuit of Pelly Bay and Gjoa Haven describe the Hayes River valley, the upper reaches of the Murchison, Kellet and Arrow Rivers as having had muskoxen 30-40 years ago (A. Helmer pers. comm. 1982). It is not known what happened to the population, but in October 1981 those river valleys were surveyed and no muskoxen or muskox sign were observed (Helmer 1981). The Back and Meadowbank river valleys also had muskoxen in the mid-nineteenth century (Back 1836, Clarke 1940) but, there are no recent records (Gunderson et al. 1955, R. Decker pers. comm. 1983). The slow eastward spread of muskoxen will, however, likely continue especially from the high density area along the upper reaches of the Simpson River. As the average annual rate of spread has been about 13 km/year, the recolonization would not be expected to, in the next 10-20 years, assist hunters of Gjoa Haven and Pelly Bay in gaining access to muskoxen.

The possibility of continued immigration from the west and southwest and emigration to the east of Kaleet River thwarts an attempt to define the "population" of the Queen Maud Gulf area. Both immigration and emigration will confound the implementation of results from monitoring the trend of population size.

The current boundaries of the management units more reflect the locations of hunting areas than the ecology of muskoxen in the area. The southern boundary of F/1-2, H/1-1, and H/1-2 could be moved to latitude 66°30'N as there is no break in the muskox distribution at 67°00'N; however, there were relatively few muskoxen in July 1979 between 66°30'N and 66°00'N except along the southwest shore of MacAlpine Lake (R. Decker pers. comm. 1983). The eastern boundary of unit H/1-2 should not be moved further east and the quota for unit H/1-2 should not be greatly increased from the current level of seven tags to prevent any slowing of the eastward spread of muskoxen, that is anticipated if the numbers of muskoxen continue to increase.

The continued increase in the numbers of muskoxen in the Queen Maud Gulf area can be predicted from the apparent absence of regulatory factors such as high levels of harvesting and predation. Nor are there reports from Inuit hunters to implicate mortality during severe winters. The comparison of densities with those documented on Arctic Islands further suggests the numbers can increase before the ranges are over-utilized.

The theoretical consequences of an introduced herbivore population are: a period of rapid increase, a severe decline (if emigration is restricted), followed by the population oscillating about a lower level (Caughley 1979). The muskoxen in the Queen Maud Gulf area are, in a sense, an introduced population and are reacting to the previously unutilized habitat by rapidly increasing their numbers. Monitoring of demographic, physiological, and behavioural characteristics (Gunn in press)

will have to be implemented if the possible decline is to be predicted. Paramount is the development of a management plan to establish a framework to guide both the monitoring of the population and a harvest strategy.

RECOMMENDATIONS

1. A management plan should be established to provide a framework for population monitoring and harvest strategy.

2. Further investigation of transect survey techniques is necessary, particularly for testing of the effectiveness of increasing coverage. The use of blocks along the high density muskox habitat was both practical and provided a precise estimate of numbers; however, the use of blocks should be tested in late winter when muskoxen are more dispersed.

3. The numbers of muskoxen estimated in the management units are sufficient to allocate quota increases but, see Recommendation No. 1. The two western management units (F/1-2 and H/1-1) should have most of the increased quota so as not to reduce the likelihood of continued eastward recolonization from unit H/1-2.

4. Ground segregations should be initiated in late winter to describe sex-age composition of the population.

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Appendix A. Muskoxen counted on and off transect during an aerial survey of Queen Maud Gulf management units, July 1982.

Transect no.	On transect		Off transect	
	right observer	left observer	right observer	left observer
1	2	18+5	1	2+1
	4	1	*12	15+6
	*2	1	3	*3
	15+3		*1	1
	*15			1
	2			1
	27+3			1
	4			
	1			
2	*4		40+5	25
			*1	
3	*1	*1	18+4	1
	1	15+3		
		1		
		1		
		3		
		*35+9		
		*27+6	*15	*1
		*10+2		
		*12		
5	0	0	0	0
6		*3	*12+1	*1
		1	1	1
				1
7		30+14	3	2
		*7	5	*2
		19+8		*3
				*2
	0	37+14	8	9
		7	0	7
8	18+4	15+2	*35+5	2
	13+5	*2	1	1
	*4		1	*22+2
	*11+1		7	*1
	*1			

Appendix A. continued

Transect no.	On transect		Off transect	
	right observer	left observer	right observer	left observer
9		*2	0	0
10	2 1	*6	0	0
	*15+2			
11	0	0	0	0
12	*23+9	*16 *2		*1
Total area	165+17	284+63	164+15	106+9
low density	76+12	123+17	76+6	36+2

* low density stratum

Appendix B. Muskoxen counted in and outside of blocks during an aerial survey of Queen Maud Gulf management unit, July 1982.

