THE EFFECTS OF ARTIFICIAL ISLANDS ON POLAR BEARS IN THE BEAUFORT SEA

GORDON B. STENHOUSE

AND

PAUL B. LATOUR

N.W.T. WILDLIFE SERVICE,

YELLOWKNIFE, N.W.T.

1983

Northwest Territories Renewable Resources

File Report No. 33

Report Prepared for Dome Petroleum Limited and
Gulf Canada Resources Inc.

ABSTRACT

Petroleum exploration and production plans in the Beaufort Sea call for the construction of numerous artificial islands. Some of these islands will be located in the transition zone between landfast and moving pack ice. The transition zone is important polar bear habitat. Accordingly, concern has arisen over the presence of artificial islands and their possible effects on polar bear movement and distribution. In addition, the presence of artificial islands may result in an increased number of bear/human encounters, which could potentially result in the destruction of an increased number of polar bears.

We flew transects radiating out from an existing artificial island (Tarsiut), a proposed island (Uviluk), and identical control sites adjacent to each of the two experimental sites. Information on polar bear tracks, their direction of travel, sighting of bears and ice types were recorded. Variability in the study areas between survey periods, especially changing ice conditions, made interpretation of the data difficult. Track data indicates that bears were concentrated in the eastern portion of the study area particularly adjacent to the Baillie Islands. That the two experimental sites affected the orientation of polar bears remains unclear, a result of environmental variability during the study period and the marked distribution differences of polar bears in the study area. No directional trends in bear movement was detected but once again our interpretation was confounded by variability and the nature of the two experimental sites. It must be emphasized that this study was preliminary, serving mainly to assess the study design and provide data with which to address future research. Study design modifications are required if a long-term program is adopted to examine the effects of artificial islands on polar bears in the Beaufort Sea petroleum exploration and production zone.

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INTRODUCTION

Seismic programs and drilling of exploratory wells were started in the Mackenzie Delta in the early 1960's. In the Beaufort Sea the first offshore drilling from an artificial island, Immerk, was conducted in 1972 by Esso Resources Canada Limited. Since then 19 artificial islands have been completed in shallow (<20 m), inshore waters off the Beaufort coast. In 1976 approval was granted by the federal government for drilling in deeper, offshore waters of the Beaufort Sea. In the summer of 1976 drillships owned by Dome Petroleum Limited began offshore work in the Beaufort. This work has continued during each of the short, summer drilling seasons since then. In the summer of 1979 Esso Resources completed construction of the Issungnak artificial island; drilling operations were completed during the winters of 1979-80 and 1980-81. This island was located in 20 m of water in landfast ice, but near the transition zone between solid, landfast ice and the moving floe ice of the Beaufort Sea. Tarsiut, an artificial island incorporating the latest design features, was constructed by Dome Petroleum for Gulf Canada Resources Inc. during the summer of 1981 in 21 m of water. When the Beaufort Sea is ice covered in winter, Tarsiut is situated in the transition zone between floe and landfast ice. Future plans call for artificial islands (Uviluk and Nerlerk) to be constructed by Dome Petroleum in 1982 and 1983 in 31 m and 47 m of water, respectively.

The 1976 approval to explore for hydrocarbons was contingent upon the completion of an environmental assessment of the Beaufort region (i.e., coastline and extending to the edge of the continental shelf). Accordingly, the Beaufort Sea Project was established in 1973 under the auspices of the federal Departments of Energy, Mines and Resources and the Department of Environment. Studies were carried out over the next 2 years in a number of fields including marine geology, marine biology, oceanography, meteorology, and wildlife biology (Milne and Smiley, 1976). Since the completion of the Beaufort Sea Project, many additional studies have been conducted on various fauna species in the Beaufort region (e.g. Stirling et al. 1977, Fraker and Fraker 1979, Alliston 1980, Fraker et al. 1981, Griffiths 1981, and Renaud and Davis 1981).

Stirling et al. (1975, 1981) reported on the population ecology of polar bears (Ursus maritimus Phipps) in the Beaufort Sea. They found that the favoured habitat type of polar bears in this region was the transition zone between the moving floe ice of the Beaufort gyre and the landfast ice extending 8-80 km from the mainland and west coast of Banks Island. This 5-20 km wide zone is characterized by generally rough ice composed of numerous pressure ridges and mounds dissected frequently by narrow leads and cracks that are continuously opening, closing and freezing. Polar bears are attracted to the transition zone because of the availability of their prey, the ringed seal (Phoca hispida) and the bearded seal (Erignathus barbatus). Stirling et al. (1981) concluded that the transition zone remains important habitat for polar bears throughout much of the December-May period; during the summer bears follow the receding pack ice farther north into the Beaufort Sea.

Concern has been expressed by local people, industry, and government agencies that the presence of artificial drilling islands in, or at the edge of the transition zone, may result in an increased number of bear/human encounters. Inevitably some of these bears would become a nuisance or threat. The subsequent killing of these nuisance bears could be deleterious to the internationally shared Beaufort polar bear population, which is thought to be at the maximum harvest level at this time (Stirling 1978). At present the N.W.T. Wildlife Service, industry, and other government agencies are cooperating in studies to determine practical and effective means of detecting and deterring bears at industrial sites and field camps located in bear habitat (Stenhouse 1982, 1983). It is therefore desirable to know how polar bears will respond to artificial islands in order to determine the amount of detection and deterrent effort required at such locations. Furthermore, determining the attractiveness of artificial islands to polar bears will allow for more meaningful predictions on the overall disturbance of polar bears in the Beaufort Sea by the presence of numerous artificial islands in the transition zone.

The present study was designed to examine the temporal distribution of polar bears around artificial islands in the transition zone. The first seasons work (1982) was designed primarily as a pilot study to test the study design and assess the feasibility of future work.

METHODS

Several considerations influenced the survey design used in this study. We did not know at what distance polar bears would respond to an artificial island and associated stimuli (e.g., odour and sound).

Because we expected more response from polar bears near the island, it was desirable to intensify sampling accordingly. If the effects of the island on polar bears were noticable only at short range, then intense sampling immediately around the island would likely detect it. Finally, we required a system that provided ease of navigation and suited the limited flying time available.

We chose a system of line transects radiating out at equal angles from a centre point (Fig. 1) to satisfy the above considerations. This allowed us high density sampling toward the centre of the sampling area. However, there was more chance of multiple counting of the same tracks the closer we were to the centre of the sampling area. We accepted this possibility in favour of intensified sampling toward the centre and the increased probability this gave us of detecting a concentration of tracks immediately around the island.

Each study site had 12, 48.3 km transects, which were flown using a Bell 206B helicopter at an altitude of 30.5 m above the ice. The helicopter was equipped with a Global Navigation System (GNS-500) for locating the transect beginning points, navigation along the transect, and precise recording of observations.

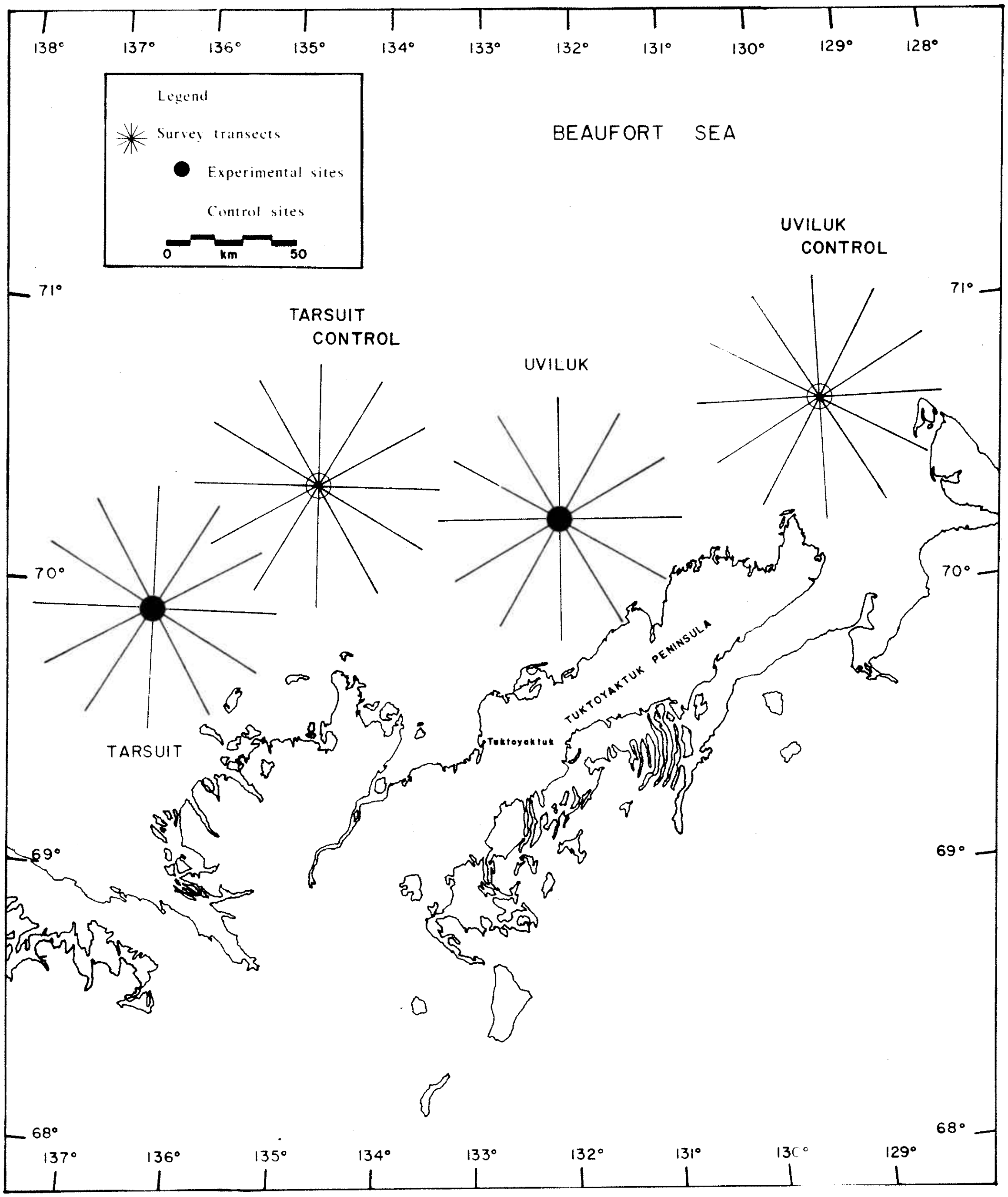

Figure 1. Map of the Beaufort Sea showing the four study sites surveyed for polar bear tracks, spring, 1982.

Surveys were flown at 160 km/h with two observers, one located in the left front seat, and the other in the right rear seat. All observations of polar bear tracks and the direction of bear movement within approximately 90 m on either side of the aircraft were recorded on cassette tape, with the exception of the first survey where note books were used. Completed studies involving low level searching and tracking of polar bears indicate that 90 m is the maximum distance at which the track information can be accurately recorded. We also recorded observations of all polar bears sighted, regardless of distance from the aircraft and their direction of travel. In addition, we recorded all seals sighted, regardless of distance from the aircraft, and sea ice types (after Stirling et al. 1981, see Appendix A). All data were later transcribed onto data sheets and then plotted on bathymetric maps.

Four study sites were established (Fig. 1). Two experimental sites had, in one case, an operating artificial island as the centre (Tarsiut) and in the other case, an artificial island under construction (Uviluk); this island had not been constructed above the water surface at the time of the study.

The Uviluk site, although not above the surface, is scheduled to begin operation in late 1982. Because this was a pilot study with the possibility of extension, we chose Uviluk as the second experimental site because of the potential for comparison of before and during drilling operations.

Two control study sites were established immediately east of each of the experimental sites. We located the control sites as closely as possible to the experimental sites to maximize the chance of each pair having similar ice types.

Surveys were conducted during three periods in 1982: 30 March - 2 April, 16-20 April, and 4-8 May. Since ice conditions change considerably and sometimes rapidly between March and May in the Beaufort Sea, and consequently the distribution of polar bears, the survey periods were spaced at regular intervals with the intention of making comparisons between the different ice conditions.

Analysis

Polar Bear Track Data

To account for cases where flight lines were eliminated during survey flights, the mean number of bear tracks observed at each site was calculated by dividing the total track count by the number of kilometers flown. For example, during the first survey glare ice was encountered southwest of Tarsiut, and consequently, two survey flight lines through this region were deleted. Similarly, when open water was encountered at the Uviluk control site during the third survey, five survey flight lines were eliminated because observations of bear tracks under these conditions were impossible.

Pair-wise comparisons of the mean number of bear tracks were made between the four study sites for each of the three survey periods. Comparisons of the mean number of bear tracks for each study site also were made across survey periods.

Polar Bear Tracks in Relation to Sea Ice Habitat

Stirling et al. (1975, 1981) clearly demonstrated that polar bears show a preference for certain ice types. Accordingly, we looked at the number of polar bears observed at each study site in relation to sea ice habitat. Each track observed during a survey flight was placed into one of the sea ice habitats used by Stirling et al. (1981) (Appendix A). Track sightings were tabulated by ice types and the results compared visually. The amount of each sea ice habitat was recorded for each transect and was used to indicate proportions of ice type at each study site.

Polar Bear Tracks - Distribution in Each Study Site

Seven zones consisting of concentric circles were plotted at each study site. The first zone (1) extended from the centre of each site to a radius of 0.32 km. This distance provided 100% aerial coverage in the first zone based on a 180 m survey strip width. The six remaining zones were arbitrarily divided at 8 km intervals providing progressively less aerial survey coverage as the distance from the centre point increased.

The number of tracks observed in each zone were tabulated and an analysis of variance was conducted to compare the number of tracks in each zone between Tarsiut-Tarsiut control and Uviluk-Uviluk control.

