FINAL REPORT

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SEASONAL USE AND FEEDING HABITS OF WALRUSES IN THE PROPOSED BRISTOL BAY CLAM FISHERY AREA

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EXECUTIVE SUMMARY

A joint industry-government resource assessment conducted in 1976-78 in the southeastern Bering Sea identified a commercially viable surf clam (Spisula polynyma) resource along the north side of the Alaska Peninsula. Since walruses (Odobenus rosmarus) inhabit the area, and since elsewhere they feed predominantly on several species of clams, including the surf clam, some concern was expressed that a clam fishery would adversely impact the walruses' food supply. In response to this concern, the North Pacific Fishery Management Council funded a study to examine the distribution, abundance, and food habits of walruses in Bristol Bay, with particular attention given to the proposed clam fishery zone. The study was conducted by the University of Alaska and the Alaska Department of Fish and Game during the period April 1980 to May 1981.

The distribution and numbers of walruses in Bristol Bay were determined by means of systematic monthly aerial surveys. Each survey included about 1,689 km of transects, of which 470 km were in the clam fishery zone. The area quantitatively surveyed each month comprised approximately 4.8% of the clam zone and 2.5% of the remainder of Bristol Bay. Twelve surveys were flown in a 14-month period; no survey was flown in July or September 1980; April and May surveys were flown in both 1980 and 1981.

Walruses were seen on every survey. Nearly all were adult or subadult males. Their estimated total numbers in Bristol Bay ranged from about 280 in January 1981 to 63,800 in May 1980. The numbers in the clam fishery zone ranged from 0 in June 1980 to February 1981 up to about 14,000 in April 1980. During winters with extensive sea ice cover, walruses may be numerous in the north half of the Bay. When ice cover is light, as it was in winter 1980-81, they apparently move into the Bay in March from the west. We estimate that about 20,000 walruses are in the Bristol Bay area, at least from May to August, with a decline in numbers thereafter. Our surveys indicated that about two-thirds of the walruses were in the clam zone in April and less than one-quarter were there in March and May. They were generally absent from the clam zone from June to February. In 1980-81, about 7% of the annual walrus-days in Bristol Bay were spent in the clam fishery zone.

Foods of walruses were identified from collections of animals at sea. In February and March 1981, 180 walruses were collected in southern Kuskokwim Bay as part of a joint US-USSR research project. Fifteen of those animals had recently been feeding, predominantly on bivalve mollusks which made up 96% by weight of the stomach contents. The most common food items in this sample were tellins (Tellina lutea) (61% of the total biomass) and surf clams (16% of the total biomass). In April 1981, a sample of four walruses was collected in the proposed clam fishery zone. Each had been feeding mainly on bivalve mollusks, which comprised about 90% of the food biomass. About 61% of the biomass was identified as surf clams and 14% as tellins. Based on the sizes

of surf clam feet in the stomachs, walrus predation was heavy on each age class from about 3 to 15 years and may have been proportional to the relative abundance of age classes in the clam population.

We calculated the amount of surf clams consumed by walruses, based on the number of walrus-days in the area (517,460-724,942 in 1980; 123,251-181,449 in 1981), the average body weight (1,200 kg for adult males), the daily food intake (5.5% of total body weight per day), and the observed proportion of surf clams in the diet (61.4% of identified remains plus 8.4% of partly digested fragments). The results indicate that the walruses using the clam zone as a feeding area in 1980 could have consumed 17-33% of the total biomass of harvestable surf clams, or about two to four times the estimated annual sustained yield. Due to the smaller number of animals using the area in 1981, the calculated impact was considerably less: about 5-11% of the harvestable biomass could have been removed by the walruses. We suggest that the walruses returned to the clam fishery zone in smaller numbers and stayed a shorter time in 1981 because they found the food supply depleted as a result of their predation in the previous year.

INTRODUCTION

A joint industry-government investigation was conducted in the southeastern Bering Sea in 1976-78 to assess the potential for development of a hydraulic dredge surf clam (Spisula polynyma) fishery in that area. The results of that investigation pointed to the presence of commercially harvestable quantities of surf clams and other bivalves in a 9,260-km^2 nearshore area in southern Bristol Bay, between Port Moller and Ugashik Bay (Hughes et al. 1977, Hughes and Nelson 1979). The Fishery Conservation and Management Act of 1976 requires that, before such a fishery can be developed, a Fishery Management Plan (FMP) and an Environmental Impact Statement (EIS) must be prepared for it. Preparation of the FMP for the proposed Bering Sea surf clam fishery was begun in 1977, but its completion has been delayed by insufficient data on: a) the biology of S. polynyma, especially its reproduction, growth, and recruitment rate to harvestable size; b) the effects of hydraulic clam harvesting on the surf clam and its associated benthic community; and c) the potential for conflict between the proposed fishery and marine mammals. Because walruses (Odobenus rosmarus) inhabit Bristol Bay in considerable numbers (Brooks 1954; Kenyon 1960; Burns 1965; Miller 1975, 1976), and because elsewhere in the Bering Sea they feed primarily on clams, including S. polynyma (Fay et al. 1977, Lowry et al. 1980), some concern was expressed that a clam fishery in this area might adversely impact the food supply of the walrus population (Stoker 1977).

The study reported here was designed to evaluate the possibility of conflict between the interests of a clam fishery and of the walruses of Bristol Bay. Its objectives were to: 1) describe the degree to which walruses inhabit the proposed clam fishery area, 2) determine whether they feed there, and 3) identify the kinds of foods eaten there and in adjacent parts of southeastern Bering Sea. The study was begun in April 1980 and completed in May 1981.

Background

Walruses are large, robust pinnipeds with uniquely large upper canine teeth (tusks), thick skin, and short, sparse hair (Brooks 1954, Scheffer 1964, Burns 1965). They inhabit arctic seas of the North Atlantic and North Pacific regions, especially ice-covered areas, where they apparently feed primarily on bivalve mollusks (clams, cockles, and mussels) and secondarily on other benthic invertebrates (Chapskii 1936, Nikulin 1941, Vibe 1950, Brooks 1954, Mansfield 1958).

The Pacific walrus (O. r. divergens) resides principally in the Bering and Chukchi Seas (Fig. 1), mainly frequenting the parts of the seasonal pack ice in which thin ice or natural openings (leads and polynyas) are common (Burns 1970, Burns et al. 1980). In summer, most of the population inhabits the southern edge of the ice in the Chukchi Sea, as well as the northern coast of Chukotka; in winter, the animals congregate in the pack ice of northcentral and southeastern Bering Sea (Fay, in press).

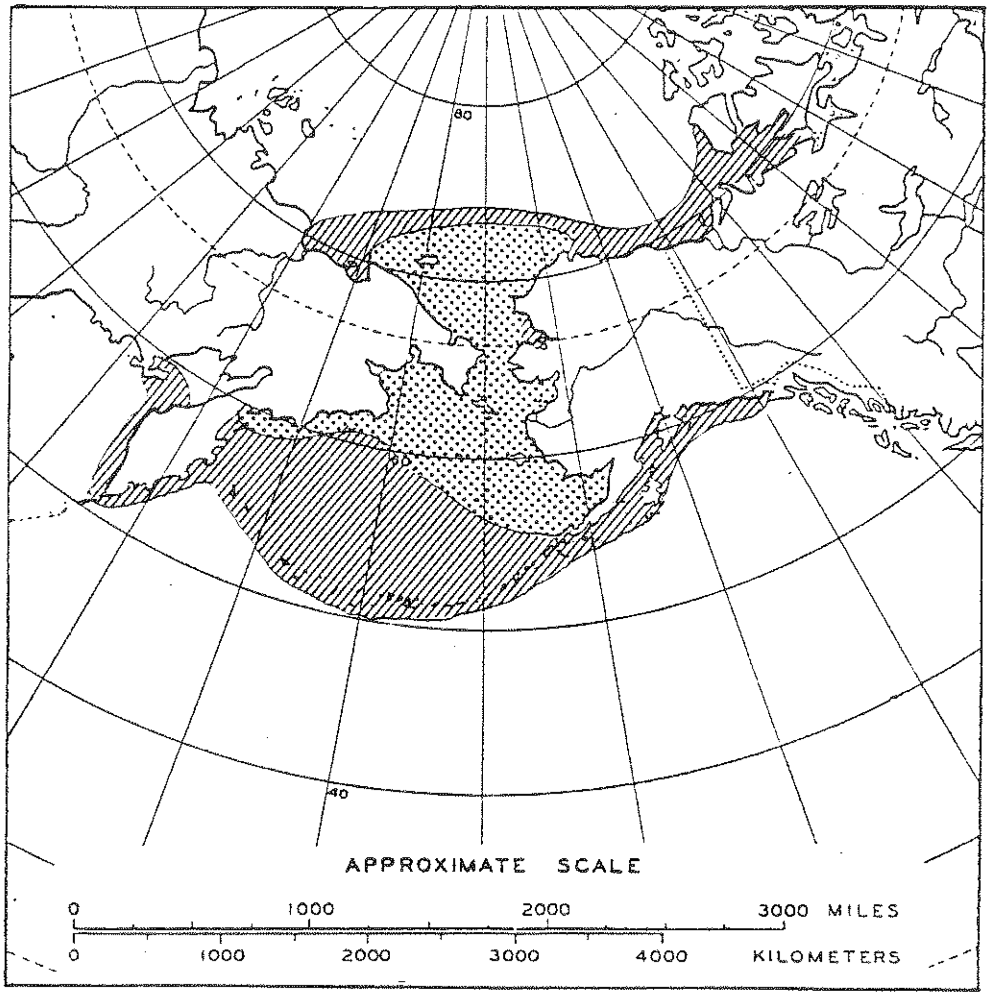

Figure 1. Distribution of the Pacific walrus population. Central stippled area is the primary range. The animals are uncommon to rare in the crosshatched areas. (after Fay, in press).

When the late winter - early spring pack ice of southeastern Bering Sea covers most of Bristol Bay, walruses are abundant in that area, at least as far east as 159°W longitude (Kenyon 1972, Burns and Harbo 1977, Krogman et al. 1979). Such extensive ice was present in five winters from 1971 to 1979 (Burns et al. 1980). From an aerial survey in mid-April 1972, Kenyon (1972) estimated that about 35,000 walruses were in the pack ice of Bristol Bay. These were mainly adult females and young, together with some males (Fay, in press). By early May of that year, the number in the Bay apparently had declined to about 17,000, judging from the results of a second survey by U.S. Fish and Wildlife Service personnel (FWS 1972). Krogman et al. (1979) estimated about 9,000 walruses in the Bay in early April 1976.

Virtually all of the females and young leave Bristol Bay during April and migrate northward toward their summering areas in the Chukchi Sea (Fay, in press). Many of the males (bulls), however, remain in the Bay throughout the summer, ranging out to sea and periodically returning to the Walrus Islands, where they go ashore to rest (Miller 1975). In recent summers, up to 12-15,000 bulls at one time have been counted on the shore of Round Island (58°36'N, 159°58'W) in the northern part of the Bay (J. Taggart and C. Zabel, pers. comm.). Round Island is the only hauling ground in the Bay that is used by these bulls throughout the summer; other sites, such as Amak Island, Walrus and Deer Islands in Port Moller, Cape Seniavin, Cape Constantine, and Cape Newenham, have been used irregularly.

Seasonal occupancy of the Bay by walruses is implied by monthly plots of sightings compiled from various sources over the past 40 years (Figs. 2 and 3). These suggest that the animals move into the northern part of the Bay in considerable numbers in February or March, are abundant throughout the Bay in April to June, then become less numerous or more widespread from July to January or February. The small number of sightings in the Bay from July to February, however, is not necessarily a reliable indicator of scarcity, for prior to 1980 there were no extensive surveys in those months; only the absence or presence of animals on Round Island was regularly recorded by State and Federal biologists working in that area.

The animals' activities at Round Island were studied in some detail by Miller (1975, 1976) and by Taggart and Zabel (unpubl. data). Through the use of color-marking and radio-tagging, these observers found that individual bulls spend 1 to 6 days ashore, then leave the island for 2- to 18-day periods, presumably to feed. Unknown, however, were the locations of feeding areas, the distances traveled to and from them, and the specific kinds of foods eaten. Three walruses taken and examined at Round Island in June 1958 had empty stomachs. The only food remains identifiable in their digestive tracts and in feces on the beach were the distintively hooked, gold-colored setae of the echiurid worm *Echiurus echiurus* and a few valves of the small cockle *Cyclocardia* sp. (Fay, in press).

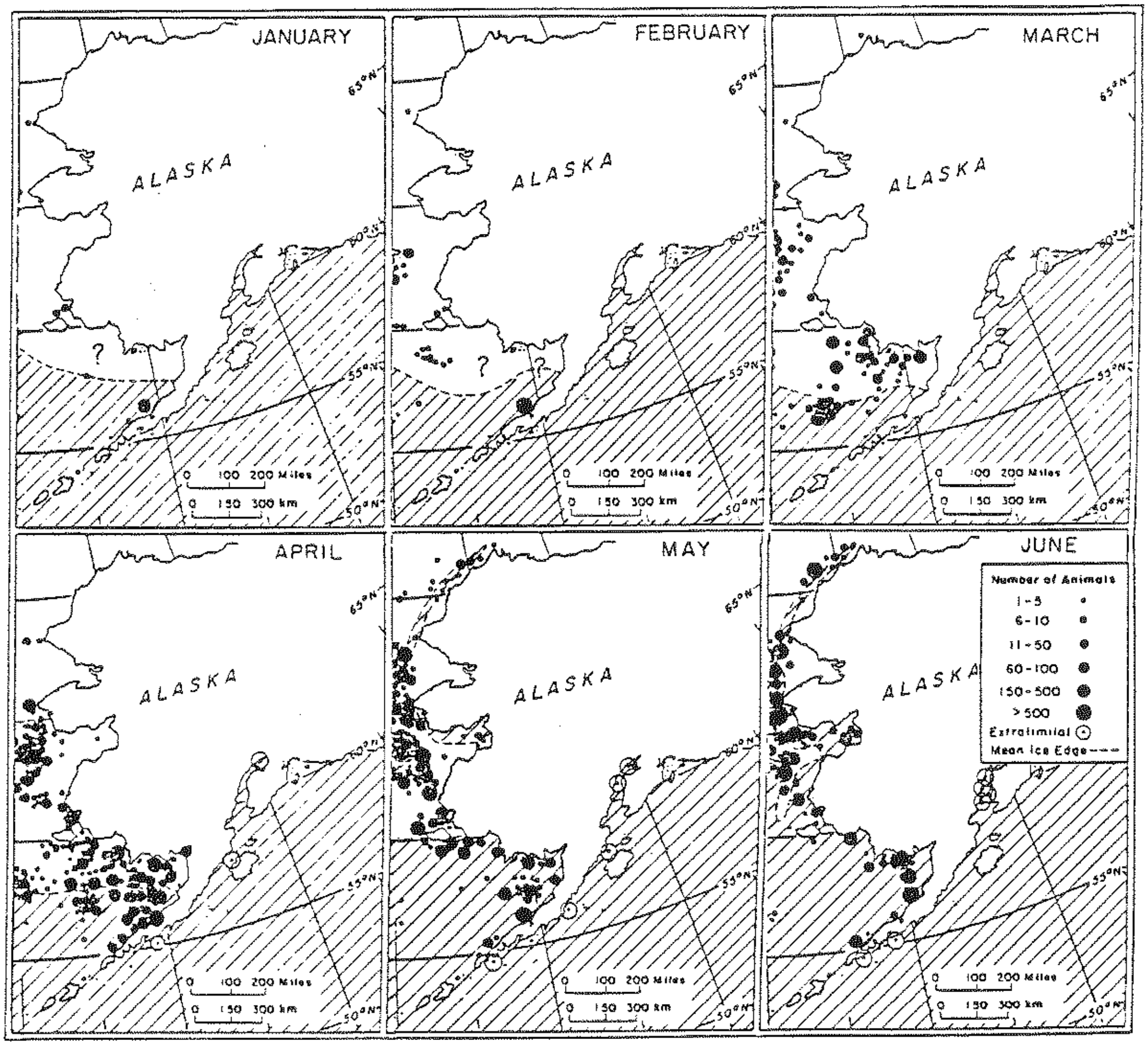

Figure 2. Distribution and relative numbers of walruses sighted each month from January to June in Alaskan waters, based on published and unpublished reports, 1930-1979. Crosshatched areas are open water. Question marks indicate areas unsurveyed. (after Fay, in press).