Block no.	Muskoxen counted in block: West inner strip	West outer strip	East inner strip	East outer strip	Total muskoxen in block	Muskoxen counted outside block: West	East
Ellice River							
69	1 2	1 1	1	1 1 1 3	12	2 25	
70			1 2 1		4		
71	1		1 5 3	1	11		
72		1	3 4 2	1	11		
73			5 1	2	8		
74	1		1 1		3		
75	2+1		1		3+1		
76	7+3			20	27+3		

Appendix B. continued

Block no.	Muskoxen counted in block: West inner strip	West outer strip	East inner strip	East outer strip	Total muskoxen in block	Muskoxen counted outside block: West	East
77	1		2		3		
79			4	9+2	13+2		
(68 and 78 not counted)							
West Atkinson Fork							
58	25 13+1 3	1 2 1 1	29+6 5 9+3 2	23+2	91+10	1 1	
59	1 1 2 12+5	1	2	1	20+5		
60	1 1 2 12+5	1	14+3 6 1 1 2 1 3 54+8 25 18 24+3 3	2	171+19		

Appendix B. continued

Block no.	Muskoxen counted in block: West inner strip	West outer strip	East inner strip	East outer strip	Total muskoxen in block	Muskoxen counted outside block: West	East
61	10+3 2		20+6 17+4 27+3 38+3	1 3	118+19		
62		2	1		3		
63	1		2		8		
64					0		
65					0		
66	3 18+9 24+4	6			51+13	11+2 13	
67	4				4		
Central Atkinson Fork							
51	2 14+3 3 5		3 2 2 2 1 26+4 1	2 13+4	76+11	76+11	15.9

Appendix B. continued

Block no.	Muskoxen counted in block: West inner strip	West outer strip	East inner strip	East outer strip	Total muskoxen in block	Muskoxen counted outside block: West	East
52	1 1 3 2	20+5	1 2	1 3 3	37+5		
53	1 35+6 15+3		1	1 13+3	76+12		
Nos. 50, 54, 55, 56, and 57 not counted							
East Atkinson Fork							
48	27+4 1 1 1 1	2	5 32+4		70+8		
No. 49 not counted							
Perry Island River							
47	3 14+3 12+2 2		1 37+6	37+9	106+20	3	
No. 46 not counted.							

Appendix B. continued

Block no.	Muskoxen counted in block: West inner strip	West outer strip	East inner strip	East outer strip	Total muskoxen in block	Muskoxen counted outside block: West	East
Perry River							
38	1 2 1 1 3 6 2 3		1 1 1 3 2	22+2	49+2	3	
40	2 1 1 2 2		1 1 2 2 2	1 24+4	42+4		7 2 1
44					0	20+3	
Nos. 36, 37, 39, 41, 42, 43, 45 not flown							
Perry Plains							
34	1 1 4 3	1 1 1		1 1 1 1 5	21	23+8	15
No. 35 not flown							

Appendix B. continued

Block no.	Muskoxen counted in block: West inner strip	West outer strip	East inner strip	East outer strip	Total muskoxen in block	Muskoxen counted outside block: West	East
Ogden River							
25	1	2 1 2 3	18+7 1		28+7		
26	19+3 2 1		1 11+4 1 38 1 2	1 1 1 1	80+7	1 30	
27			3		3		
28	2 1 1		10+6	1	15+6		
29	2	1	20	4	27		
30	13+4 30+10 4 1 10+2 2	3 17+4 1			81+20	1 1 1 1	

Appendix B. continued

Block no.	Muskoxen counted in block: West inner strip	West outer strip	East inner strip	East outer strip	Total muskoxen in block	Muskoxen counted outside block: West	East
31	1	6+1	12+2		19+3		
Nos. 32 and 33 not flown							
Amark River							
16	39+5 4+1 3		20+5 2 24+8 3	1	96+19		
17	3		4+1		7+1		
18			12+8		12+8		
19					0		
20	1				1		
21	4		1	4	9	1	
22	11+1				11+1	25+3	
No. 15 not flown							

Appendix B. continued

Block no.	Muskoxen counted in block				Total muskoxen in block	Muskoxen counted outside block	
	West		East			West	East
	inner strip	outer strip	inner strip	outer strip			
Simpson River							
3	3 3 17	13+2 1			37+2		
4	19 1	22+4 1 15+8	6 35+6 3	5+2	107+18		
5	1 1 17 3 2 35+4		9		68+4	1	
6	13+2 32+4	23+5			68+11	19+4 14+3	
7	1 3		3		7		
8	2				2		
9	2		1		3		25
10			2 9	2	13		

Appendix B. continued

Block no.	Muskoxen counted in block: West inner strip	West outer strip	East inner strip	East outer strip	Total muskoxen in block	Muskoxen counted outside block: West	East
11		8+2 30+3			38+5		
12		11+3 21+6 18+3	2 1		53+12	50+7 25+6	1
Klutschak River							
1	1		2		3		
2					0		