Polar Bear Tracks - Direction of Travel

To examine whether artificial islands influence the movements and direction of travel of polar bears each set of polar bear tracks observed during the survey flights was assigned a direction of travel using the four major co-ordinates of their respective quarters. Because of snow conditions, or in the case of old tracks, the direction of a small number of tracks observed could not be determined.

Within every zone (1-7) along each transect (A-L) the direction of travel was compared with the possible directions of travel toward the next adjacent inner zone (Fig. 2). For example, a track heading south, southwest or southeast on transect A was classed as moving towards an adjacent inner zone (i.e., 7 to 6, or 5 to 4, etc.). The number of tracks moving towards an adjacent inner zone were compared to the number of tracks heading away from this adjacent zone.

It is recognized that this breakdown of track direction has limitations, since it is possible for a bear to be heading towards the next zone when we crossed its path, but perhaps 2 km further, this same bear may have turned 360° and proceeded away from the inner zone. For the purposes of this discussion, however, we assume that the probability of this happening is the same within each of the seven zones, at both experimental and control sites, and across the three surveys. This assumption has not been tested.

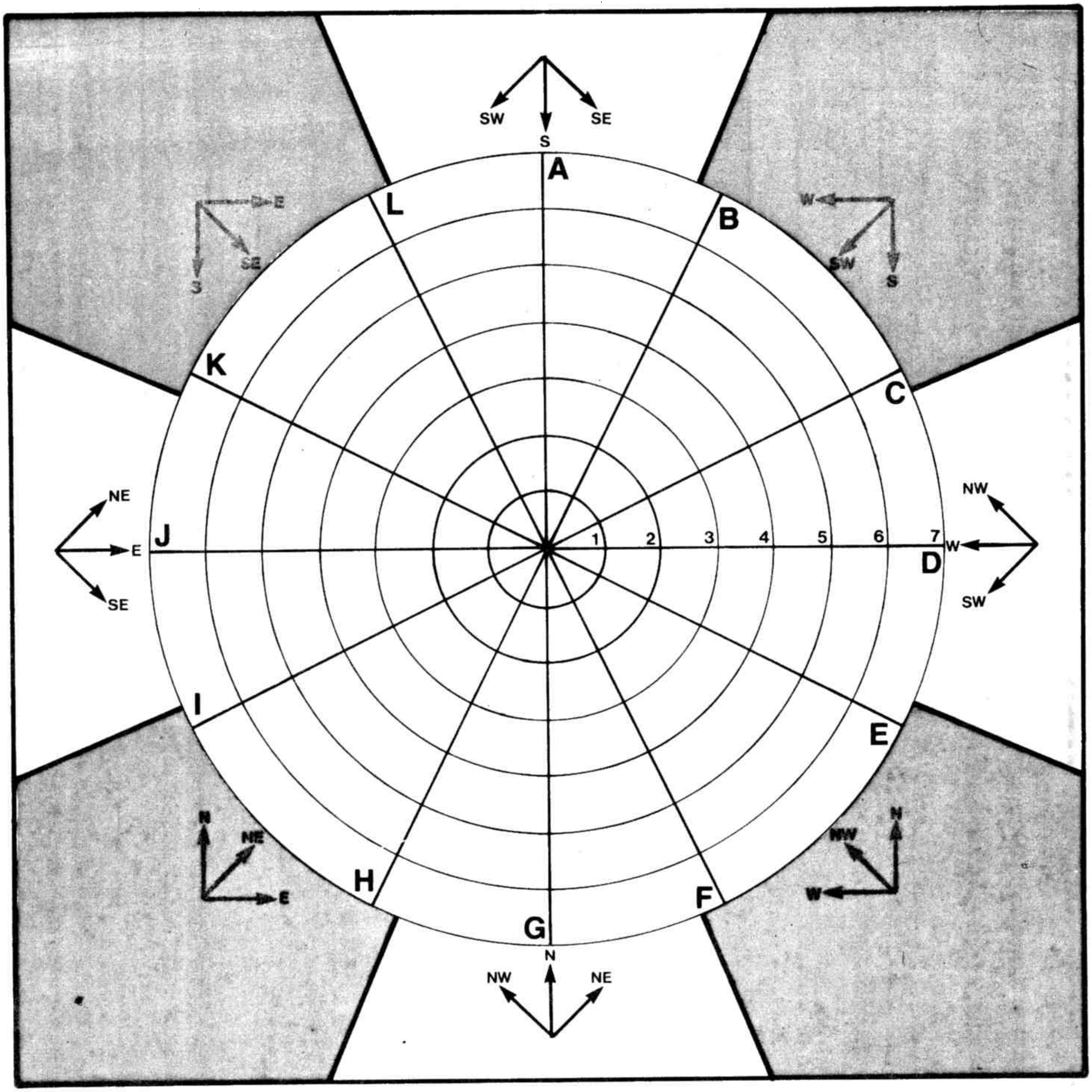

Figure 2. Transects, zones and directions used in polar bear track directional analysis, Beaufort Sea, spring, 1982.

RESULTS

Tracking and Weather Conditions

Tracking conditions during the first survey were hampered by crusted snow, a result of early March precipitation, at all sites except Uviluk control where soft snow persisted and tracking conditions remained good. Tracking conditions during the second survey were good at all four sites because a snowfall occurred after the first survey. Snow conditions were good for tracking at all sites during the third survey.

Major changes in ice conditions occurred between the second and third surveys. The north half of the Uviluk control site was located in open water at this time, while the south half of the site was still locked in landfast ice. Approximately 70% of the Uviluk site was covered with broken pan ice while the remaining 30% remained as solid ice during the third survey. At Tarsiut and Tarsiut control, considerable ice movement occurred between the second and third surveys resulting in many open and newly refrozen leads north of the floe edge.

Weather conditions were similar during the three surveys with clear sunny skies providing visibility to 15+ km. However, prior to completing the fourth study site (Uviluk) during the second survey, weather conditions deteriorated making it impossible to fly. After waiting 5 days with no improvement in the weather conditions, we decided not to fly the Uviluk site. It was felt that storm winds probably covered bear tracks at this site thus eliminating the potential for track comparisons between Uviluk and Uviluk control.

Polar Bear Track Data

The number of polar bear tracks observed were not evenly distributed across the four study sites (Table 1). During the first two surveys, the Uviluk control site had approximately three times as many tracks as did Uviluk, Tarsiut, or Tarsiut control. In the third survey, the number of tracks decreased at all sites except Uviluk, which remained approximately the same.

Significant differences were found between the mean number of bear tracks observed at the Tarsiut experimental and Tarsiut control sites during each of the three aerial surveys (Table 2). Significantly more tracks were found at Tarsiut experimental than at Tarsiut control during surveys 1 and 2, while during the third survey significantly fewer tracks were observed at the Tarsiut experimental than at the control.

At Uviluk experimental and Uviluk control, significant differences were found only during the first survey; significantly more tracks were observed at the control site. No comparisons could be made between these two sites from data collected during the second survey because Uviluk experimental was not flown.

Table 2 also indicates that all other site comparisons of the mean number of tracks showed significant differences except for Tarsiut control - Uviluk experimental during the third survey. Significant differences in the mean number of tracks occurred across the surveys at every site except Uviluk (Table 3). When the results of the third survey were deleted from the same analysis, only the Tarsiut control site showed a significant

Table 1. Number of polar bear tracks, polar bears, and seals observed during the three aerial surveys, Beaufort Sea, spring 1982.

Study site	Number of Tracks			Number of polar bears			Number of seals		
	Survey 1	Survey 2	Survey 3	Survey 1	Survey 2	Survey 3	Survey 1	Survey 2	Survey 3
Tarsiut	107	167	4	0	5	0	0	0	15
Tarsiut control	120	54	35	4	0	1	0	0	8
Uviluk	46	-	53	0	-	0	3	-	77
Uviluk control	443	437	82	4	3	0	0	4	2
Total	716	658	174	8	8	1	3	4	102

Table 2. Mean track comparisons between study sites during the three aerial surveys, Beaufort Sea, spring, 1982.

Survey Number	Tarsiut experimental Mean±SD	Tarsiut control Mean±SD	Uviluk experimental Mean±SD	Uviluk control Mean±SD	Test[a]
1	10.7±6.0	10.0±4.1			t=2.77*
	10.7±6.0		3.8±3.0		U=21.5**
	10.7±6.0			36.9±23.5	U=14.0**
		10.0±4.1	3.8±3.0		t=4.43**
		10.0±4.1		36.9±23.5	U=17.0**
			3.8±3.0	36.9±23.5	U=5.0*
2	15.2±11.0	4.5±4.4			U=18.5**
	15.2±11.0			36.4±27.8	U=32.0**
		4.5±4.4		36.4±27.8	U=6.0**
3	0.3±0.7	2.9±2.7			U=27.5**
	0.3±0.7		4.4±5.0		U=18.0**
	0.3±0.7			6.8±7.3	U=17.0**
		2.9±2.7	4.4±5.0		t=0.96
		2.9±2.7		6.8±7.3	U=51.0**
			4.4±5.0	6.8±7.3	t=0.99

a Mann-Whitney U test used when sample variances were significantly different such that F>Fmax (P<0.05), and a t-test was used when sample variances were homogeneous.

* P<0.05

** P<0.001

Table 3. Mean track comparisons at each study site across the three aerial surveys, Beaufort Sea, spring 1982.

Study site	Survey 1 Mean±SD	Survey 2 Mean±SD	Survey 3 Mean±SD	Test
Tarsiut	10.7±6.0	15.2±11.0	0.3±0.7	[a] $H=125.9$*
Tarsiut control	10.0±4.1	4.5±4.4	2.9±2.7	$H=124.7$*
Uviluk	3.8±3.0		4.4±5.0	[b] $t=0.35$
Uviluk control	36.9±23.5	36.4±27.8	6.8±7.3	$H=127.0$*

a Kruskal-Wallis H test

b t-test used because only two surveys flown.

* $P<0.001$

difference ($T=3.17$, $P<0.05$) in the mean number of tracks across surveys 1 and 2. This finding indicates that the results of the third survey account for the significant difference in the mean number of tracks at Tarsiut experimental, Tarsiut control and Uviluk control across the three surveys.

Polar Bear Tracks in Relation to Sea Ice Habitat

Stirling et al. (1981) identified seven distinct sea ice types; four of these ice types were observed during this survey (Appendix 1). Figures 3 through 6 illustrate the major (defined as the ice type which covered >50% of the transect) and minor (defined as the ice type which covered the largest remaining proportion of the transect) ice types observed along each transect at the four study sites during the first two surveys. Polar bear tracks were not equally distributed across the four sea ice habitat types (Table 4). For example, 50.1% of the overall track sightings were made in type 4 sea ice, while 30.3% of the sightings were made in type 1 sea ice. Table 4 also shows that the percentage of the different sea ice habitats varied between the four study sites, and that type 4 and type 1 sea ice were most common. In addition there was little change in the percentage of the different sea ice habitats observed during the first and second surveys, at each study site. The percentage of ice habitat at each site is not included for survey 3 because of the ice conditions previously mentioned.

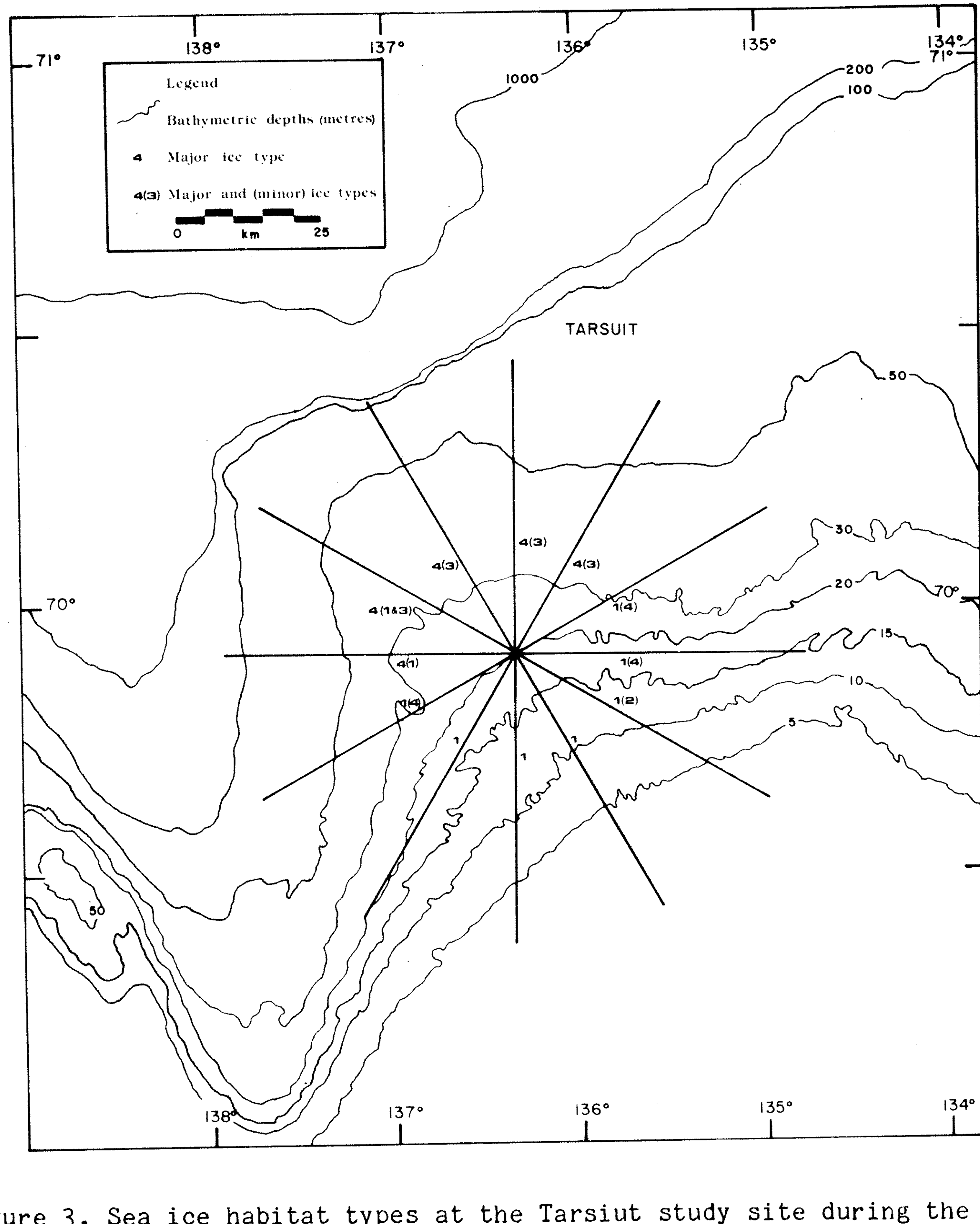

Figure 3. Sea ice habitat types at the Tarsiut study site during the first and second surveys, Beaufort Sea, spring, 1982.