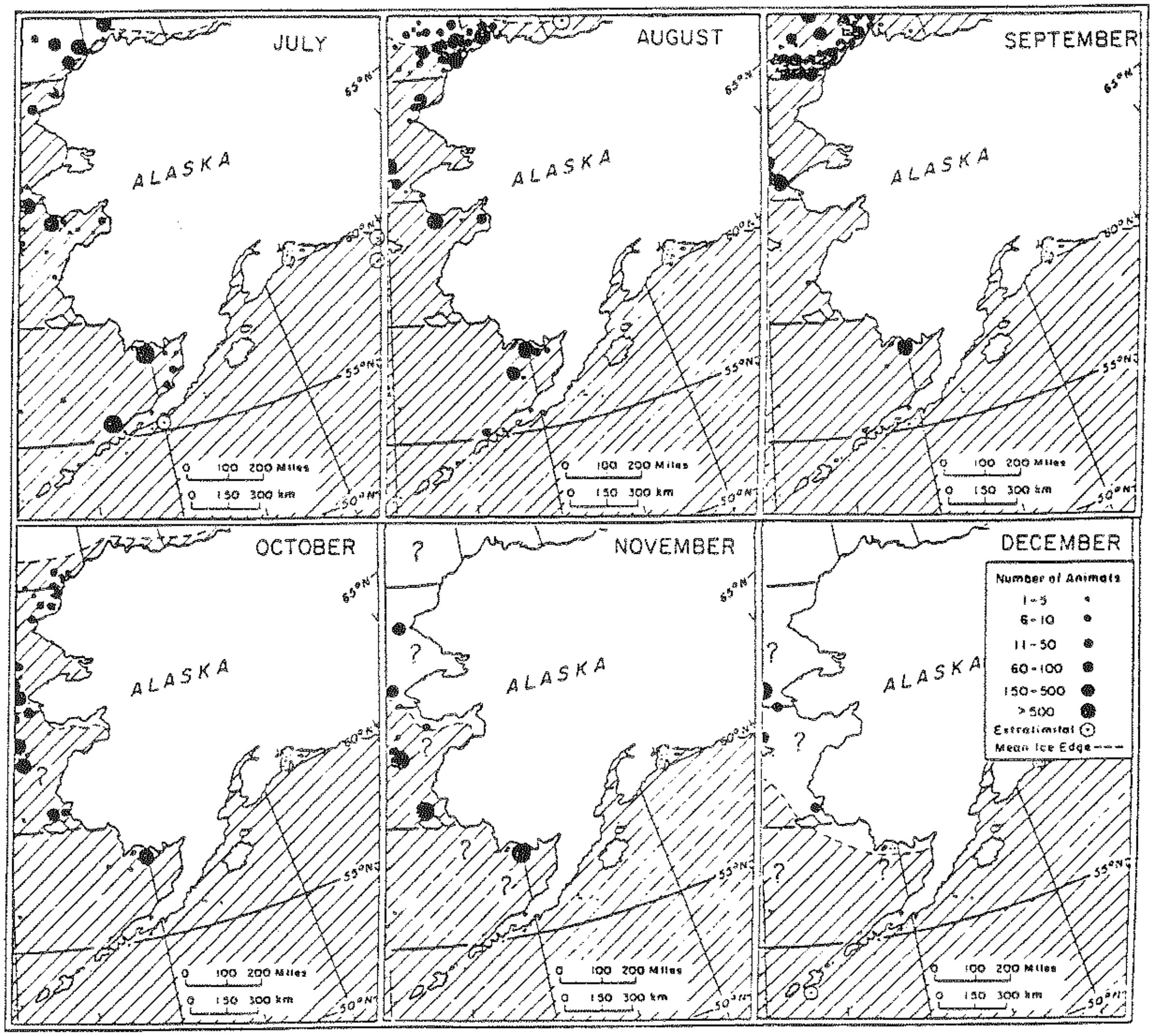

Figure 3. Distribution and relative numbers of walruses sighted each month from July to December in Alaskan waters, based on published and unpublished reports, 1930-1979. Crosshatched areas are open water. Question marks indicate areas unsurveyed. (after Fay, in press).

Studies by Nikulin (1941), Brooks (1954), Krylov (1971), Fay et al. (1977), and Lowry et al. (1980) of the stomach contents of walruses taken in the northern Bering and Chukchi Seas in spring and summer have indicated that the primary foods there are bivalve mollusks. In individual cases, however, other organisms such as polychaetes, hydrozoans, holothureans, tunicates, or seals made up half or more of the stomach contents. Those findings suggest that walruses are adaptable in choice of foods, at least to the extent that they are not wholly dependent on bivalves. Overall, more than 60 different genera of marine organisms have been identified as foods of the Pacific walrus (Fay, in press), some of which may be alternate prey that can be used where mollusks are scarce.

Up to 1980, only three samples of stomach contents had been examined from walruses in southeastern Bering Sea, and these mostly were not reported quantitatively. The first, by Tikhomirov (1964), indicated that 50 animals taken about 240 km southwest of Nunivak Island in March 1962 had fed principally on "shrimps, crabs (including a few king crabs), and lesser amounts of mollusks." He remarked that these food items were quite different from those in the Chukchi Sea in summer, "where the basic food of walruses is mollusks."

The second sample was taken in January 1970 by E. Muktoyuk and S. W. Stoker, about 240 km southeast of Nunivak Island. There, the animals (2 males) had fed almost entirely on mollusks. The stomach of one contained 10.9 kg of only one kind of prey, Greenland cockles (*Serripes groenlandicus*), while the other contained 3.7 kg of mainly whelks (*Neptunea* spp. and *Buccinum* spp.) with some cockles and tunicates (Fay, in press).

The third sample (21 animals) was taken by Y. A. Bukhtiarov (Fay et al., in prep.) about 260 km east of the Pribilof Islands in late March and early April 1976. Bivalves, mainly cockles, predominated in those stomachs, making up at least 90% by weight of the contents. Of secondary importance by weight were tanner crabs (*Chionoecetes* spp.), whelks, and tunicates.

Each of those samples was taken over comparatively deep water (65-90 m), outside the primary area in which *Spisula polynyma* is known to occur in abundance (Fig. 4). For that reason, one would not expect that species to have been well represented, even if it were a major element in the diet elsewhere. Furthermore, only the smallest sample (January 1970) was fully analyzed; the others were only grossly inspected before being discarded. The presence or absence of surf clams in the diet of walruses in the Bristol Bay region, therefore, was not adequately tested by these samples.

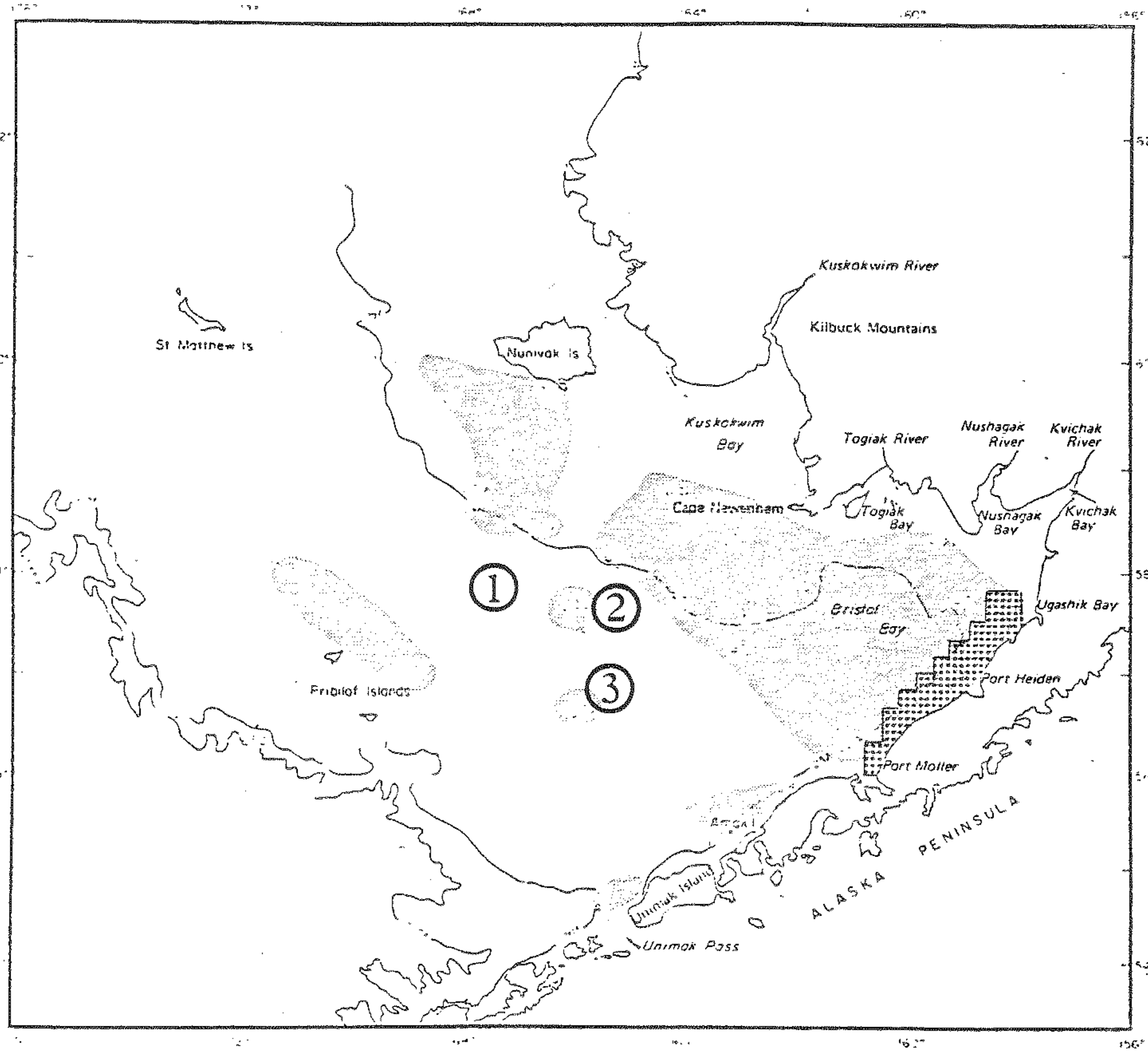

Figure 4. Locations in southeastern Bering Sea where walruses were obtained for analysis of stomach contents prior to this study: 1) March 1962; 2) January 1970; 3) March-April 1976. Lightly stippled areas show distribution of the surf clam, Spisula polynyma (after Feder et al. 1980). Heavily stippled area at right is the proposed surf clam fishery zone.

METHODS

The seasonal distribution and relative numbers of walruses inhabiting the proposed clam fishery zone (hereafter called clam zone) and other parts of Bristol Bay were determined by means of systematic, monthly aerial surveys. The feeding habits of walruses in the Bay were determined by examination of stomach contents of animals collected at sea.

Distribution and Relative Numbers

For purposes of survey design and data analysis, we divided Bristol Bay into two regions, the clam zone and the remainder of the Bay east of about 161°W longitude. The area of each of these two regions was estimated as 9,185 and 44,854 km^2, respectively.

Surveys were of the strip-transect type along a predetermined flight path (Fig. 5). Flights originated and terminated at King Salmon. Each survey included several legs through the clam zone along the north side of the Alaska Peninsula, 2-9 km offshore, and a series of five north-south legs crossing Bristol Bay with shorter, generally east-west legs connecting them. Known walrus haulouts at Cape Seniavin and Round Island also were surveyed at a distance of about 1 km so that the number of walruses on them could be estimated. The standard survey included approximately 1,689 km of transects of which 470 km were in the clam zone. Due to minor navigational errors and occasional patches of inclement weather, the actual transects sometimes deviated slightly from the standard pattern.

Two types of charter aircraft were used in the aerial surveys: Piper Navajo for the first 10 and Piper Aztec for the last two. This change was necessary because the Navajo was not available at the time of the last two surveys. Both types of aircraft were twin-engine, low-wing design with automatic pilot, radar altimeter, and other standard navigating equipment and instrumentation. Flight altitude and direction were controlled by the radar altimeter and automatic pilot. Navigation was by means of visual landmarks and ADF (automatic direction finder) triangulation fixes from navigating beacons at Dillingham, King Salmon, and Port Heiden. With both types of aircraft, a refueling stop was necessary midway through each survey. The fueling stop usually (10 occasions) was made at Port Heiden. Refueling was done once at Cold Bay and once at Dillingham.