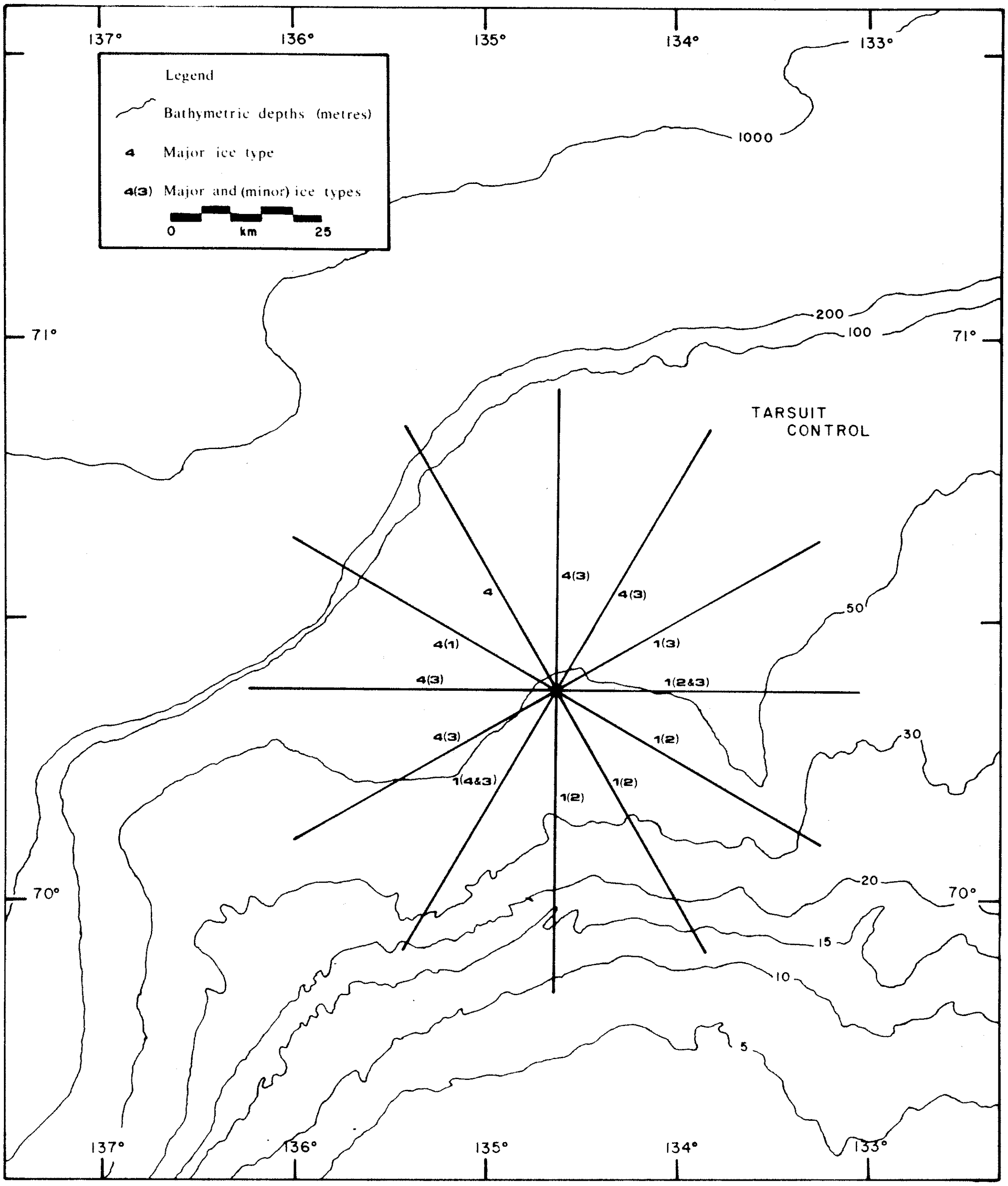

Figure 4. Sea ice habitat types at the Tarsiut control study site during the first and second surveys, Beaufort Sea, spring, 1982.

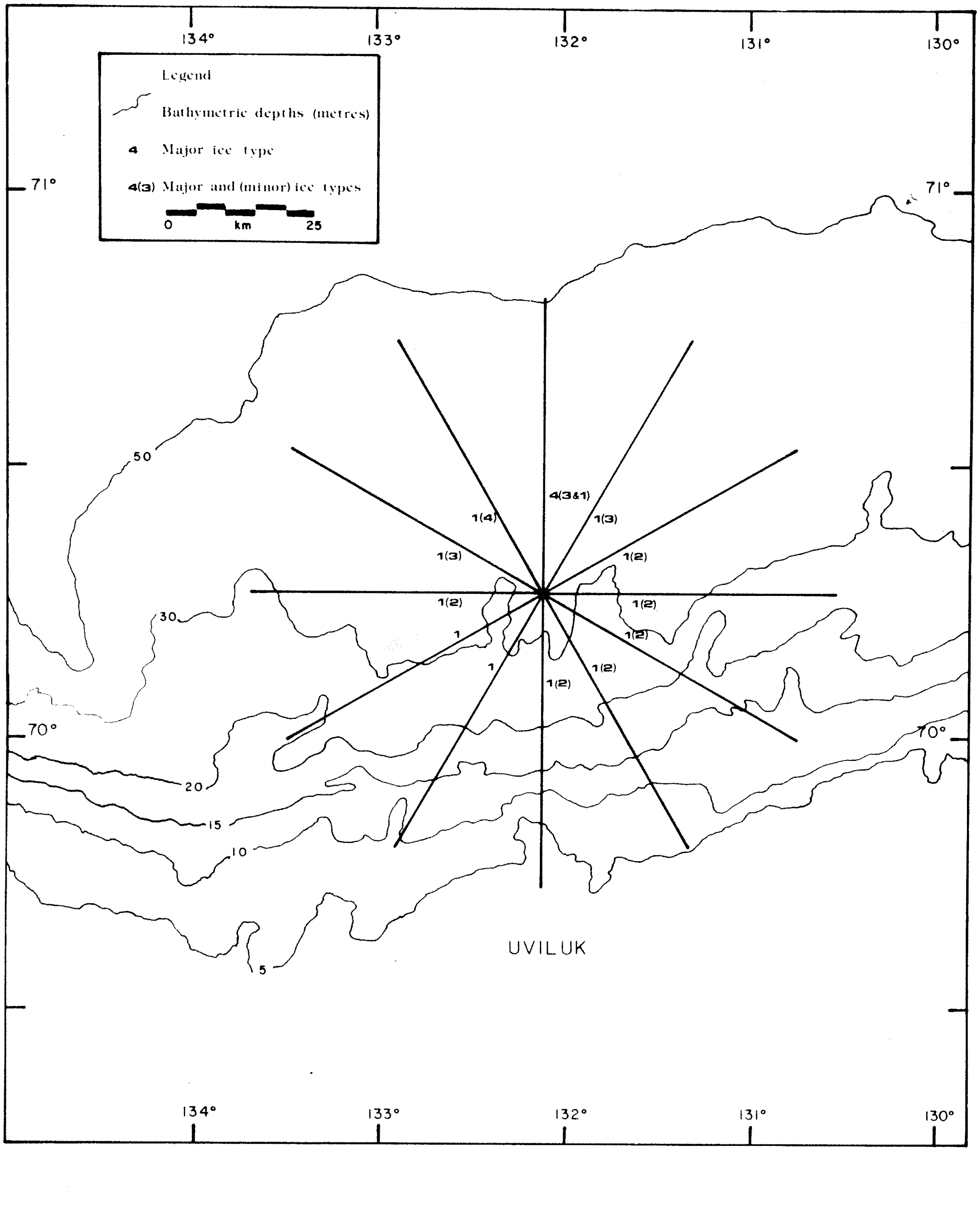

Figure 5. Sea ice habitat types at the Uviluk study site during the first and second surveys, Beaufort Sea, spring, 1982.

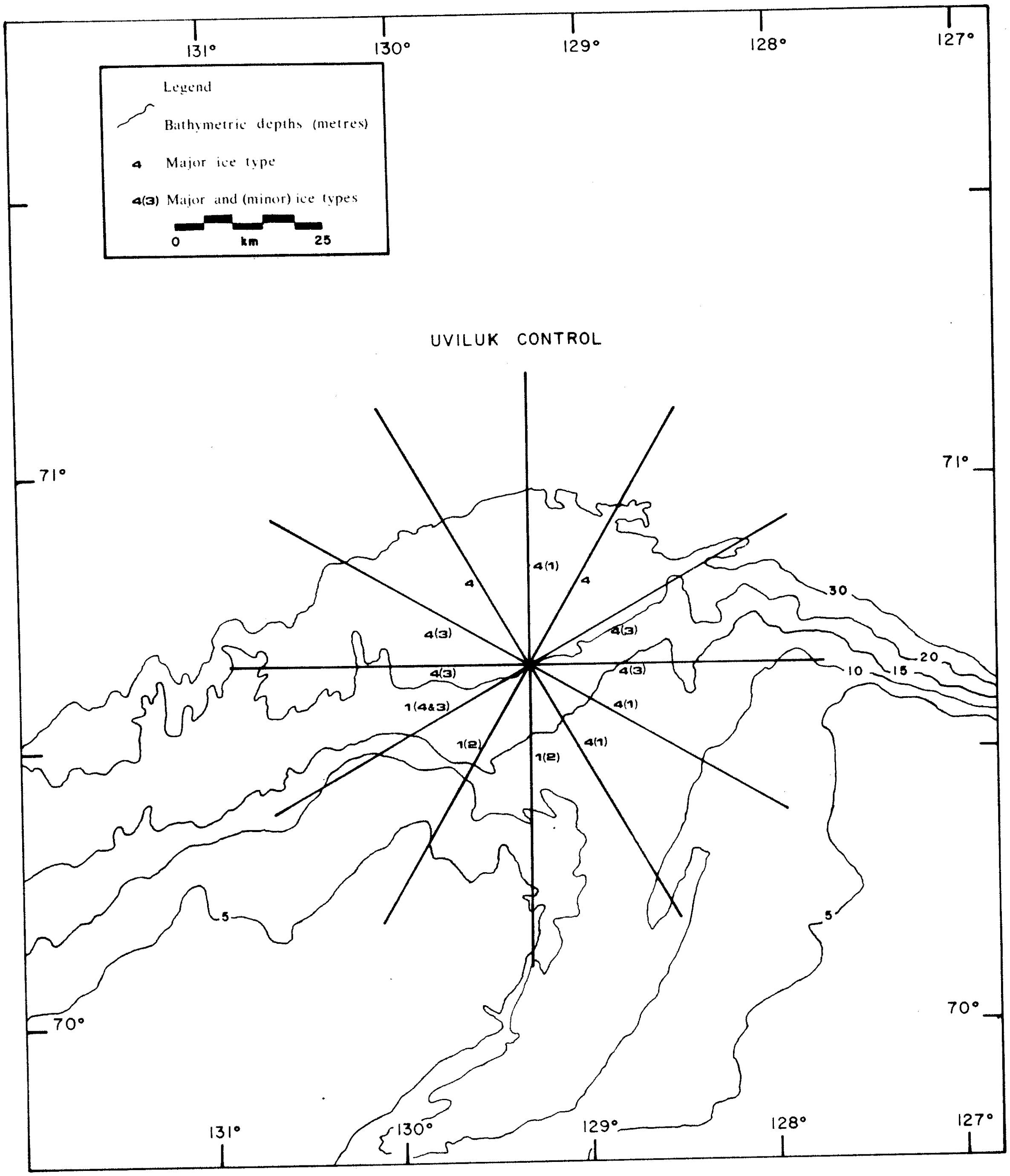

Figure 6. Sea ice habitat types at the Uviluk control study site during the first and second surveys, Beaufort Sea, spring, 1982.

Table 4. Total number of polar bear tracks observed in each sea ice type at the study sites, Beaufort Sea, spring, 1982.

Study site	Survey	Ice types 1	2	3	4
Tarsiut	1	44(33)*	7(8)	17(15)	40(44)
	2	74(30)	13(6)	19(18)	68(46)
	3	0	0	1	3
Tarsiut control	1	44(41)	10(6)	19(24)	51(29)
	2	19(35)	4(4)	12(29)	19(32)
	3	11	2	5	16
Uviluk	1	34(60)	6(21)	3(3)	3(16)
	2	-	-	-	-
	3	23	6	14	5
Uviluk control	1	100(15)	11(2)	71(11)	262(72)
	2	103(14)	10(2)	50(14)	255(70)
	3	14	4	15	49

* percent of ice habitat observed at study site.

The Uviluk control site had the greatest amount of major type 4 ice habitat compared to any of the other sites. Since the largest percentage of tracks occurred in the type 4 sea ice (Table 4) it is not surprising that the Uviluk control site had the greatest number of tracks in all three surveys. Stirling et al. (1981) also found the majority of tracks observed were located in type 4 sea ice habitat. The Uviluk site had the smallest amount of major type 4 sea ice habitat, and correspondingly the lowest number of tracks (Table 1) occurred at this site. However, the relationship between sea ice types and bear tracks is less clear at Tarsiut (Fig. 3) and Tarsiut control (Fig. 4). In both cases the major type 4 sea ice is found in the northwest quadrant of the survey flight lines. The Tarsiut site has more major type 1 habitat, with no minor sea ice habitat on the same transects, than does the Tarsiut control site. In addition, the majority of the type 1 habitat is located on the southeast quadrant at both these sites.

Polar Bear Tracks - Distribution in Each Study Site

Of the two comparisons made, Tarsiut (Fig. 7) versus Tarsiut control (Fig. 8) and Uviluk (Fig. 9) versus Uviluk control (Fig. 10), only the Uviluk vs. Uviluk control comparison showed significant differences ($F=9.05$, $df=13$, $P<0.05$) in the number of bear tracks in the seven zones. The large number of tracks counted at the Uviluk control site during the first survey (N=413) probably accounted for these observed differences. While only the

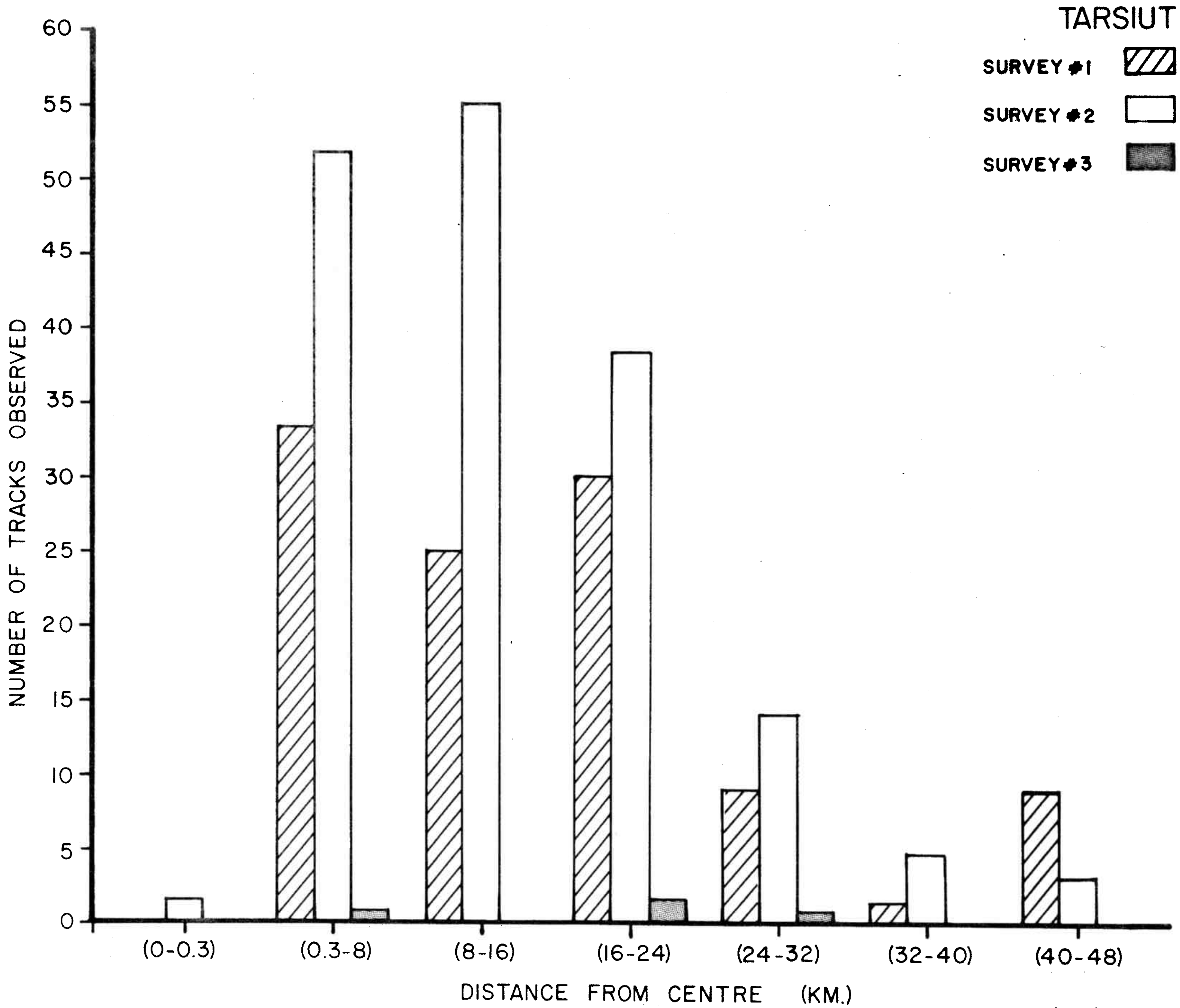

Figure 7. Number of polar bears tracks observed at the Tarsiut site during three aerial surveys, Beaufort Sea, spring, 1982.

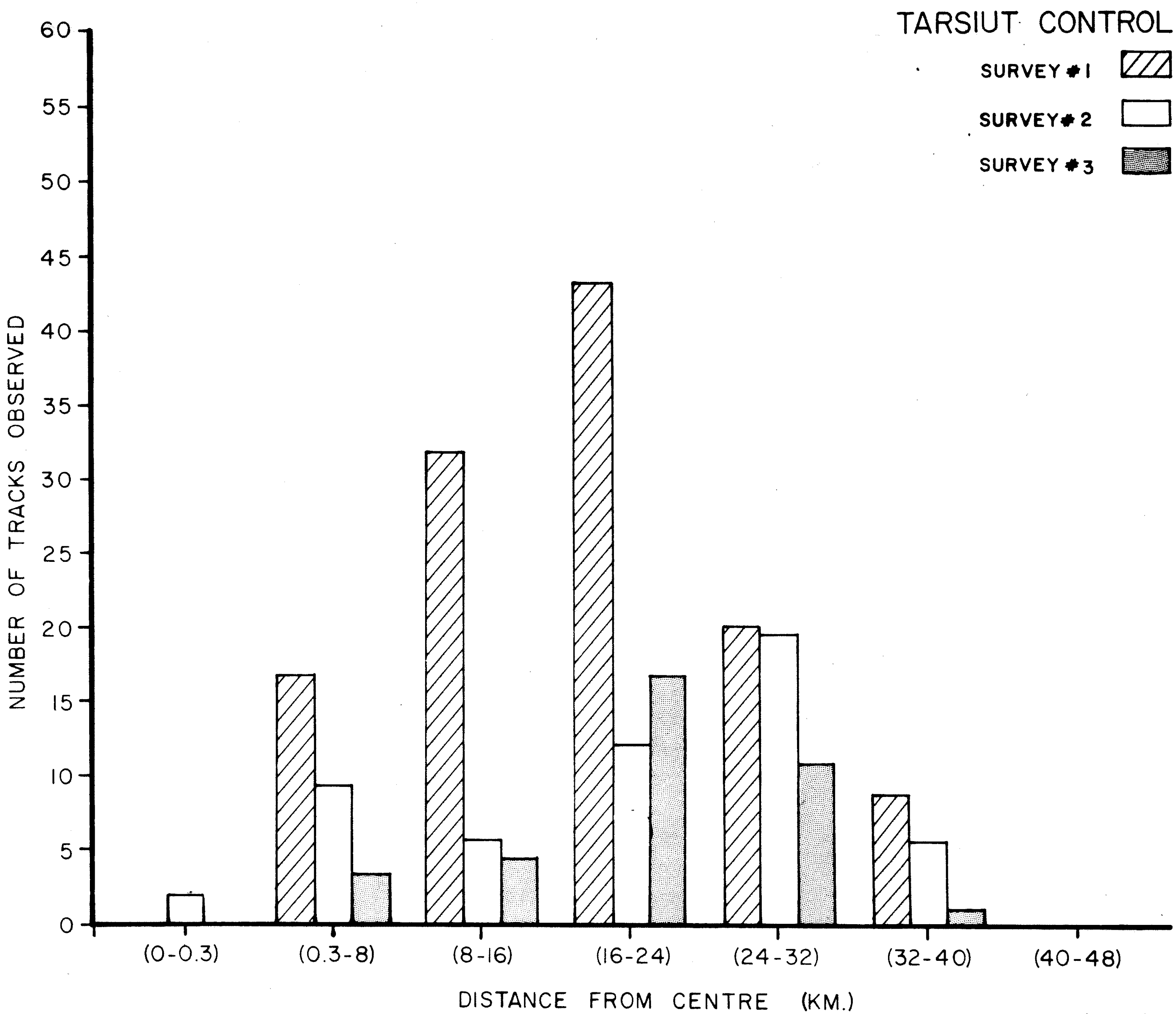

Figure 8. Number of polar bears tracks observed at the Tarsiut control site during three aerial surveys, Beaufort Sea, spring, 1982.

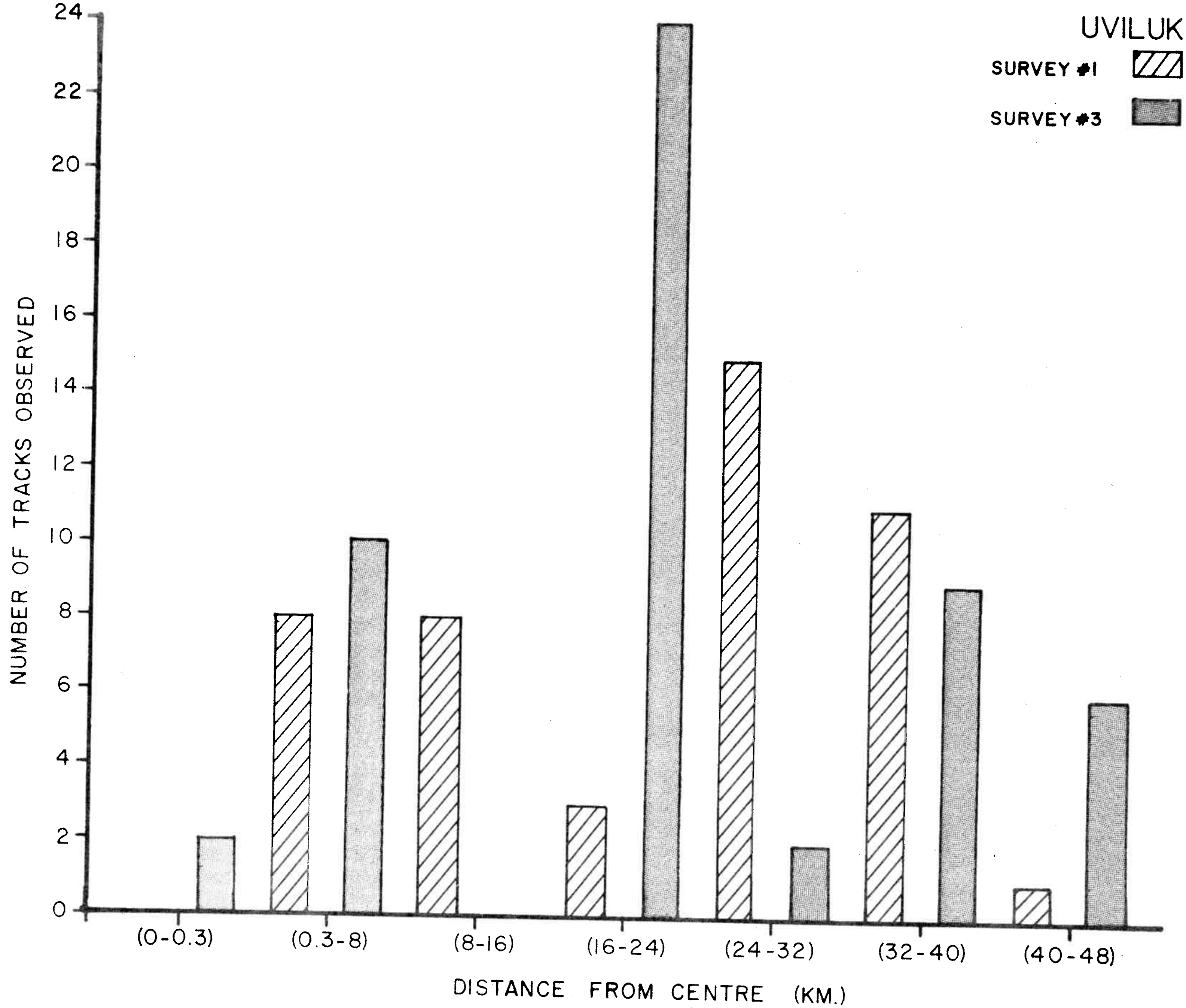

Figure 9. Number of polar bears tracks observed at the Uviluk site during two aerial surveys, Beaufort Sea, spring, 1982.