Surveys were flown at an altitude of 150 m except when low ceilings prevented flying at such a height. Surveys were continued in low ceiling conditions, provided that an altitude of at least 75 m could be maintained. Average ground speeds on surveys were generally between 270 and 330 km/hr.

The number of observers on each flight ranged from two to four, including one of the principal investigators and one or more of the following: C. Smith (ADF&G), K. Taylor (ADF&G), J. Taylor (USFWS), D.

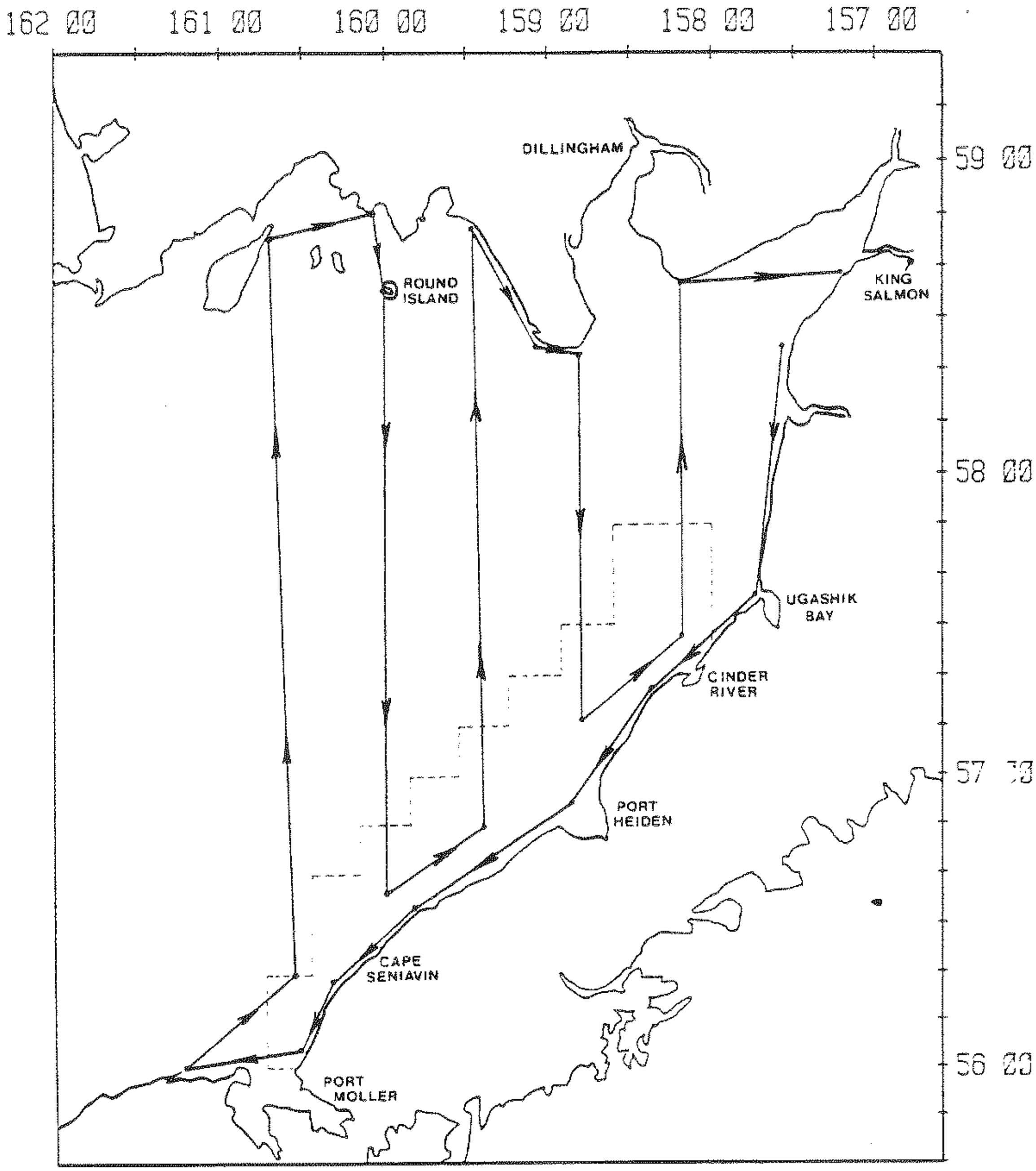

Figure 5. Map of Bristol Bay indicating standard aerial survey transects, clam fishery zone, and locations mentioned in the report.

Sellers (ADF&G), M. McNay (ADF&G), B. Kelly (UA), B. Dinneford (ADF&G), and L. Aumiller (ADF&G). All observers had previous experience in aerial surveys. On each flight, one observer sat in the right front (copilot's) seat and one in the rearmost seat on the left side. When a third observer was available, that person usually sat in the rearmost seat on the right side. On two occasions a fourth observer sat on the left side of the aircraft. Observers were in continous communication with one another and with the pilot through a headset-intercom system.

Each observer recorded the start and end point of each survey leg, weather and sea state conditions, and any marine mammals sighted. Each record was accompanied by the time to the nearest minute.

Transects were divided into four parts, an inner and outer strip on each side of the aircraft. The width of each strip was predetermined by trigonometric calculation of the angle required to delimit its outer edge (Fig. 6). Each observer measured those angles from his position in the aircraft, using a hand-held clinometer (PM-5/360 PC: Suunto Instruments, Helsinki), and noted their intercepts with structural features of the aircraft which could then be utilized as routine reference points. Each sighting was recorded as being in a particular strip or "outside," if it was beyond the limit of the outer strip.

In our initial survey design, we anticipated using 0.46 km as the width of each strip, therefore resulting in coverage of 0.93 km on each side of the aircraft and a total transect width of 1.85 km. On the first flight, however, structural features of the aircraft were found to prevent views directly ahead of the plane and below the fuselage, therefore reducing the width of each inner strip to 0.39 km. For all later surveys, the angles were recalculated to allow for this "blind spot," giving full desired width to the inner strip (Fig. 6). On two surveys, the width of each strip was reduced to 0.23 km in order to test sightability of walrus in relation to distance from the aircraft. On one other flight (7 April 1981), strip widths were reduced to 0.23 km since, due to low ceiling, the entire survey was flown at a 75-m elevation. On all remaining flights except one, 0.46 km was used as the width of each strip. A strip width of 0.46 km on each side of the aircraft resulted in a coverage of approximately 4.8% of the area in the clam zone and 2.5% of the remainder of Bristol Bay. Relevant characteristics of each survey are summarized in Table 1.

Sightings were recorded on survey data sheets and were entered into a DEC (Digital Equipment Corporation, Maynard, Massachusetts) VT-78 microprocessor system. The data entry program calculated the position (latitude and longitude) of each sighting, based on the time of the sighting and the time and location of start and end points for that leg. Accuracy of data entry was checked manually and by a data checking program. Programs were developed to plot the locations of walrus sightings as well as to calculate the density of walruses observed in and out of the clam fishery zone. Variance of density was calculated as (Estes and Gilbert 1978):

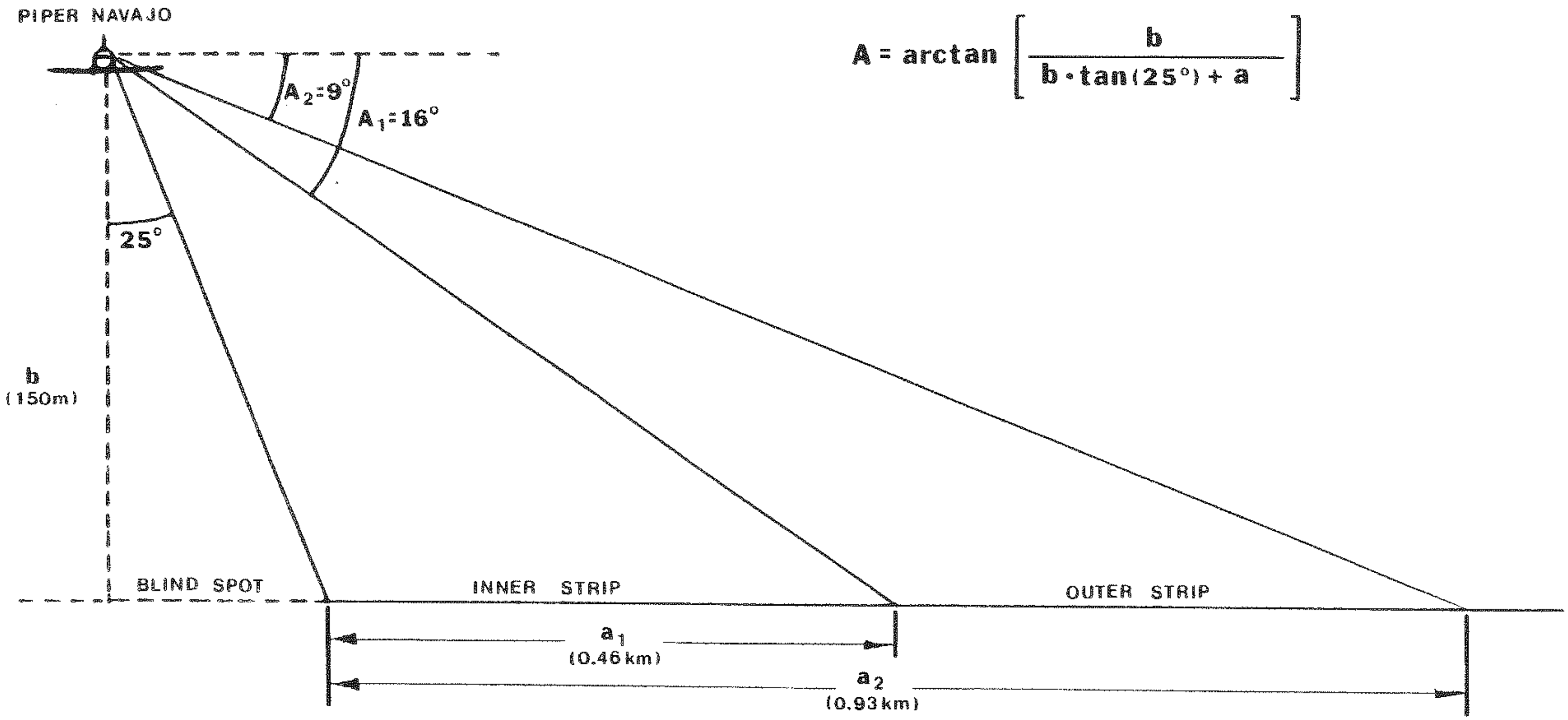

Figure 6. Diagram of the viewing angles delimiting the survey strips on one side of the Piper Navajo aircraft and the method of calculation.

Table 1. Summary of parameters of aerial surveys.

Date	Aircraft	Altitude (m)	Track width (km) Inner	Track width (km) Outer	Survey length (km)	Observers
16 April 1980	Navajo	150	0.39	0.46	1700	2 each side
27 May 1980	Navajo	150	0.25	0.23	1704	2 left rear, 1 right front
23 June 1980	Navajo	150	0.23	0.23	1536	1 left rear, 1 right front
22 August 1980	Navajo	150	0.46	0.46	1691	1 left rear, 1 right front, 1 right rear
18 September 1980	Navajo	150	0.46	0.46	1634	1 left rear, 1 right front
17 October 1980	Navajo	150	0.46	0.46	1691	1 left rear, 1 right front
15 November 1980	Navajo	150	0.46	0.46	1495	1 left rear, 1 right front
22 January 1981	Navajo	150	0.46	0.46	1689	1 left rear, 1 right front
10 February 1981	Navajo	150	0.46	0.46	1689	1 left rear, 1 right front
10 March 1981	Navajo	150	0.46	0.46	1689	1 left rear, 1 right front
7 April 1981	Aztec	75	0.23	0.23	1622	1 left rear, 1 right front, 1 right rear
7 May 1981	Aztec	150	0.46	0.46	1689	1 left rear, 1 right front, 1 right rear

$$S_{\hat{R}}^2 = \{\Sigma(Y_i^2/X_i) - \hat{R}\Sigma Y_i\}/(n-1)(\Sigma X_i)$$

where $\hat{R}$ = mean density of walruses; Y_i = the number of walruses in strip i, and X_i = the area of strip i. In the calculation of variance, each leg or portion thereof that was surveyed in each zone is considered as a sample unit.

Because nearly all of the walruses sighted were in the water (with the exception of those on Cape Seniavin and Round Island), and because those beneath the surface could not be seen, we estimated the actual number of walruses in the water by applying a correction factor to those counted at the surface. This was based on Fay's (in press) compilation of data from various sources on surface:subsurface times for feeding walruses. At depths of 40-79 m, similar to those in much of the survey area, the mean surface:subsurface time was approximately 1:6. This indicated that, for each walrus seen at the surface, six were below the surface and could not be seen. Therefore, the calculated densities of visible walruses were multipled times seven to estimate the actual densities of walruses in the water.

Feeding Habits

In order to determine the feeding habits of walruses in the Bristol Bay region and, specifically, in the clam zone, we planned to take at least 10 but not more than 60 animals that were feeding or had recently fed. The actual number taken would depend on a) their presence, hence availability in those areas, b) their feeding there, and c) the observed variation in composition of their stomach contents. Judging from past records (Figs. 2 and 3), we expected the animals to be in the Bristol Bay region from late winter to summer and in the clam zone from April to June. We presumed that, if present, they would be feeding to some degree. If the stomach contents were highly variable in composition, a larger sample would be needed to describe feeding habits than if they were relatively uniform.

Walruses were collected from vessels operating in the region during February, March, and April. Each was taken non-selectively as regards sex and age, except that we were obliged by conditions of a Federal permit to take equal numbers of males and females in the February-March series. Each of the animals was killed by a single shot to the central nervous system from a high-powered rifle. In all instances, the taking was done by or with the assistance and guidance of an Alaskan Eskimo with at least 40 years of experience in the hunting of walruses in the Bering Strait region. The animals taken in February-March were killed on the ice, where they had hauled out to rest after feeding. Those in April were taken while in the water. Each animal was brought aboard the ship for examination.

For each collected animal, the date, location, sex, and stomach contents were recorded. Age was determined by counts of annual cementum layers in longitudinal sections of the mandibular teeth, as described by Mansfield (1958), Burns (1965), Krylov (1965), and Fay (in press). Stomach contents were washed in sea water to remove the fine, particulate digesta and to separate the organic matter from the heavier inorganic sediments. The identifiable prey were then sorted into taxonomic groups to the finest degree possible. Each group was weighed to the nearest gram and the number of individuals counted. Fragments not assignable to Genus or Species often were assignable to Class, Order, or Family groups. For these, the number of individuals could not be determined, but the weight was recorded. The weight of inorganic sediments was recorded separately.

Identifications of prey were based on visual comparison of items in the stomachs with expertly identified whole specimens in the reference collections of the Institute of Marine Science, University of Alaska, Fairbanks.

RESULTS

Distribution and Relative Numbers

Twelve aerial surveys were flown during the period from April 1980 to May 1981; one survey was flown in each month, except July and December 1980. We attempted to survey in July but were prevented by a prolonged period of bad weather. The December survey was not attempted since the short daylight period was judged to be inadequate for a complete survey in one day.

On the first survey, widths of inner and outer strips were 0.39 and 0.46 km, respectively. Significantly more walruses were sighted in the inner strip than in the outer strip (93 vs. 4, $\chi^2 = 51.714$, $p < 0.001$). On the second survey, the width of each strip was reduced to 0.23 km. Results from that survey indicated no significant difference in the number of sightings in the inner and outer strips (84 vs. 67, $\chi^2 = 0.960$, $p > 0.30$). These findings indicated that the probability of sighting walruses in the water was significantly greater within 0.46 km than beyond that point, and that there was no appreciable difference in sightability within the inner and outer halves of that 0.46-km strip. Therefore, in analysis and presentation of results, an effective transect width of 0.46 km on each side of the aircraft was used, with the exception of the first survey for which the width was 0.39 km.

In the survey aircraft, the view of the observer in the right-front seat was partially obstructed by features of the cockpit and the right-hand engine, while the rear-seat observers had a clear, unobstructed view of the survey strips by looking behind the wing. On two surveys when substantial numbers of walruses were seen in the water and there were only the right-front and left-rear observers, 52 walruses were seen on the right side, while 125 were seen in the same strip width on the left. Hence, on those surveys (27 May and 18 September 1980), the number counted by the right-forward observer and left-rear observers was equilibrated by multiplying the right-side counts by a correction factor of 2.4. On the remaining surveys, either three or more observers were present or few (10 or less) walruses were seen in the water, and the numbers of sightings on each side were similar.

On six of the surveys, the planned track lines were followed precisely; on the other six, some deviations occurred due to weather and navigation problems. Nevertheless, we covered approximately the same amount of area within and outside of the clam fishery zone on each survey (Table 2).

Weather conditions varied considerably within and between surveys, but we believe that the weather conditions encountered did not significantly affect our ability to sight walruses within the 0.46-km wide survey strips.

Walruses were seen on every survey (Figs. 7-18), and, with the exception of a small group hauled out on sea ice in March 1981, all were either in the water or hauled out on land. All animals appeared to be adult or subadult males. Within the clam zone, they were seen hauled out only at Cape Seniavin in April of each year. During the April surveys, walruses were also numerous in the water in the clam zone (Figs. 7 and 17). Some were also present in the clam zone each year during March (C. Smith, pers. comm., Fig. 16) and May (Figs. 8 and 18).

Outside of the clam zone, walruses were seen hauled out at Round Island during 10 surveys. None were there in January or March 1981. Because ice covered all of northern Bristol Bay in December 1980, they were probably absent then, as well. In January, the hauling area was completely iced in; in March, high tide and strong winds caused surf to break over the entire haulout. The estimated number of walruses hauled out on Round Island during the remainder of the surveys ranged from a low of 40 in February 1981 to 9,700 in August 1980. Sightings of walruses in the water outside of the clam zone were most numerous in May of each year, and in August and September 1980 (Figs. 8, 10, 11, and 18). Those sightings were mostly within 90 km south and southeast of Round Island. On all other surveys, fewer than 15 walruses were sighted in the water outside the clam zone, and those were generally near Round Island or south of there in the western part of Bristol Bay.

The estimated density of walruses visible in the water showed great seasonal variation, both in and out of the clam zone (Table 2). During October, November, January, and February, we sighted fewer than 0.01 per km^2 overall. Densities greater than 0.04 per km^2 were observed in the clam zone during April of both years and in May 1980. In the remainder of the Bay, more than 0.04 per km^2 were seen in May of both years and in August 1980.

The total number of walruses in and outside of the clam zone was estimated for each survey (Table 3). The estimated number of walruses

Table 2. Calculated density of walruses visible in the water in and out of the clam fishery zone in Bristol Bay at the time of each aerial survey.

Date	Area surveyed (km^2)		No. walruses sighted		Density of sightable walruses (per km^2)		Std. deviation	
	In clam zone	Out of clam zone	In	Out	In	Out	In	Out
16 April 1980	381.9	941.9	77	12	0.2016	0.0127	0.0172	0.0015
27 May 1980	444.0	1126.8	19	202	0.0428	0.1793	0.0040	0.0199
23 June 1980	438.4	975.5	0	10	0.0	0.0105	--	0.0018
22 August 1980	491.0	1119.5	0	53	0.0	0.0473	--	0.0081
18 September 1980	400.9	1107.7	0	29	0.0	0.0260	--	0.0029
17 October 1980	443.5	1118.5	0	2	0.0	0.0018	--	0.0002
15 November 1980	236.2	1153.6	0	3	0.0	0.0026	--	0.0011
22 January 1981	445.4	1120.2	0	1	0.0	0.0009	--	0.0001
10 February 1981	442.1	1121.5	0	1	0.0	0.0009	--	0.0001
10 March 1981	438.5	1125.6	1	14	0.0023	0.0124	0.0005	0.0022
7 April 1981	450.3	1057.0	23	3	0.0511	0.0028	0.0050	0.0003
7 May 1981	449.1	1115.9	2	76	0.0045	0.0681	0.0013	0.0074

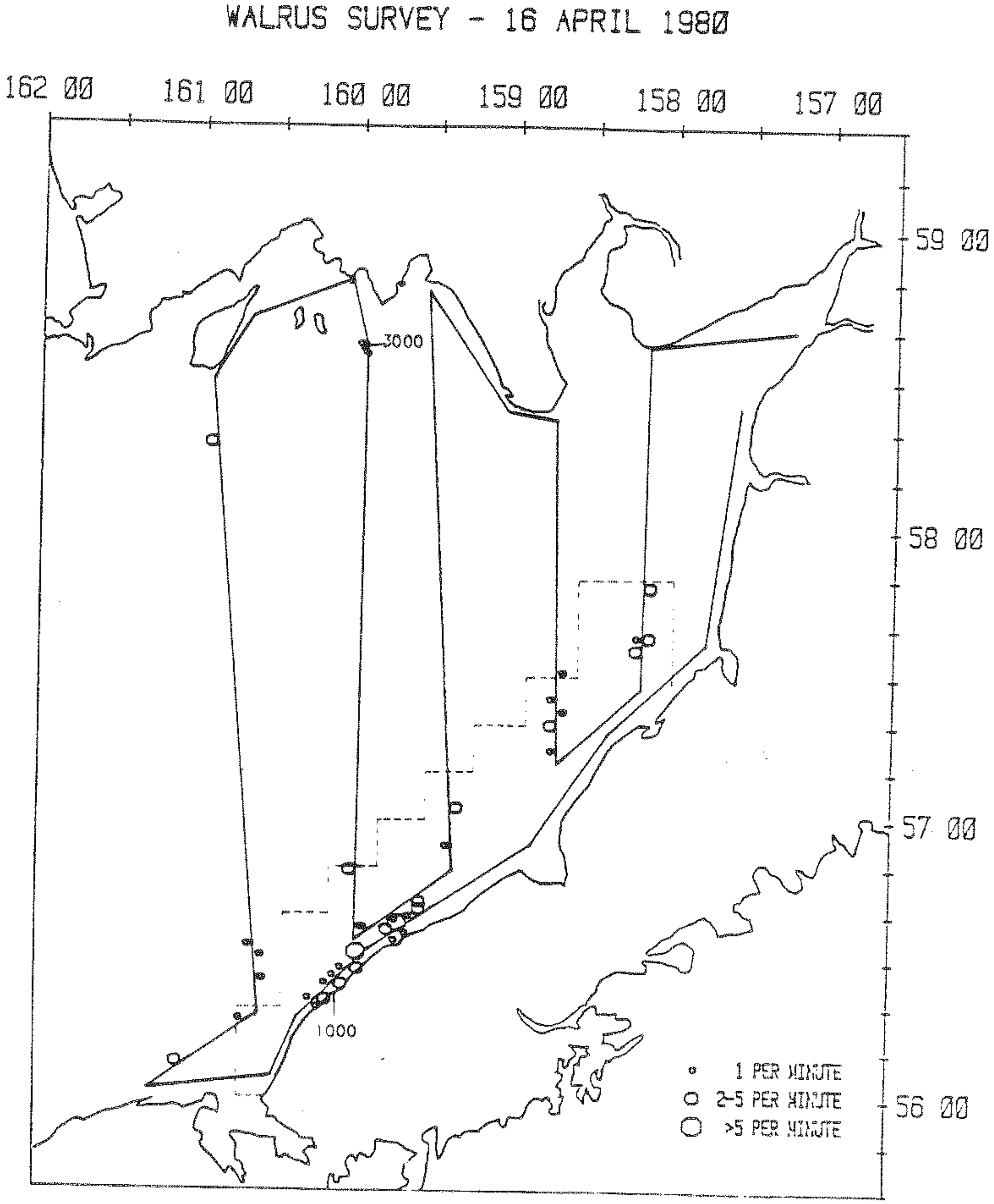

Figure 7. Track lines and sightings of walruses from the 16 April 1980 survey.

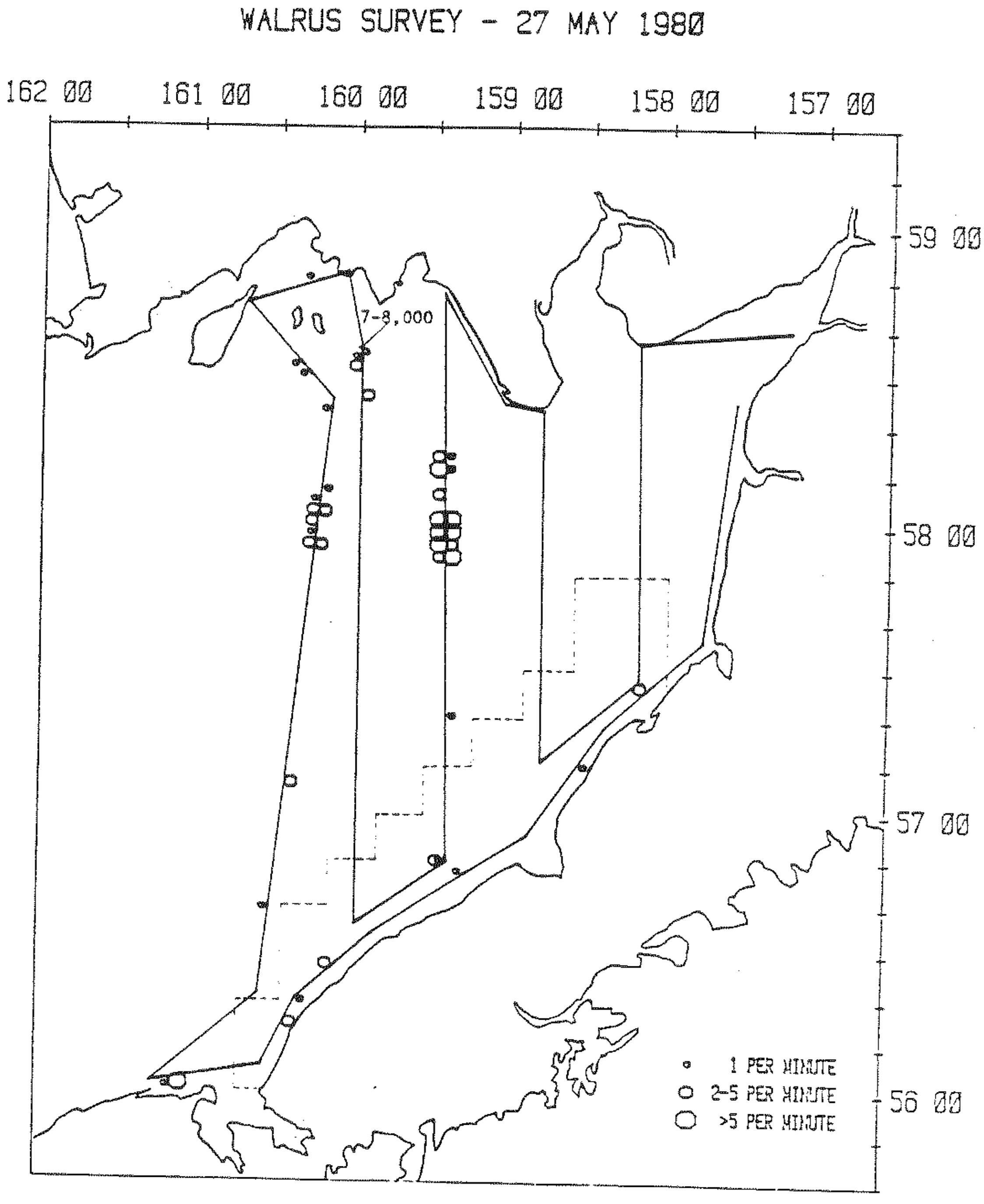

Figure 8. Track lines and sightings of walruses from the 27 May 1980 survey.