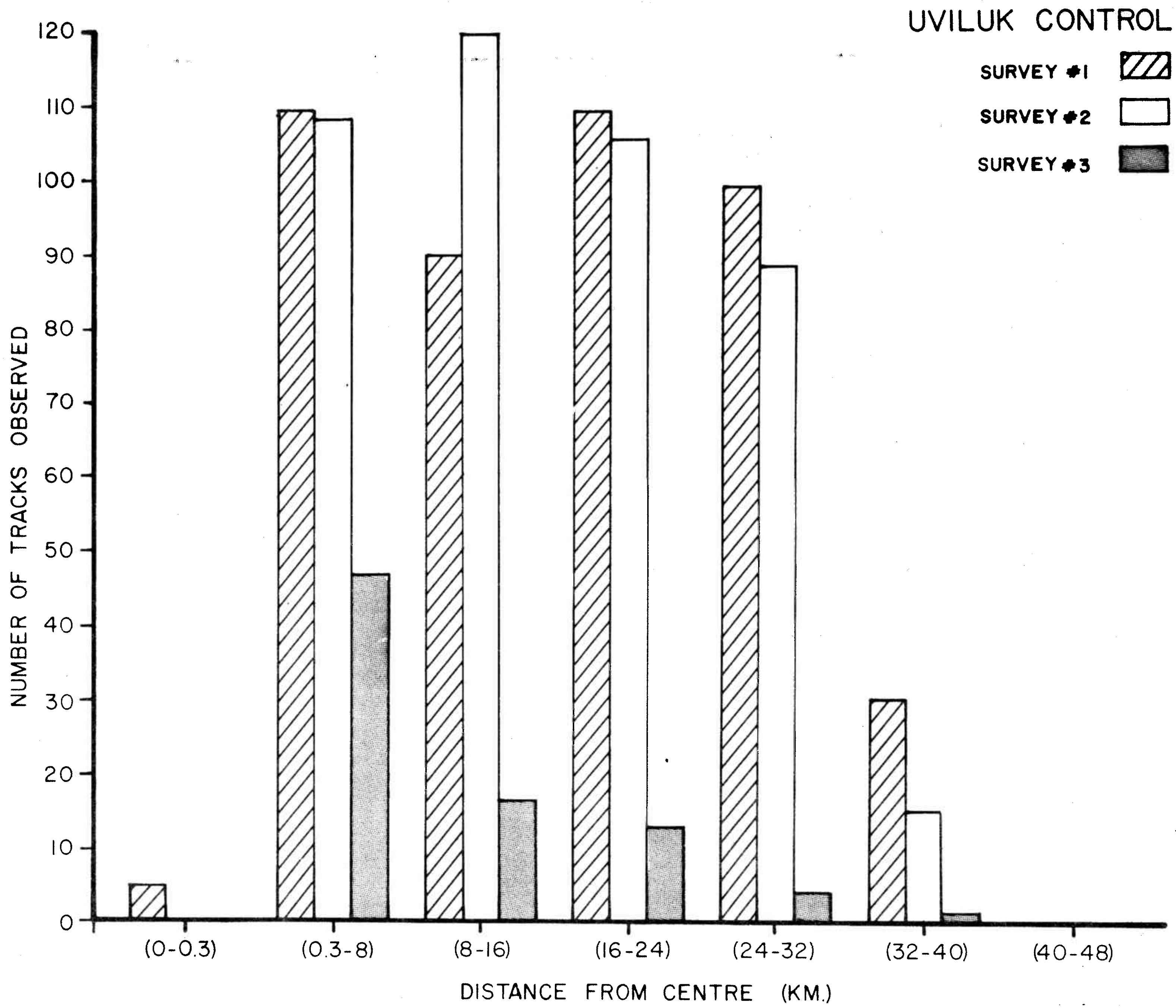

Figure 10. Number of polar bears tracks observed at the Uviluk control site during three aerial surveys, Beaufort Sea, spring, 1982.

Tarsiut site was operational at the time of these surveys, these data indicate that bear track concentrations do not increase in proximity to the island. However, the sea ice habitat in the vicinity of the study site would appear to have an affect on the distribution and concentration of bear tracks. A detailed account of bear tracks observed in the concentric circles at each study site is presented in Appendix B.

Polar Bear Tracks - Direction of Travel

During the first survey, 90% of the tracks at the Tarsuit and 0% of the tracks at the Tarsuit control continued towards the centre of the study sites in the inner zones (2 - 1) (Table 5). In contrast, 32% of the tracks at Tarsuit and 56% at Tarsuit control continued toward the centre of the study sites in the inner zones (2 - 1) during the second survey. The track direction for the other zones at these same sites does not reveal any consistent differences in the relative number of tracks leading to adjacent inner zones.

The track direction data for the Uviluk and Uviluk control sites was difficult to compare given the disparity in sample sizes between these sites during the surveys. The largest percentage of tracks moving towards adjacent inner zones occurred in the two innermost zones (e.g. 3-2, 2-1) at the Uviluk control site during all three surveys.

Table 5. Percentage of tracks moving towards adjacent inner zones, Beaufort Sea, spring 1982.

Site	Survey no.	N	Zones 7-6	6-5	5-4	4-3	3-2	2-1
Tarsiut	1	36	33(3)	100(1)	0(2)	33(12)	37(8)	90(10)
	2	146	50(2)	50(4)	83(12)	54(28)	57(53)	32(47)
	3	3	0(0)	0(0)	0(1)	0(1)	0(0)	0(1)
Tarsiut control	1	46	0(0)	100(2)	40(10)	43(14)	36(14)	0(6)
	2	50	0(1)	50(8)	35(17)	44(9)	17(6)	56(9)
	3	34	0(0)	0(5)	25(12)	45(11)	50(4)	0(2)
Uviluk	1	20	0(1)	100(6)	33(6)	100(1)	50(2)	50(4)
	3	32	57(7)	50(2)	66(3)	13(16)	0(1)	33(3)
Uviluk control	1	99	0(2)	7(15)	64(11)	48(21)	42(26)	42(24)
	2	294	0(0)	7(15)	64(11)	48(21)	42(26)	42(24)
	3	73	0(0)	100(1)	66(3)	36(11)	40(20)	13(38)

Numbers in brackets depict number of tracks observed within zones.

Other Possible Factors Affecting the Distribution of Polar Bears in the Study Area

During the aerial surveys we encountered a large number of low level aircraft flights associated with the operation of the Tarsiut artificial island. During the second survey two helicopters were slinging gabions to Tarsiut from a staging area on Hooper Island, a distance of approximately 55 km. If each helicopter made approximately two round trips per hour, and the helicopters were flying a minimum of 12 hours per day, there were approximately 96 low level flights to the southeast of Tarsiut each day for a period of 3 weeks.

While conducting the third survey at the Tarsiut experimental site, additional low level aircraft traffic was encountered to the northeast of Tarsiut. The icebreaker Kigoriak was stopped in the ice at 135.10°N - 70.08°W, approximately 47 km from Tarsiut experimental. At this time two helicopters were slinging equipment to Tarsiut from the Kigoriak. The exact number of flights between the Kigoriak and Tarsiut is unknown; however, it is estimated that at least 50 trips a day were made for a period of approximately 10 days.

The goal of the present study was to determine if the presence of artificial islands in the Beaufort Sea had an effect on the distribution of polar bears. It is possible that activities associated with the operation of artificial islands (e.g., low level aircraft flights) may have affected the distribution of polar bears in this region, and more specifically, around the Tarsiut experimental site. The observed low level flights therefore, may have had an effect on the data gathered during the second and third surveys near the Tarsiut site.

To date there has been no quantitative research conducted on how polar bears respond to low level aircraft flights. However, there exists a great deal of anecdotal information, primarily collected by bear researchers. This information suggests that polar bear response to helicopter disturbance is variable (R. Schweinsburg pers. comm.). Response is likely due to a number of factors including age, sex, weather, habitat, duration of disturbance, physical condition of the bear, as well as the bears' previous experience with helicopters.

Little is known about the possible short or long-term effects of large numbers of low level aircraft flights on polar bears within a localized area. For this reason low level aircraft flights are another factor which must be considered when interpreting the results of studies such as this.

DISCUSSION

This project was a pilot study to determine the best approach for assessing the distribution of polar bears in relation to artificial islands in the Beaufort Sea. The study design was developed on the basis of previous research completed on polar bears, seals, and sea ice habitat. Also, the study design was determined by logistical and financial limitations. At the onset of this study, it was acknowledged that 3 to 5 years of research would be required to accumulate an adequate data base with which to address the question, that being, does artificial island development affect the distribution of bears? The results of the present work provide data which identify areas of concern (e.g., bears do not avoid artificial islands), and will be useful in charting the direction of any future work.

Although the study period was marked by variable weather and ice conditions, the three survey periods were short enough to ensure that conditions remained stable within those periods. Comparison of track distributions within surveys suggest that there is an eastward gradation of increasing polar bear abundance within the study area. Comparisons across the three surveys indicate an overall decrease in polar bear relative abundance within the study area during the study period with the eastward gradation in relative abundance being upheld. This is in general agreement with Stirling et al. (1981) who found that polar bears were most abundant at, and in the vicinity of, the Cape Bathurst polynia. The decreased relative abundance of polar bears over the three study periods probably resulted from a corresponding movement of bears farther out into the Beaufort Sea with the receding pack ice. During the third survey major sections of open water were encountered at the Uviluk control site; a great deal of broken pan ice was observed at the Uviluk site. A large number of open leads and refrozen young ice was observed at the Tarsiut and Tarsiut control sites during the third survey. Because progressively fewer tracks were observed during surveys 1-3, despite improving track conditions during the three surveys, we believe that our interpretation of overall relative abundance is valid.

Our data is inconclusive as to whether polar bears gravitated toward the centres of the experimental sites. In fact, only the Tarsiut experimental-Tarsiut control comparison could be used to examine this question; the Uviluk experimental existed only as a partially constructed mound below the sea ice. For the Tarsiut comparisons, there was variability across the surveys. The two sites demonstrated centrally oriented concentrations of polar bear tracks. The significant differences detected in the Uviluk comparisons were probably a result of the large numbers of bear tracks recorded at Uviluk control, especially during the first survey.

No directional trends in polar bear tracks were detected. Once again the only meaningful comparisons possible were generated from the Tarsiut sites; however, the results were ambivalent depending on the survey. It should be remembered that Tarsiut, the only operating artificial island, was found to have bear tracks approximately 0.3 km from the site. This, when considered with the nuisance polar bear destroyed on the relief well platform beside Tarsiut in May 1982 (N.W.T. Wildlife Service Field Report No. TU-2) and the frequent sighting of bears by island personnel, indicate that polar bears do not avoid artificial islands, and can gain access to them. Therefore polar bears pose a threat to personnel working at the site.

Several modifications to this study's design are in order if work is to continue. The star survey design should be retained but in a scaled down form. It is our belief that the effects on polar bear distribution by artificial drilling islands will be localized and that the broad area encompassed by the present survey sites is not necessary.

We stress that a long-term approach is required to adequately address the question of polar bear distribution and the presence of artificial drilling islands in the Beaufort Sea. Sea ice patterns can change annually, and given the importance of sea ice characteristics on polar bear movement and distribution, survey results could change correspondingly. Artificial islands that through chance alone are located in sea ice most favourable to polar bears could lead to spurious interpretation of the data. It will always be important to keep separate the presence of an artifical island from where it is located when interpretating the results presented herein.

It must be stressed that the data from this survey were gathered when one artificial island (Tarsiut) was in operation. The possible cummulative effects of additional artificial islands and the activities associated with them, on polar bears in the Beaufort Sea remain unknown.

RECOMMENDATIONS

1. As long as artificial islands continue to be constructed and utilized in the Beaufort Sea, polar bear populations inhabitating this region should be monitored.

2. A data collection program focusing on polar bear distribution, and relative abundance around artificial islands should be continued.

3. A data collection program focusing on polar bear behaviour around artificial islands should be initiated.

4. The survey design used in this study should be continued but with the following modifications:
   a) Surveys should be conducted during the fall (mid-November), mid-winter (February) and late winter (April-May) each year.
   b) Study sites should be reduced by 1/3 to 1/2 the size of the 1982 study sites.

ACKNOWLEDGEMENTS

This project was funded by Dome Petroleum Ltd. and Gulf Canada Inc.

We would like to thank John Ward, Dome Petroleum, for his encouragement and logistical support throughout the course of this research. Paul Gray assisted in the establishment and coordination of the research program and provided guidance at each phase. Our helicopter pilot, Bogden Dudaravich of Quasar Helicopters Ltd. provided safe, professional service during our aerial surveys.

Drs. Ian Stirling and Michael Kingsley, Canadian Wildlife Service, suggested the unique and practical survey design used in this study. Marc Cattet assisted in the field research during the third survey period, and provided skillful and precise data plotting, drafting and data analysis.

Paul Gray, Jim McComisky, Ray Schweinsburg, Ian Stirling and John Ward reviewed the manuscript and made helpful suggestions.

Paul Voudrach was most helpful in providing logistical support and generous hospitality during our stay in Tuktoyaktuk.

PERSONAL COMMUNICATIONS

R. Schweinsburg, N.W.T. Wildlife Service, Yellowknife, N.W.T.

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Appendix A. Classification of sea ice habitat types.

The following sea ice classification scheme is from Stirling et al. 1981.

Type 1: stable flat areas interspersed with pressure ridges that have not moved for a long time; ridges drifted with snow and suitable for seal lairs; snow of variable depth on the flat ice between the pressure ridges; usually in mouths of bays and landfast ice out from coastlines.

Type 2: as above but without extensive drifts suitable for seal lairs; ice between ridges is usually bare; appears particularly rough because of lack of snow cover and drifts.

Type 3: the floe edge where leads are wide (>1 km), usually with small open or refrozen leads parallel to floe edge or emanating from pressure ridges not usually heavily drifted; includes areas of less than 7/8 ice cover where large floes are intermixed with leads and patches of open water.