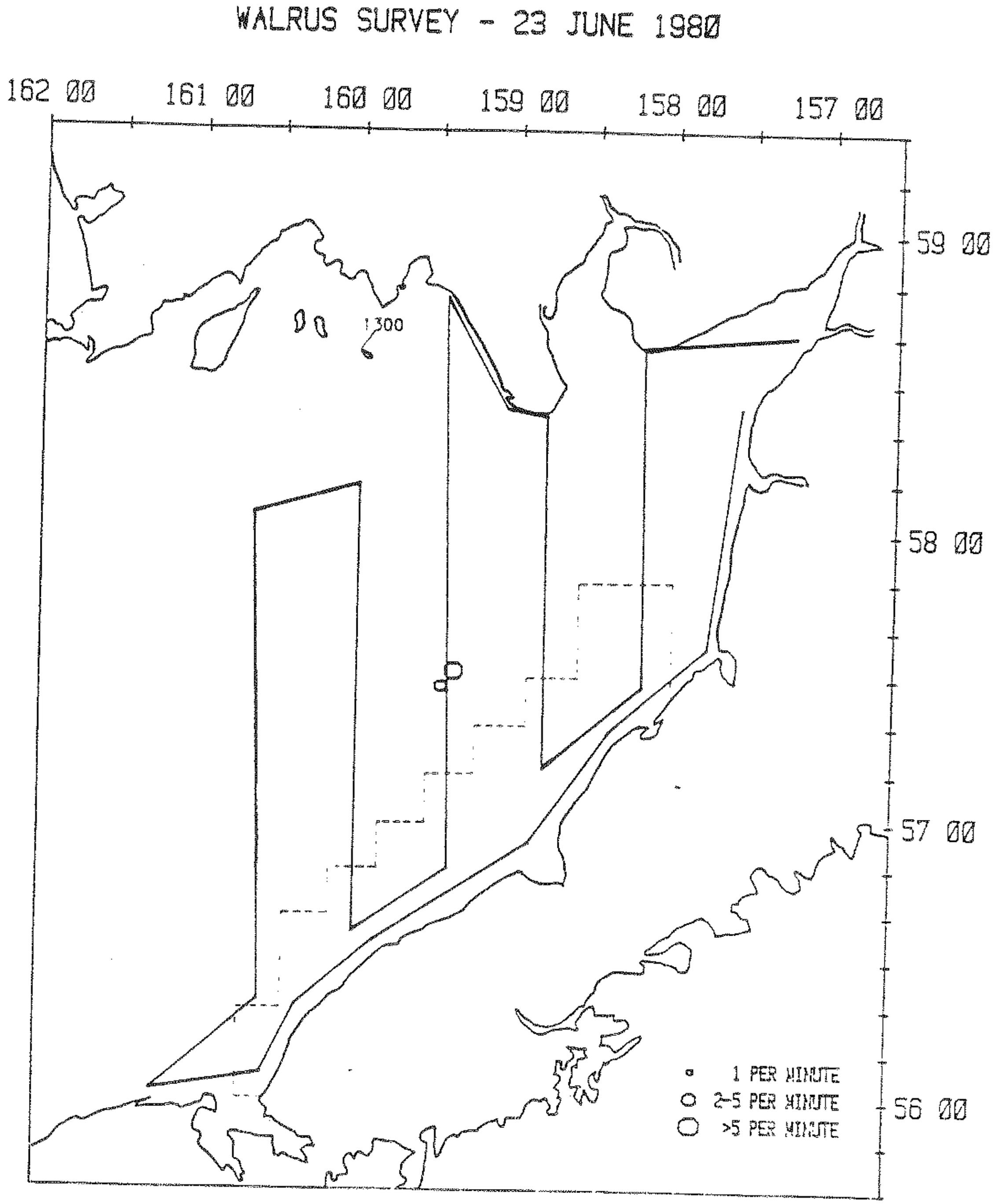

Figure 9. Track lines and sightings of walruses from the 23 June 1980 survey.

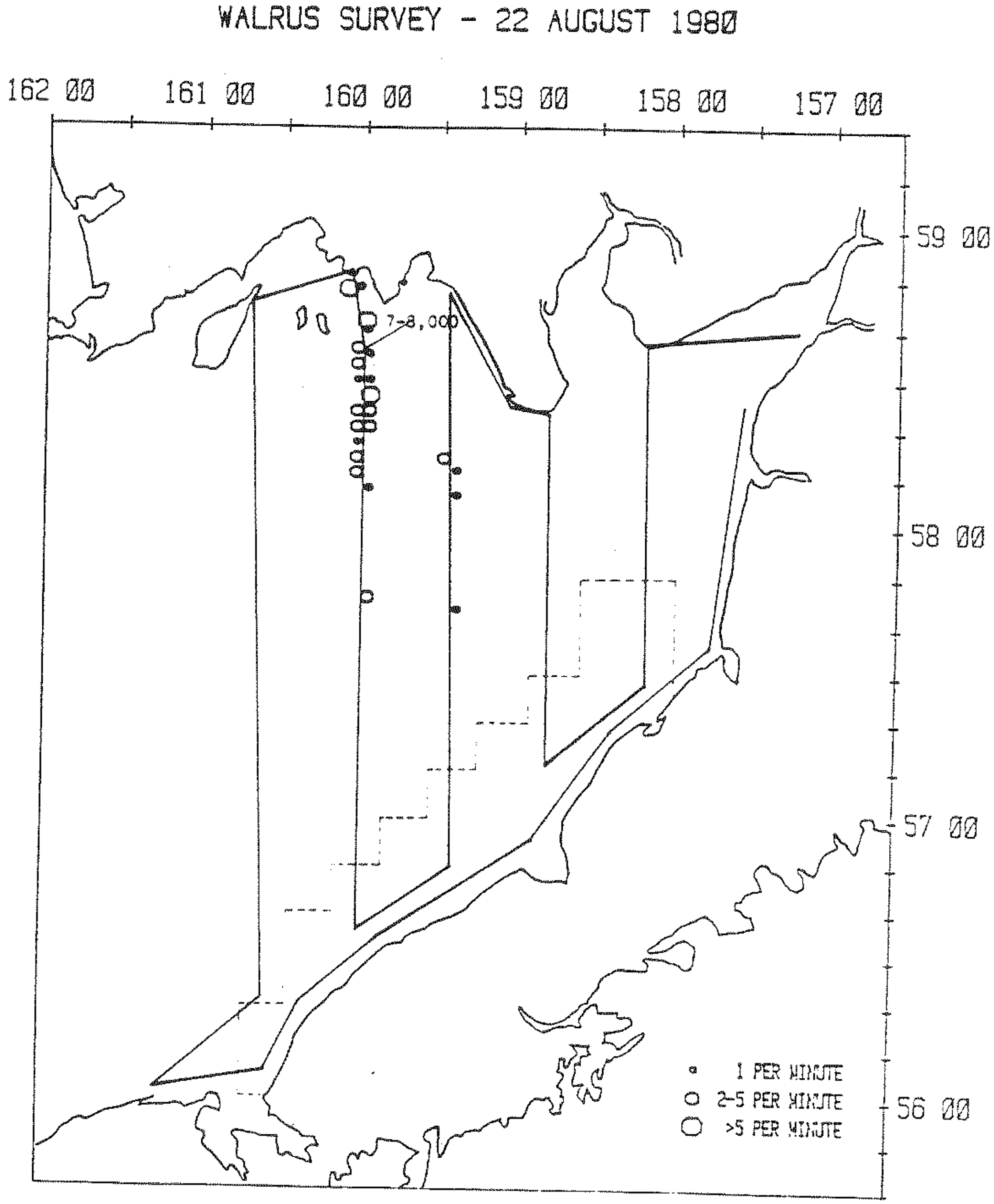

Figure 10. Track lines and sightings of walruses from the 22 August 1980 survey.

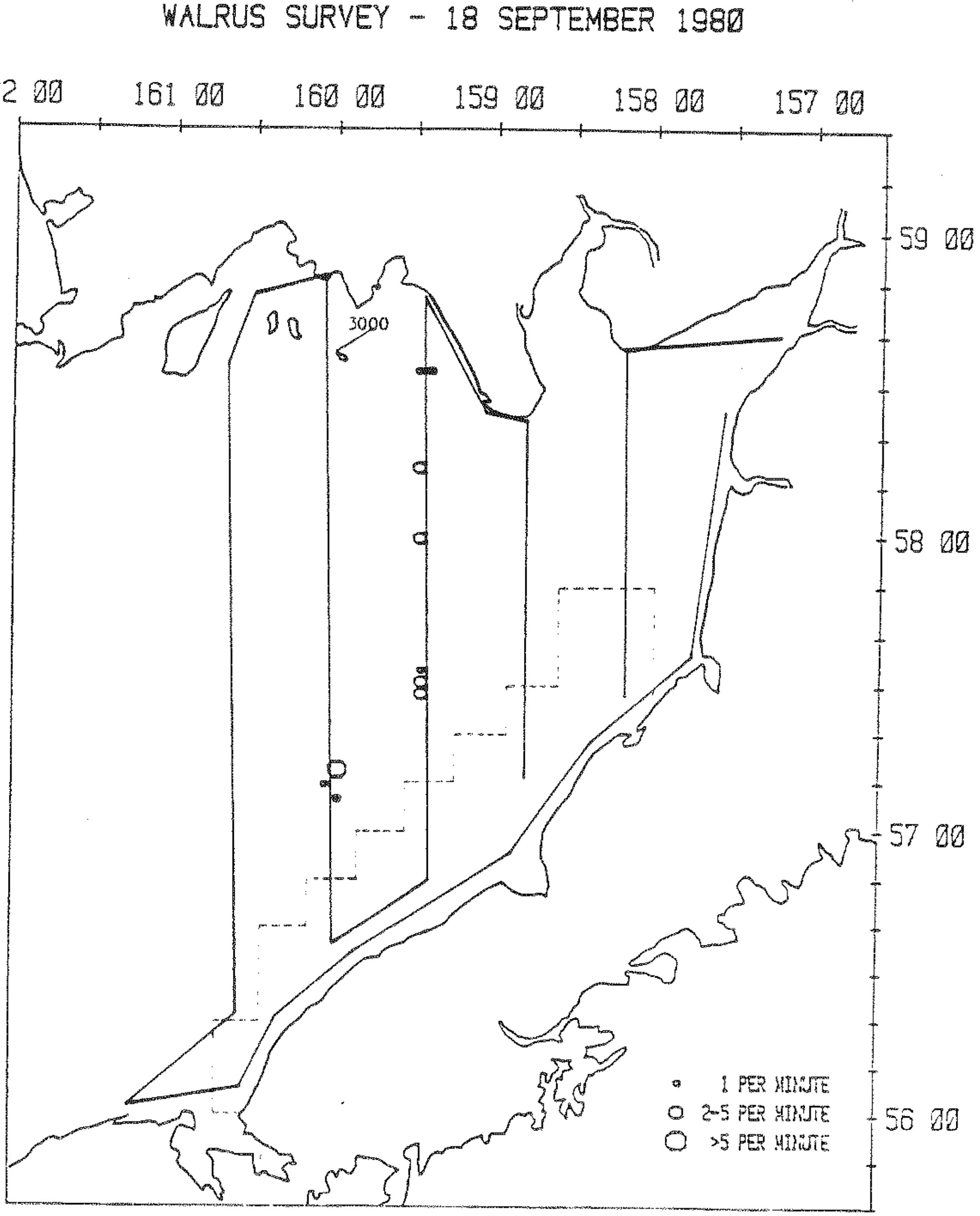

Figure 11. Track lines and sightings of walruses from the 18 September 1980 survey.

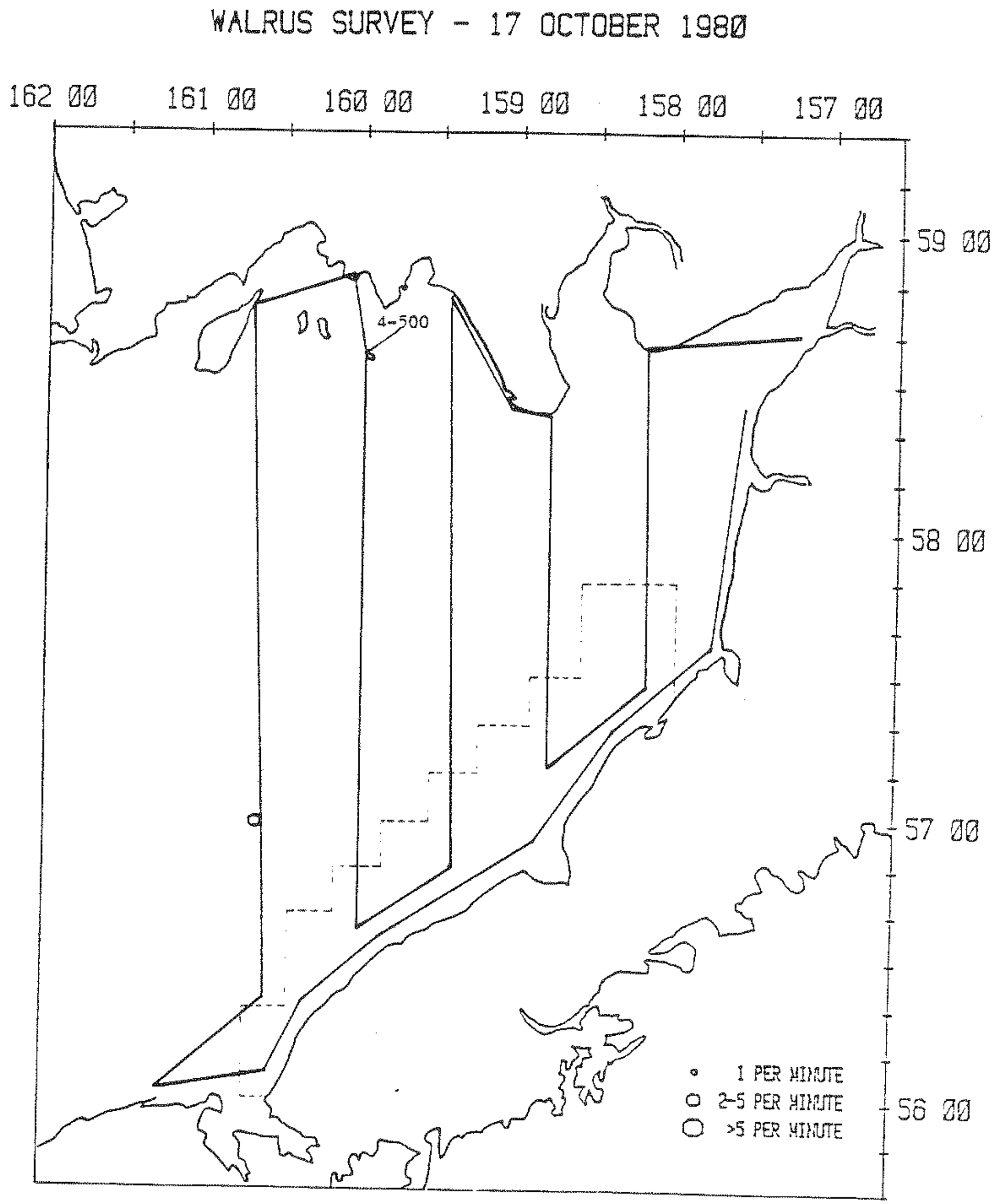

Figure 12. Track lines and sightings of walruses from the 17 October 1980 survey.

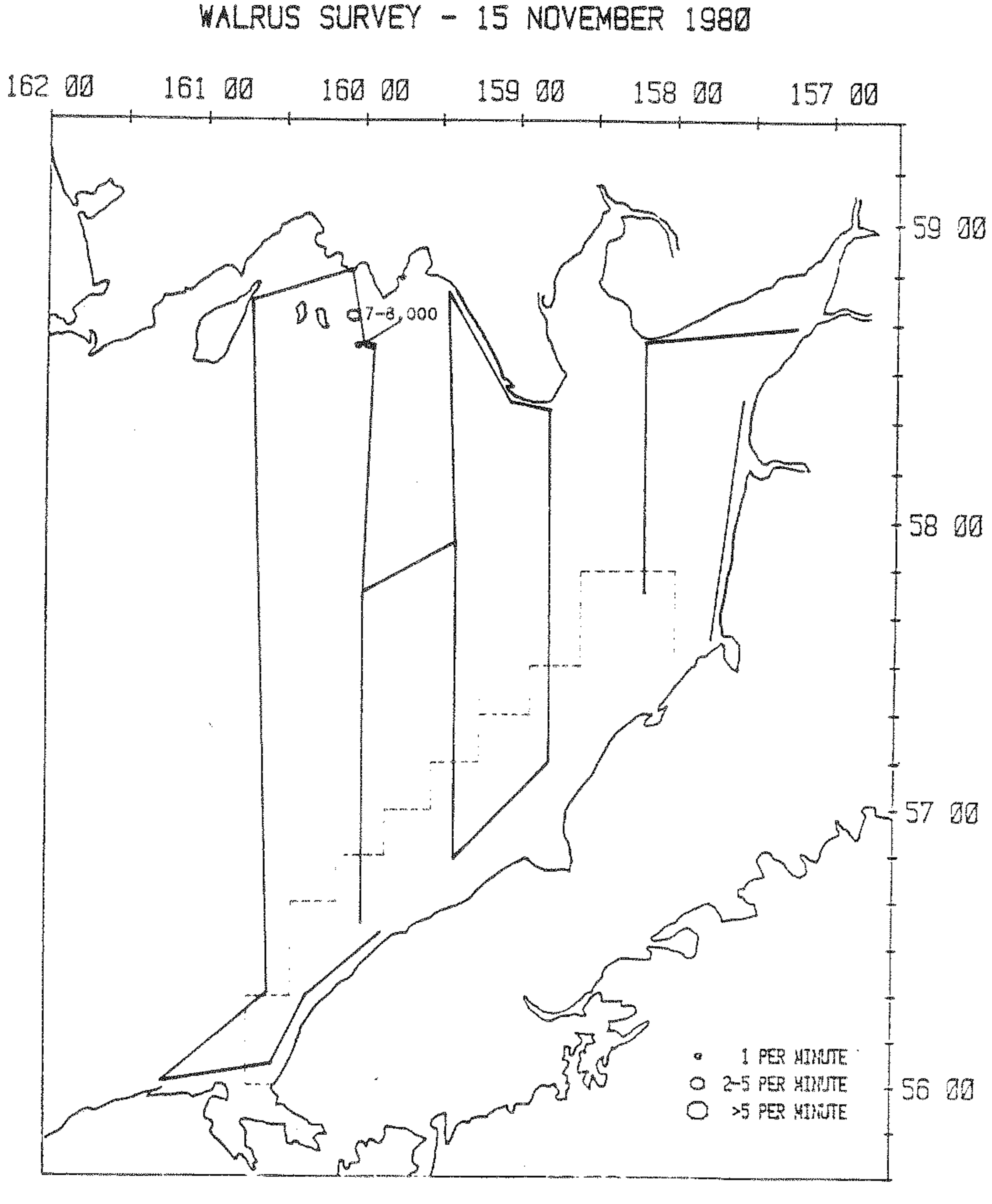

Figure 13. Track lines and sightings of walruses from the 15 November 1980 survey.

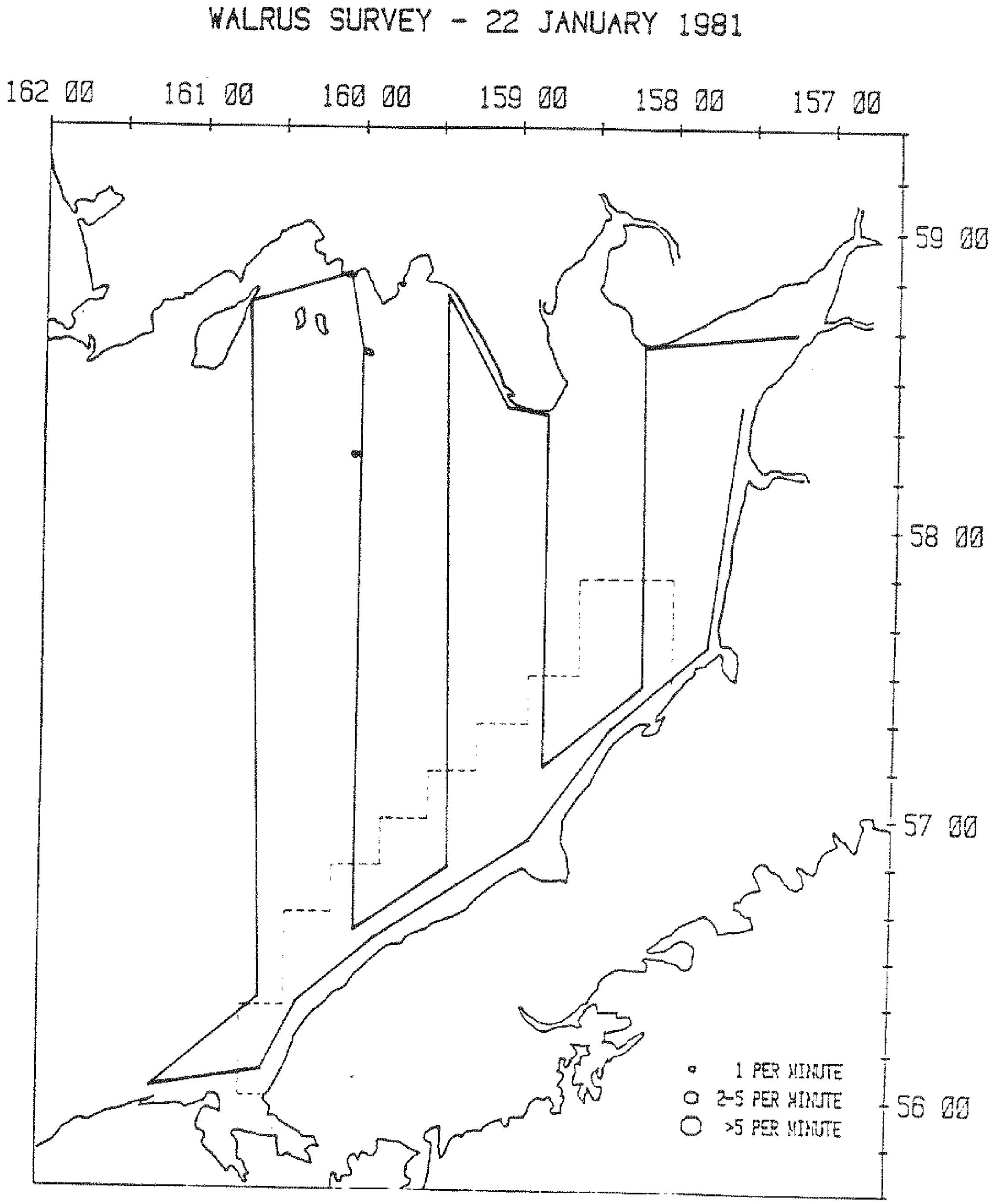

Figure 14. Track lines and sightings of walruses from the 22 January 1981 survey.

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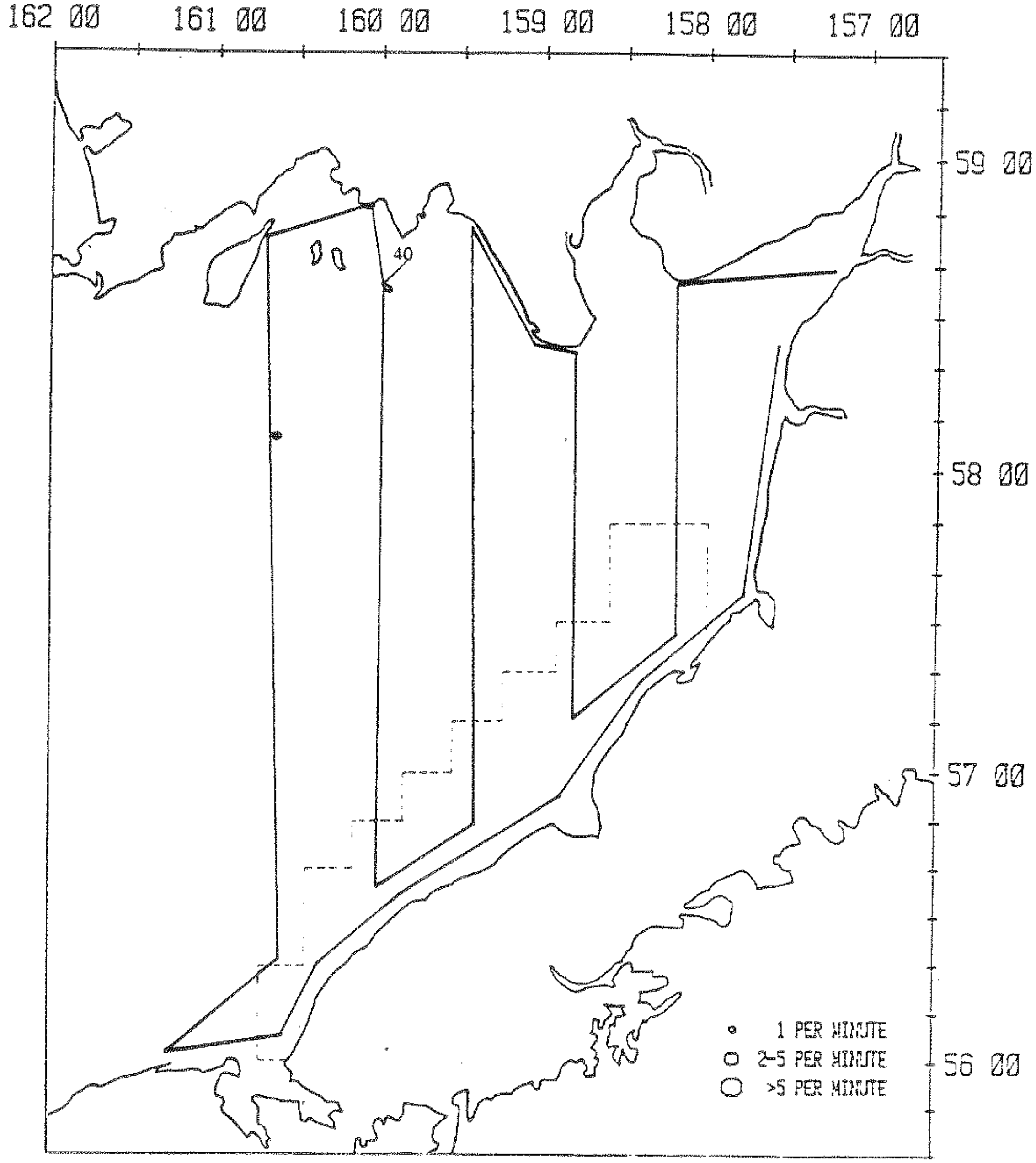

Figure 15. Track lines and sightings of walruses from the 10 February 1981 survey.

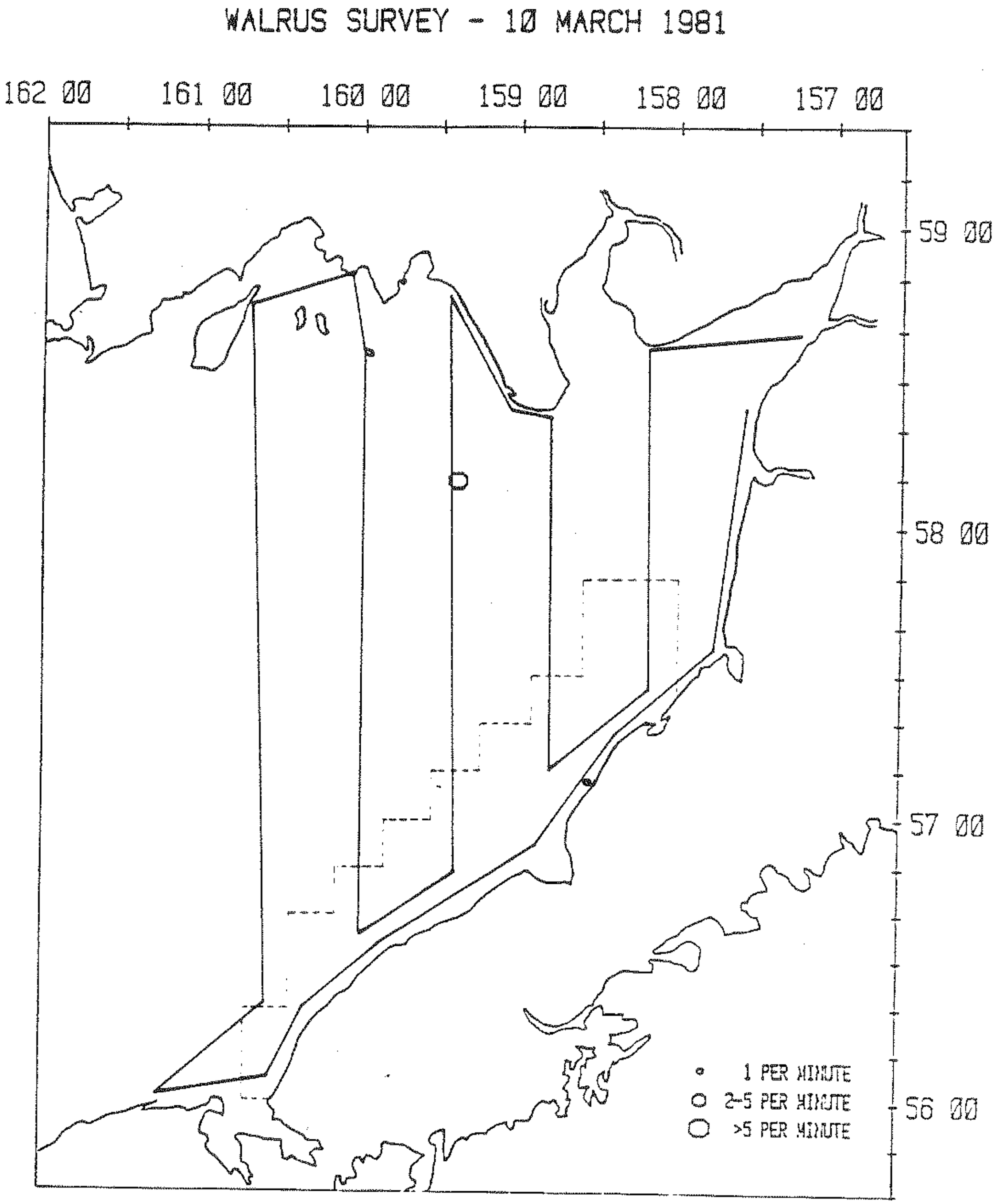

Figure 16. Track lines and sightings of walruses from the 10 March 1981 survey.