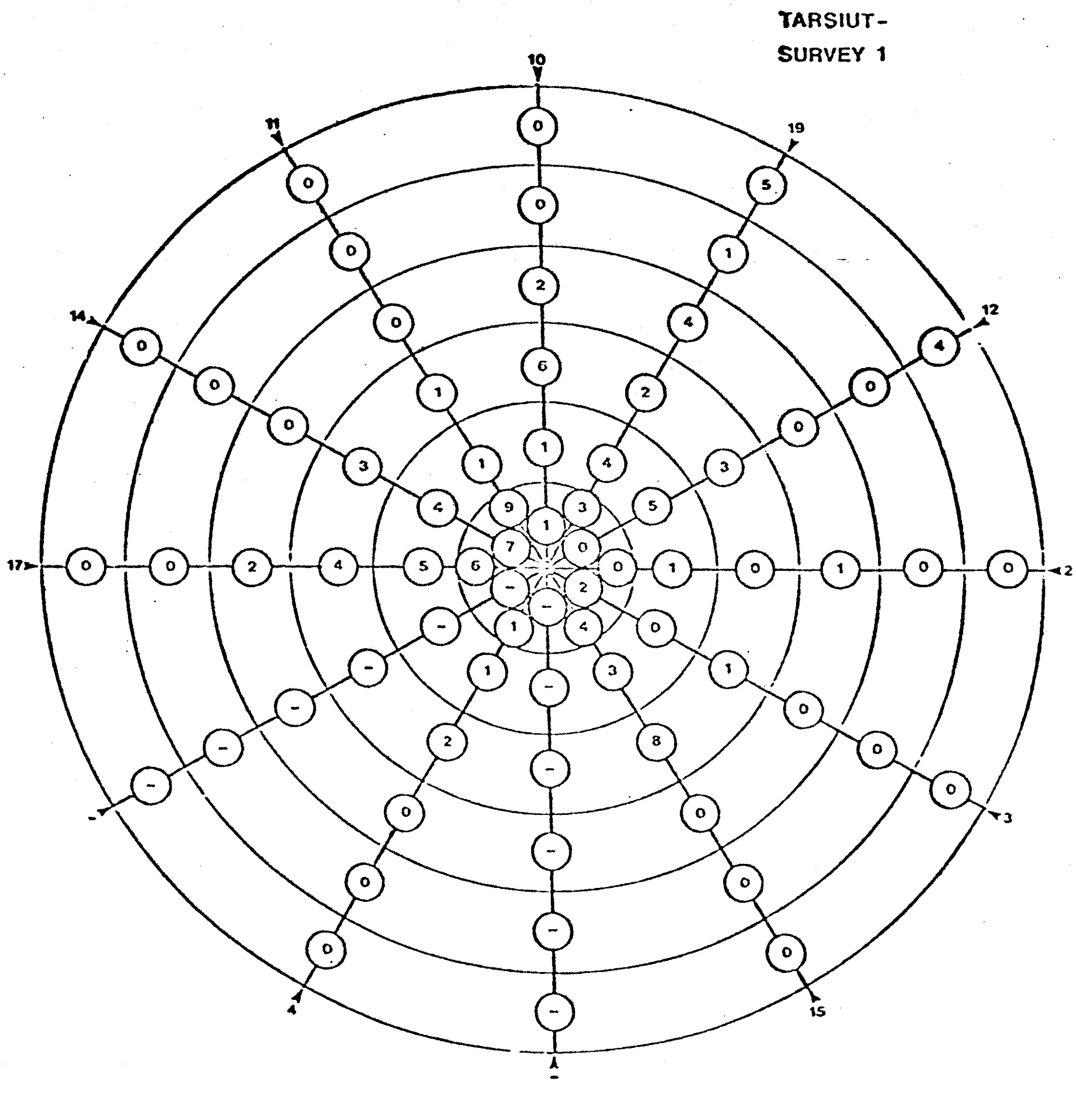
Type 4: areas of 7/8 ice cover or more in "active zones", such as around Baillie Islands; wind and currents cause much movement of ice, followed by refreezing creating intermittent lanes or patches of refrozen young ice; bare or only slightly drifted.

Type 5: areas of continuous heavy pressure ice that have not moved for a long time; relatively uncommon except in small areas such as Cape Kellet or in years such as 1974.

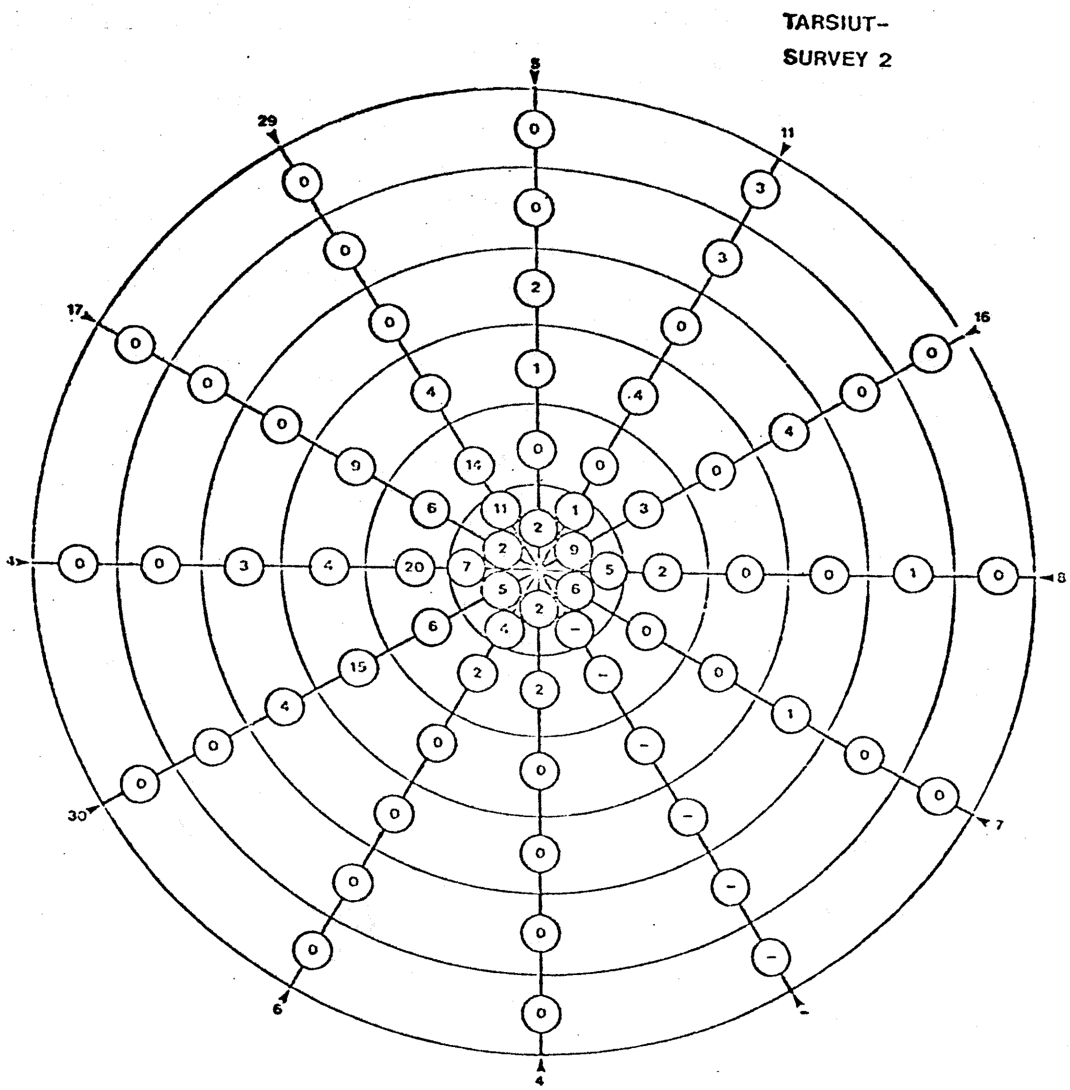
Type 6: rough ice along coastline; develops in ridges parallel to the coast because of the tide; characteristic in areas with steep banked coastlines such as parts of southern Banks Island; less common along the mainland coast.

Type 7: deep bays and areas of smooth landfast ice such as Prince Albert Sound; held in place by small offshore islands; variable snow cover and fewer ridges than Type 1; not common in the Western Arctic.

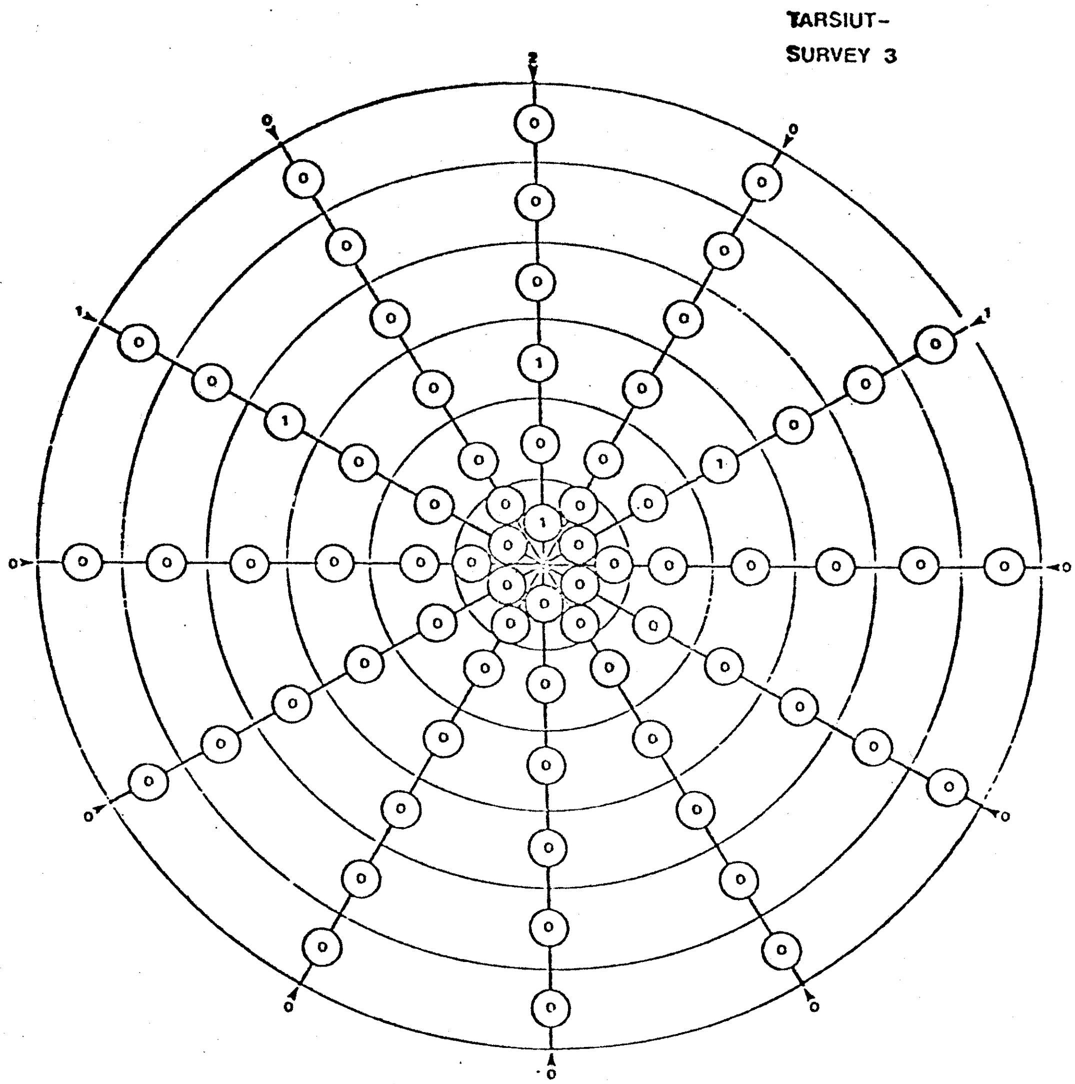
Appendix B. Track counts at each study site during surveys 1 to 3.



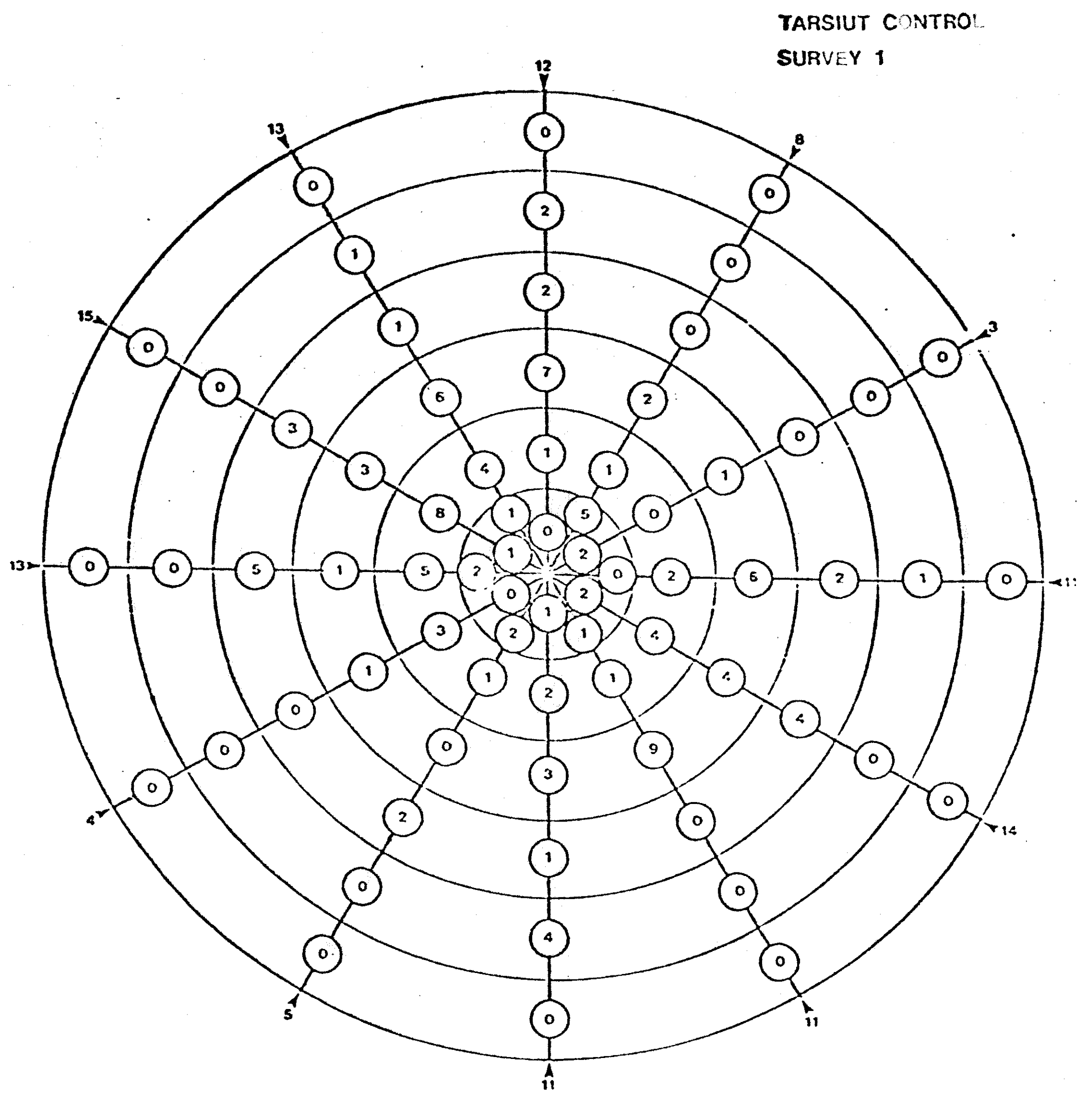
Track counts at the Tarsiut study site during survey 1.