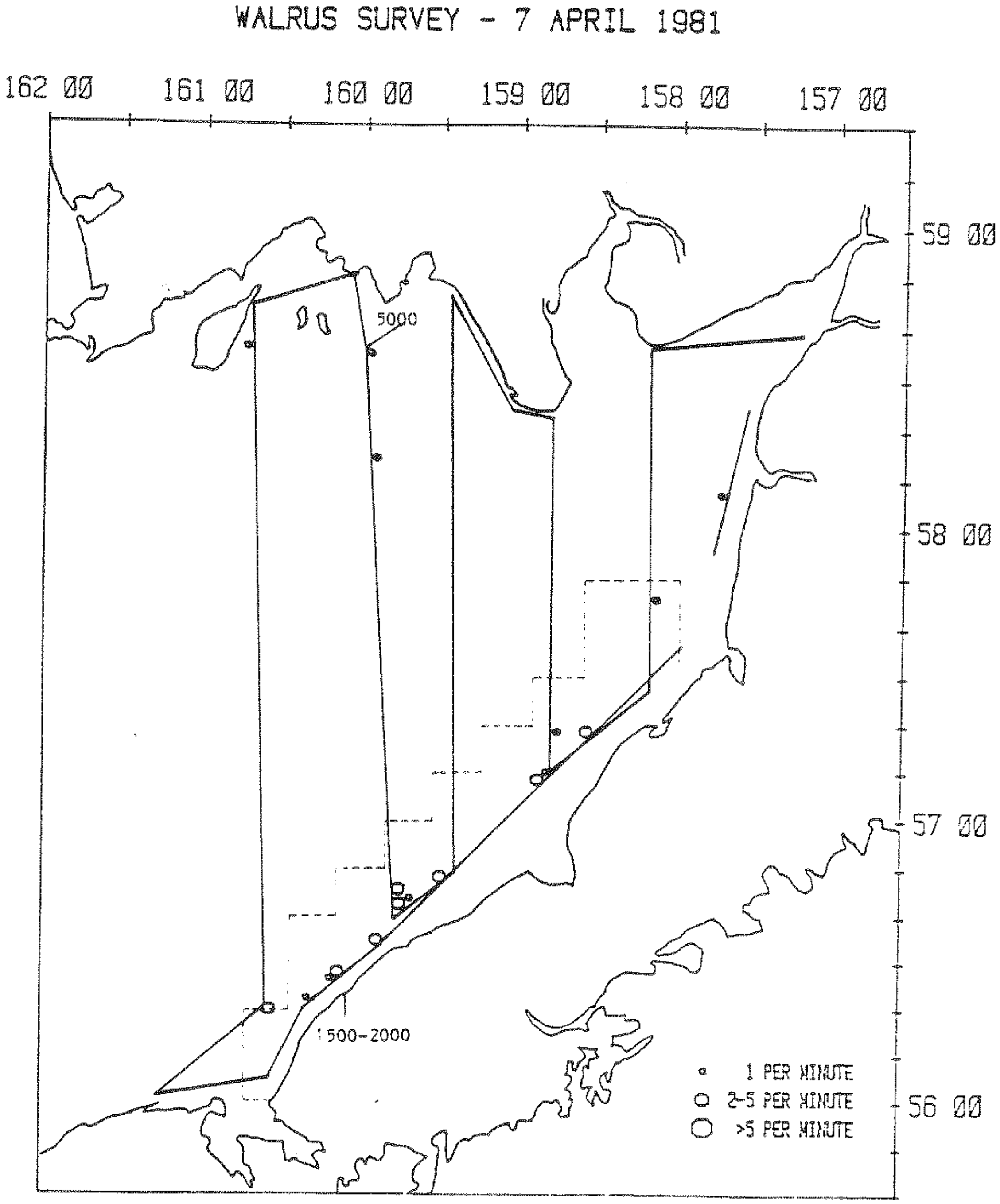

Figure 17. Track lines and sightings of walruses from the 7 April 1981 survey.

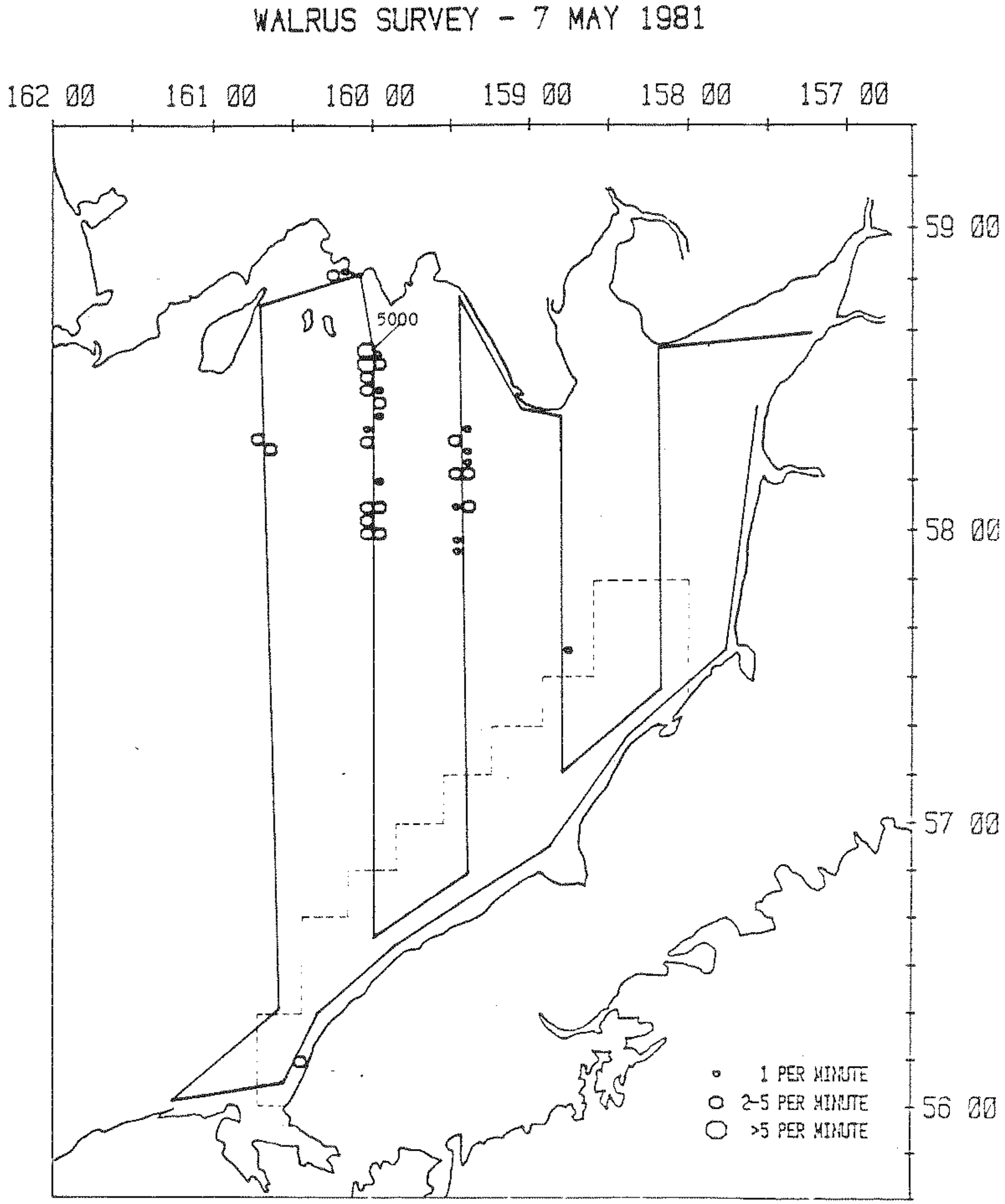

Figure 18. Track lines and sightings of walruses from the 7 May 1981 survey.

Table 3. Estimated total numbers of walruses in and out of the clam fishery zone at the time of each aerial survey.

Date	Estimated no. of walruses in the water[a]		No. walruses hauled out on land		Estimated total no. of walruses		Percent total walruses in clam zone
	In clam zone	Out of clam zone	In	Out	In	Out	
16 April 1980	12,962	3,988	1,000	3,000	13,962	6,988	66.6
27 May 1980	2,752	56,296	0	7,500	2,752	63,796	4.1
23 June 1980	0	3,297	0	1,100[b]	0	4,397	0.0
22 August 1980	0	14,851	0	9,700[b]	0	24,551	0.0
18 September 1980	0	8,163	0	2,100[b]	0	10,263	0.0
17 October 1980	0	565	0	450	0	1,015	0.0
15 November 1980	0	816	0	7,500	0	8,316	0.0
22 January 1981	0	283	0	0	0	283	0.0
10 February 1981	0	283	0	40	0	323	0.0
10 March 1981	148	556	0	0	148	556	21.0
7 April 1981	3,285	879	1,750	2,500	5,035	3,379	59.8
7 May 1981	289	21,382	0	5,000	289	26,382	1.0

a Areas estimated as 9,185 km^2 in the clam fishery zone and 44,854 km^2 in the remainder of the survey area. Density values in Table 2 were multiplied times 7 to account for animals below the surface, except for March 1981, when all animals sighted were hauled out on the ice.

b Based on ground counts made at Round Island (J. Taggart and C. Zabel, pers. comm.).

in the clam zone ranged from 0 during June 1980 to February 1981 to about 14,000 in April 1980. Several thousand walruses were estimated to be in the clam zone at the time of our surveys also in May 1980 and April 1981. The estimated number of walruses in the portion of Bristol Bay surveyed outside of the clam zone ranged from about 280 on 22 January 1981 to 63,800 on 27 May 1980. We estimated that more than 20,000 walruses were in the Bay outside of the clam zone in May of both years and in August 1980, and more than 6,000 were there in April, September, and November 1980. Walruses in the clam zone made up a substantial portion of the estimated total number of animals in Bristol Bay only in March and April.

Feeding Habits

We attempted to collect walruses for information on their feeding habits in the Bristol Bay region during three vessel cruises, as follows:

1. R/V Resolution, 10-16 June 1980--Our aerial survey on 27 May 1980 (Fig. 8) indicated that, while most of the animals were in the northern part of the Bay, some remained in the proposed clam fishery zone at that time. We had intended to begin the collecting trip on 1 June but were delayed by scheduling problems with the vessel and delays in obtaining the necessary Federal collecting permit. The ship traversed the fishery zone from northeast to southwest on 11 June, at about 4 to 9 km from shore, but no walruses were sighted (Fig. 19). On 12 and 13 June, stormy weather forced the ship to take shelter in Port Moller. During 14-15 June, the ship searched the clam zone from Port Moller to Ugashik Bay, but, again, no walruses were sighted. Judging from these negative results that walruses were essentially absent from the fishery zone, the field party returned to Naknek on 16 June. The subsequent aerial survey on 23 June verified that walruses were indeed absent from the southern half of the Bay (Fig. 9).

2. ZRS Zvyagino, 21 February-18 March 1981--This was a joint Soviet-American research cruise, arranged under the aegis of the Marine Mammal Project, US-USSR Environmental Protection Agreement, and the mutually designed cruise plan called for collection of about 200 walruses from a wintering concentration which usually occurs in or near Bristol Bay. Our aerial survey on 10 February (Fig. 15), however, disclosed that walruses were virtually absent from the Bay, apparently due to the lack of suitable ice. On the basis of that information and the distribution of ice indicated by satellite imagery, the ship was directed to southern Kuskokwim Bay, where we located the concentration on 25 February. The animals there were in waters 25 to 45 m deep, comparable to depths in the clam zone, and they were within the known area of surf clam abundance. From 25 February to 10 March, 180 walruses were collected (90 males, 90 females), 15 of which (3 males, 12 females) recently had been feeding on benthic invertebrates. This is not a high proportion but is typical for a series of specimens taken

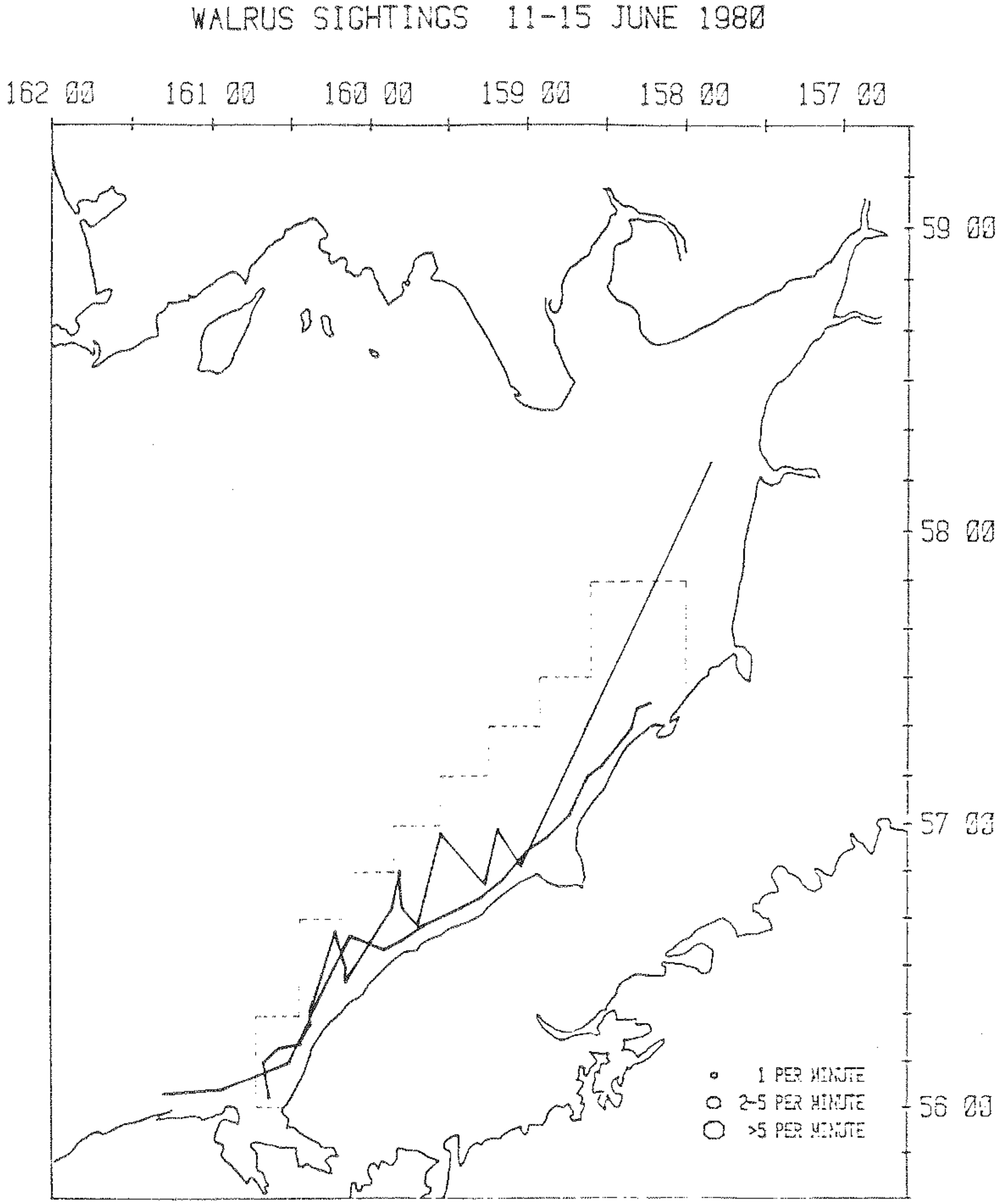

Figure 19. Approximate track lines from the walrus collection cruise, 11-15 June 1980.

on the ice, for their digestive rate is rapid, and only those that have recently hauled out are likely to have food remaining in the stomach.