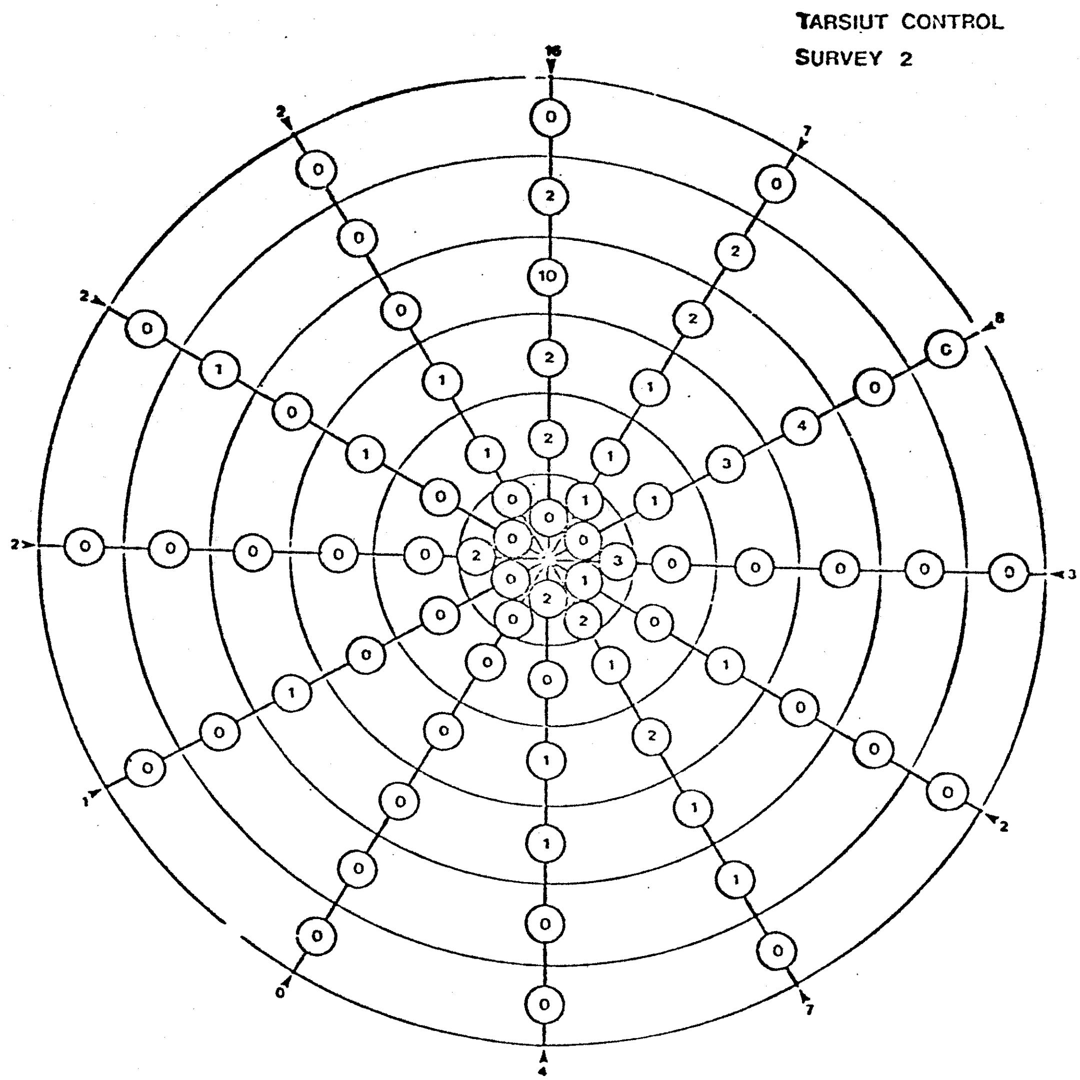
Track counts at the Tarsiut study site during survey 2.



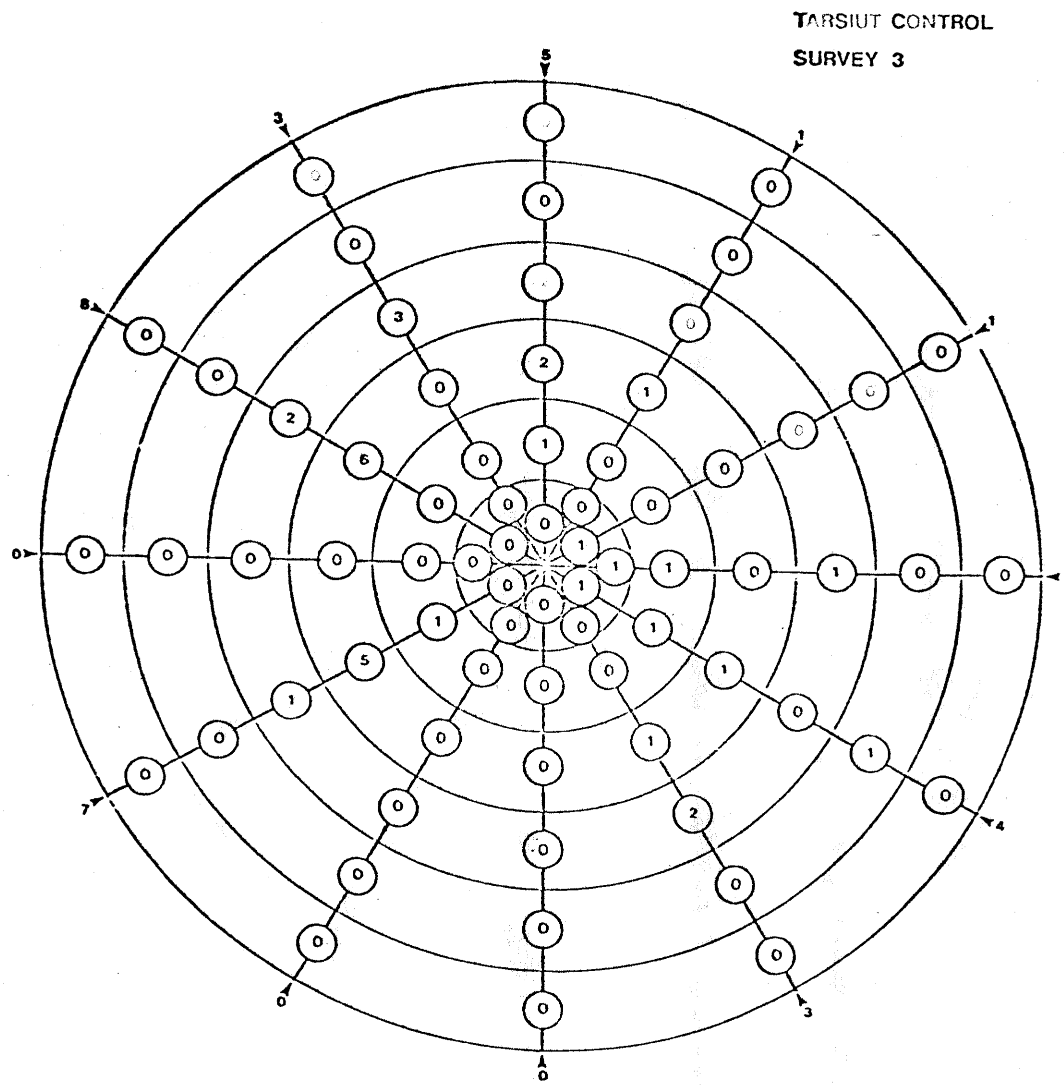
Track counts at the Tarsiut study site during sruvey 3.



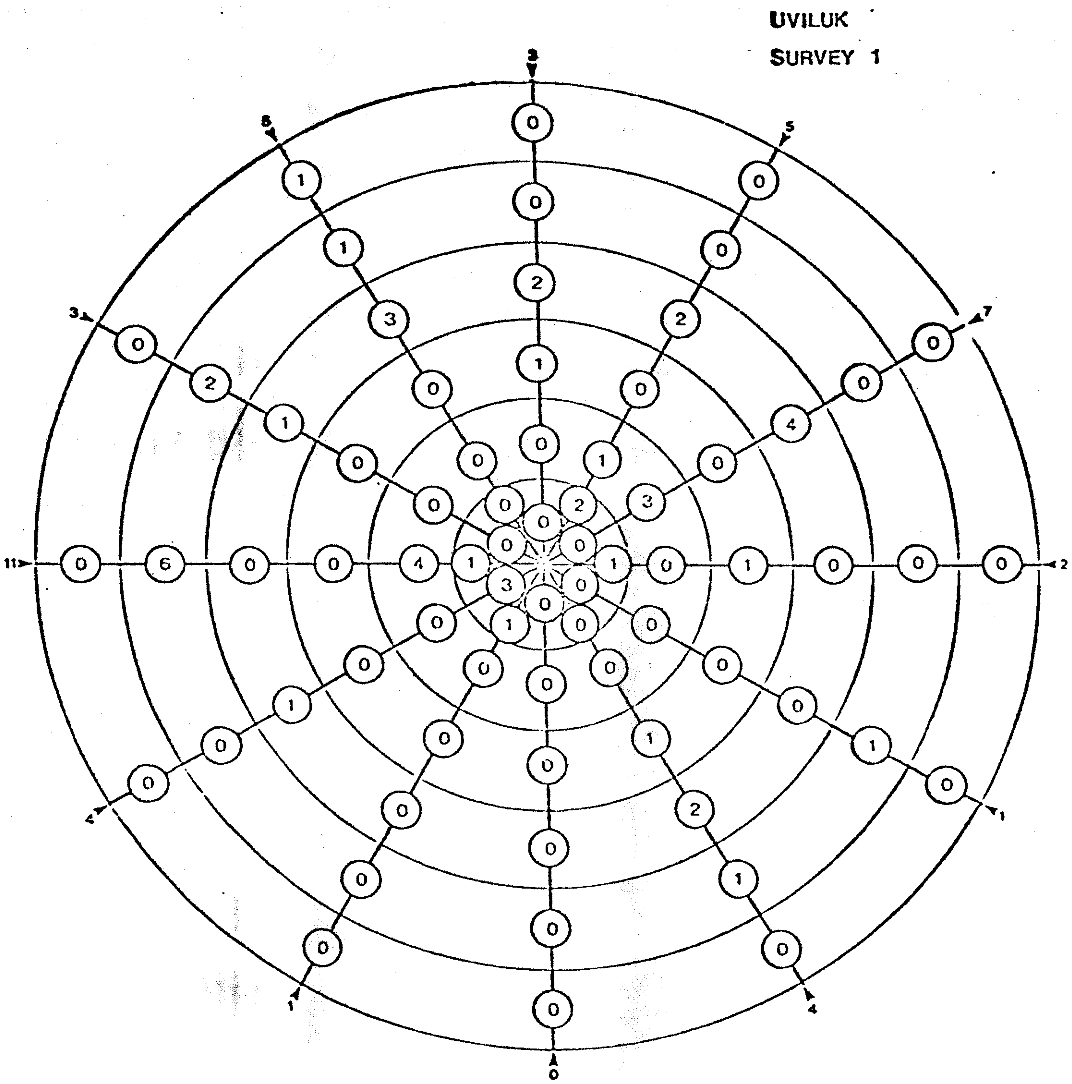
Track counts at the Tarsiut control site during survey 1.



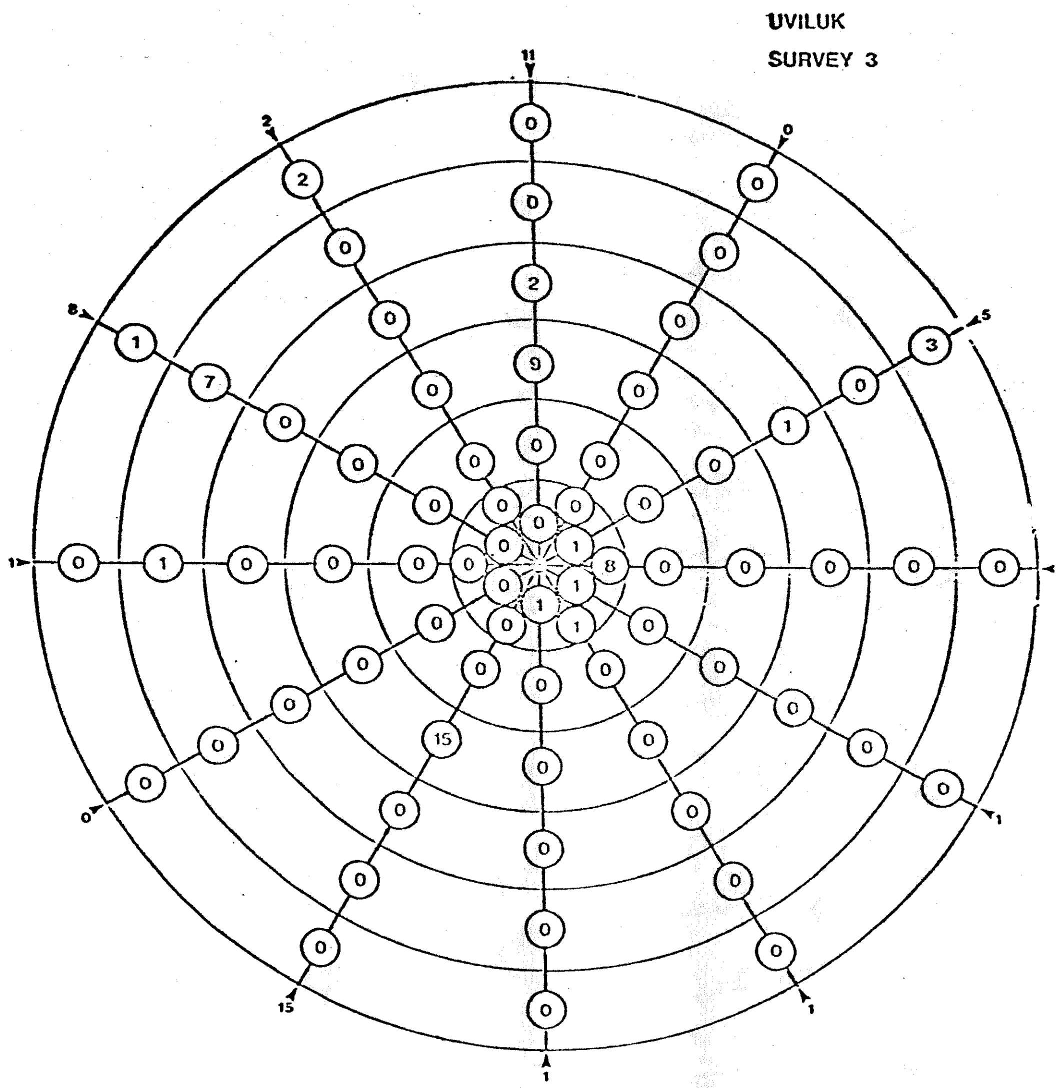
Track counts at the Tarsiut control site during survey 2.



Track counts at the Tarsiut control site during survey 3.



Track counts at the Uviluk study site during survey 1.



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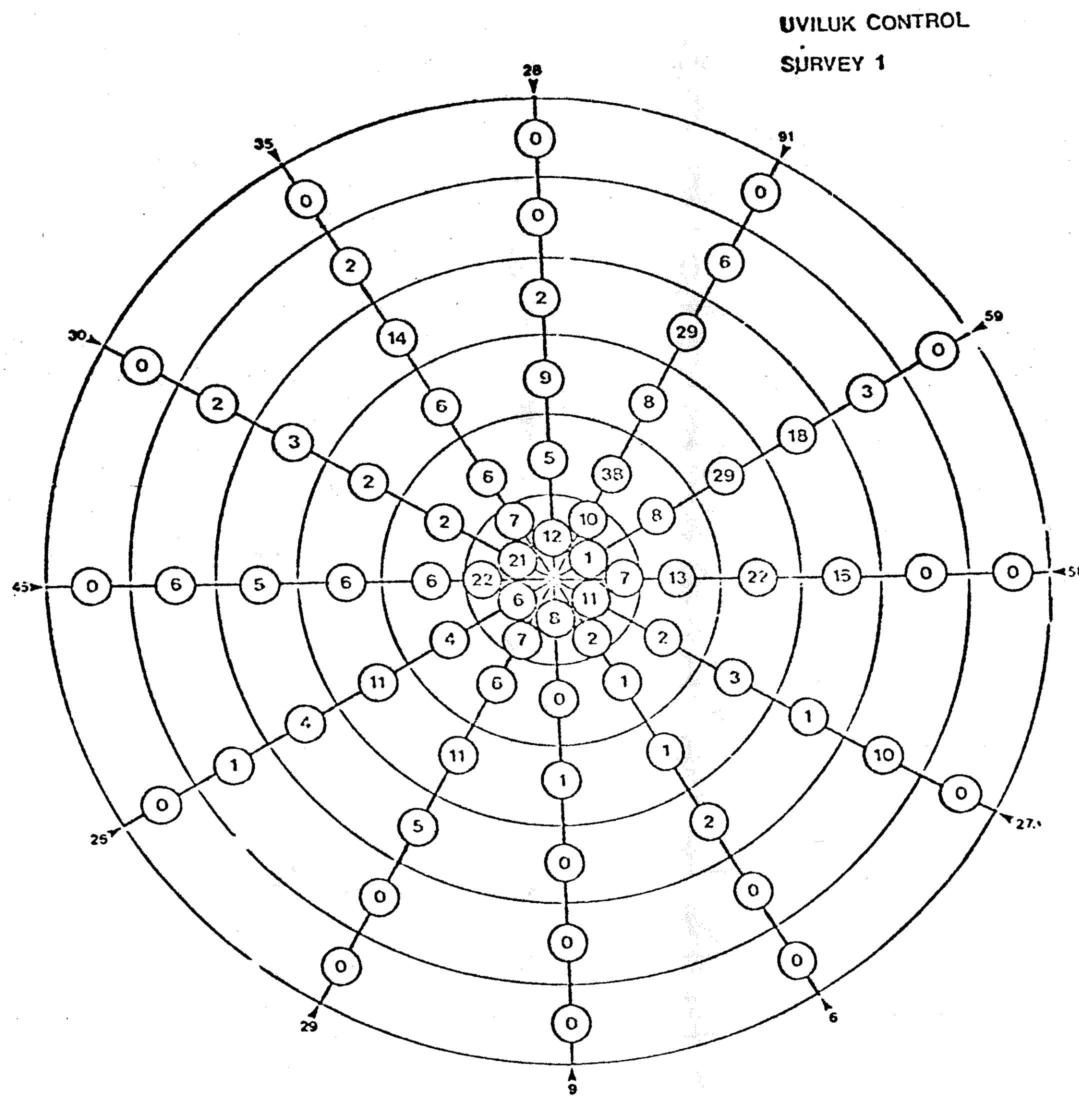
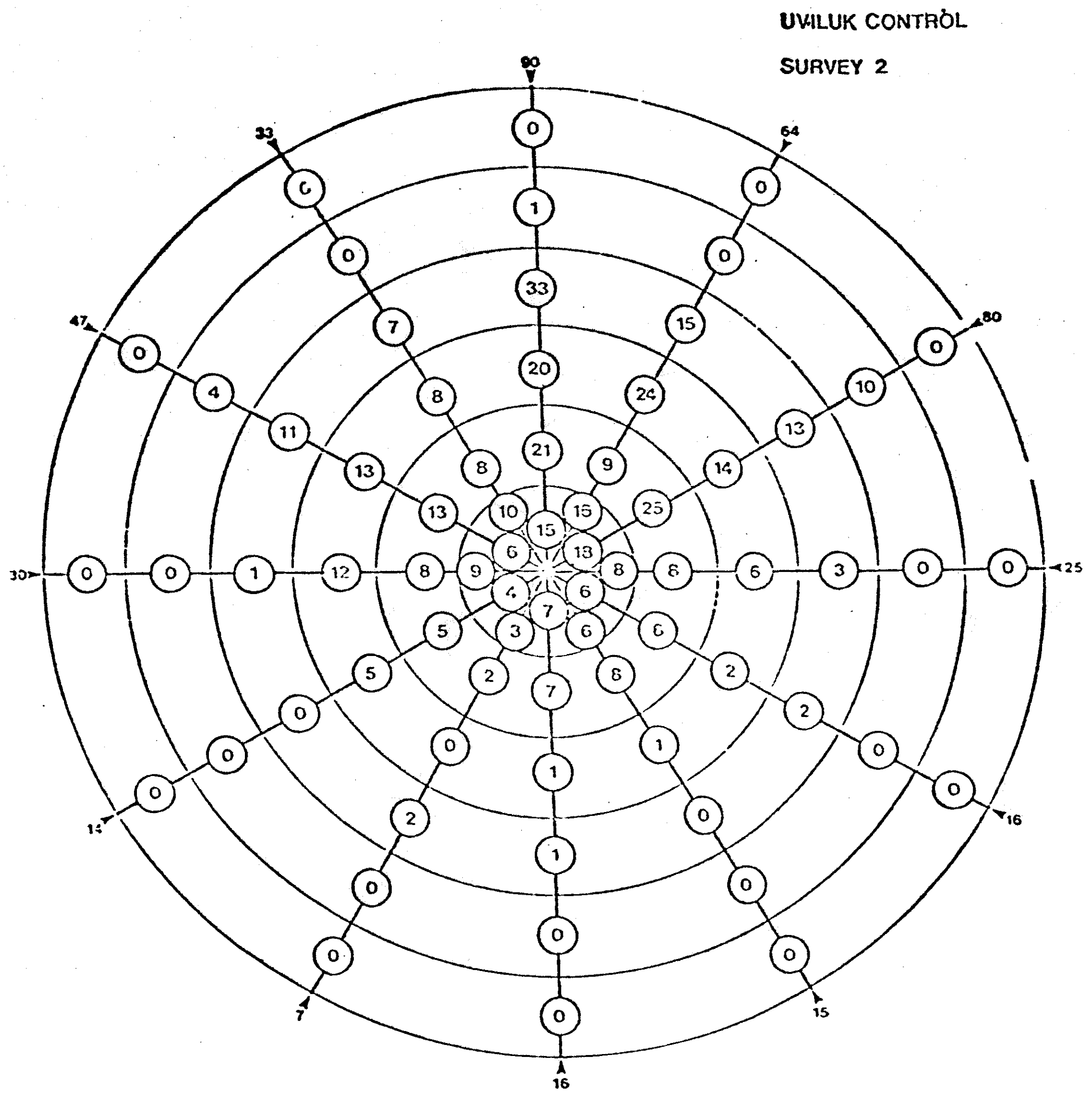


Track counts at the Uviluk control site during survey 1.



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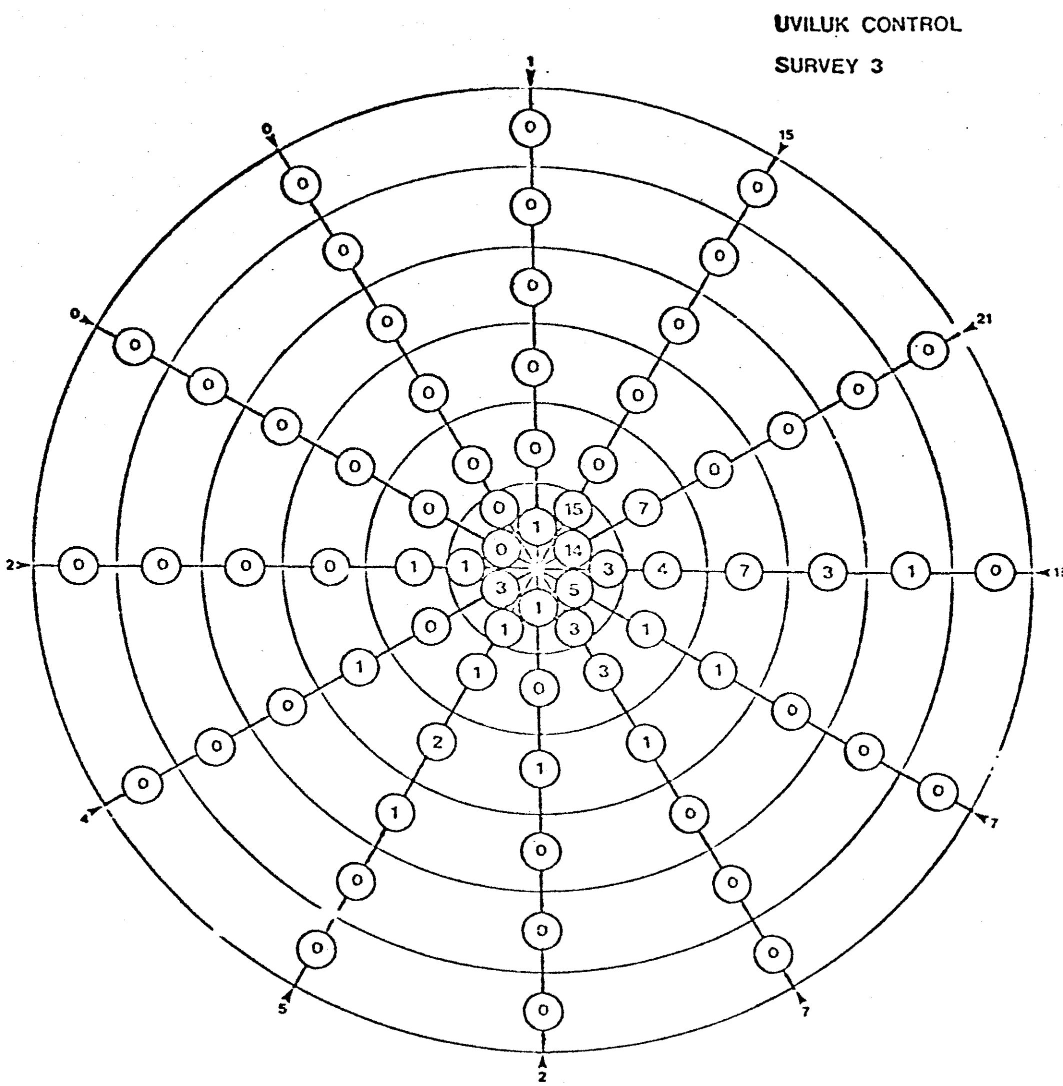

Track counts at the Uviluk control site during survey 3.