The proportion of males with food in the stomach was significantly lower than of females ($\chi^2 = 4.86$, $p < 0.5$), and this appears to have been primarily due to the high proportion of mature males in the sample (Table 4). The frequency of occurrence of food in the stomachs of females and the younger males was an order of magnitude greater than in the bulls. We noticed also that the digestive tract of nearly all of the bulls was shrunken to smaller size than that of the females and young males, suggesting that these bulls were feeding not at all or very infrequently at that time. The collection was made at the end of the winter mating season, and nearly all of the adult males that we sighted were either engaged in breeding displays, fighting, or sleeping on the ice near the herds of females, whereas the females and the young males often were seen in the water and appeared to be feeding.

The animals with food in the stomach were taken in three samples, 2 to 3 days apart, and in slightly different locations (Fig. 20). The first (N=7) was taken on 2 March in the vicinity of 58°51'N, 164°40'W, where water depths were from 25 to 35 m; the second (N=3), on 6 March, was at 58°37'N, 166°56'W, where the water was 35 to 45 m deep; and the third (N=5), on 8 March, was in the vicinity of 58°45'N, 165°24'W, back in the shallower (25-35 m) waters. The variation among individuals in composition of their stomach contents was comparatively low in each location, and the differences between samples were not large (Table 5).

In general, these 15 walruses had fed primarily on bivalve mollusks, which made up 96% of the total wet weight biomass (33.1 kg) and 94% of the total number of prey (5,867) in the stomachs. In each location, they had fed most intensively on tellinids (presumably Tellina lutea) and to a lesser extent on surf clams, cockles (Serripes spp.), and razor clams (Siliqua alta) (Table 6). Polychaetes (mainly Nephtys sp.) and echiurids were next in order of importance, followed by snails (mainly Polinices sp.), crustaceans (including gammarid amphipods, crangonid shrimps, and hermit crabs), and sea anemones (Appendix I). About 10% of the total sample was made up of partly digested fragments of meat and periostracum from the bivalves; fragments of the shells made up about 0.2% of the total biomass. The largest amount of food in one stomach was 5.8 kg; the average amount was 2.2 kg. In addition to food, the stomachs contained more than 1.2 kg of sand and gravel and one feather from a cormorant, Phalacrocorax sp.

3. R/V Resolution, 2-21 April 1981--The ship with field party aboard arrived in Bristol Bay on 7 April, at which time our aerial survey showed that some walruses were present in the proposed clam fishery zone (Fig. 17). Efforts to collect specimens from that zone were made during 8-13, 17-18, and 20 April. The collecting was more

Table 4. Frequency of occurrence of food in the stomach contents of walruses taken in southern Kuskokwim Bay in February-March 1981, in relation to their sex and age.

Sex and developmental class	Age (years)	Sample size		
		Total	With food in stomach	
			Number	Percent
MALES				
Juvenile	2 - 7	8	1	12.5
Subadult	8 - 14	13	1	7.7
Adult	15 - 40	69	1	1.4
FEMALES[a]				
Juvenile and subadult	2 - 6	13	2	15.4
Adult	7 - 40	75	10	13.3

[a] Excluding two 1-year-old sucklings which had milk in the stomach.

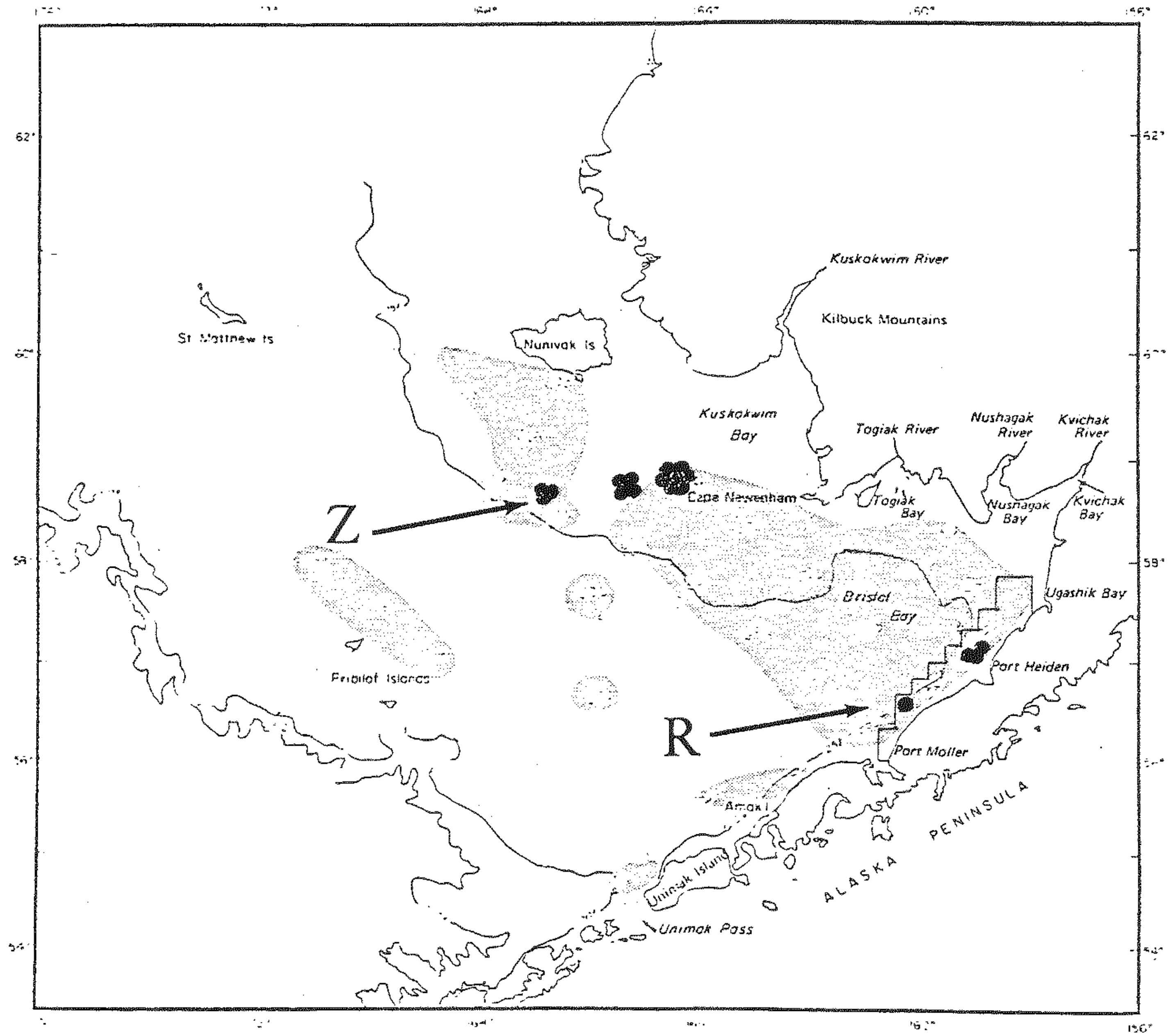

Figure 20. Locations in which samples of walruses were collected during the cruise of the ZRS Zvyagino in February-March 1981 (Z) and of the R/V Resolution in April 1981 (R). Stippled area is the known surf clam distribution (after Feder et al. 1980).

Table 5. Frequency of occurrence (f) and within-sample variation in percentage composition (by weight) of stomach contents from walruses taken in southern Kuskokwim Bay, March 1981.[a]

Prey taxon	Sample 1 (N=7)		Sample 2 (N=3)		Sample 3 (N=5)	
	f	Percentage	f	Percentage	f	Percentage
Hydrozoans	1	0.2	0	--	0	--
Polychaetes	5	0.1 - 1.4	2	0.1 - 2.2	2	0.3 - 0.4
Echiurids	2	1.0	3	1.2 - 11.1	2	0.6 - 0.7
Gastropods	7	<0.1 - 0.3	2	0.2 - 1.3	2	0.5 - 2.2
Bivalves:						
Serripes	5	3.3 - 9.0	3	11.4 - 18.2	4	2.2 - 5.4
Tellina	7	39.9 - 74.5	3	50.9 - 60.0	5	4.6 - 78.4
Spisula	7	11.8 - 36.7	3	9.7 - 14.1	5	2.8 - 47.1
Siliqua	6	1.7 - 3.4	3	2.7 - 5.2	4	1.0 - 5.7
Fragments[b]	7	5.7 - 22.8	3	8.0 - 9.2	5	6.0 - 44.8
Crustaceans	2	0.1 - 0.4	2	<0.1 - 0.1	4	0.4 - 4.7

[a] For full details of findings in each specimen, see Appendix I.

[b] Fragments of bivalves, not assignable to genus due to partial digestion.

Table 6. Composition of combined stomach contents from 15 walruses taken in southern Kuskokwim Bay, 2-8 March 1981.

Prey taxon	No. of individuals		Wet weight	
	Number	% of total	Grams	% of total
Hydrozoans	4	<0.1	13	<0.1
Polychaetes	150	2.6	254	0.8
Echiurids	114	1.9	813	2.4
Gastropods	53	0.9	87	0.3
Bivalves:				
Serripes	162	2.8	2,221	6.7
Tellina	4,839	82.5	20,184	60.9
Spisula	283	4.8	5,352	16.1
Siliqua	229	3.9	985	3.0
Astarte	3	<0.1	2	<0.1
Fragments[a]	--	--	3,182	9.6
Crustaceans	30	0.5	52	0.2
Total	5,867	100.0	33,143	100.0

[a] Fragments of bivalves, not assignable to genus due to partial digestion.

difficult than anticipated, for the animals were widely scattered in small groups of one to seven (mean, 3), hence not easily located or followed in the usually choppy seas. In the 9 days of effort, we cruised about 1,055 km in search of the animals and obtained only four specimens. These were all mature bulls which had been feeding prior to being collected. The first was taken at 56°33.5'N, 160°11'W in the vicinity of Port Moller, where the water was about 35 m deep. The other three were obtained in the vicinity of 57°10'N, 158°55'W, near Port Heiden, where depths ranged from about 25 to 35 m.

These animals had fed primarily on bivalve mollusks, which comprised about 90% of the total wet weight biomass (20.6 kg) and 97% of the total number of prey (3,349) in the stomachs. The frequency of occurrence and proportional amounts of each kind of prey per stomach varied considerably in this small sample (Table 7), but in each case the principal prey were tellins and surf clams, which overall made up most of the contents (Table 8). The specimen from the Port Moller area also had consumed a large volume of hydrozoans (sea anemones) and several tanner crabs and sea cucumbers (Cucumaria sp.), which were not present in the other specimens. One of those from the Port Heiden area had fed almost exclusively on surf clams, while the other two had eaten substantial amounts of tellins as well (Appendix I). About 11% of the total wet weight biomass in the stomachs consisted of partly digested meat and periostracum from the bivalves; fragments of clam shells made up about 0.2% of the total biomass. The largest quantity of food in one stomach was 11.1 kg; the average amount was 5.2 kg. The stomachs also contained a total of more than 0.7 kg of sand and gravel.

DISCUSSION

Distribution and Numbers

Based on our aerial survey coverage, a seasonal pattern of walrus distribution in Bristol Bay is evident. Because the results of our surveys during April and May of both years were markedly similar, we are confident that the distribution pattern shown by our surveys is a reliable portrayal of walrus use of Bristol Bay during years of minimal ice coverage. In "heavy" ice years, walruses are more widely distributed in the Bay and may extend into the clam area during February-April (Kenyon 1972, Braham et al. 1977, Burns and Harbo 1977, Burns et al. 1980). Such conditions did not occur during this study.

The walruses occurred in the clam zone in substantial numbers in March to May (Figs. 7-8, 16-18; C. Smith, pers. comm.). In previous years, they have been seen hauled out at several locations in and near the clam fishery zone during April to July. We have received reliable reports of walruses hauled out in the Ugashik Bay-Cinder River area

Table 7. Frequency of occurrence (f) and within-sample variation in percentage composition (by weight) of stomach contents from walruses taken in the proposed clam fishery zone of Bristol Bay, April 1981.[a]

Prey taxon	Port Moller (N=1)		Port Heiden (N=3)	
	f	Percentage	f	Percentage
Hydrozoans	1	16.3	0	--
Polychaetes	1	<0.1	2	<0.1
Echiurids	1	<0.1	0	--
Gastropods	1	1.2	2	0.2 - 0.5
Bivalves:				
Serripes	1	0.2	1	0.8
Tellina	1	10.7	2	20.9 - 70.8
Spisula	1	52.9	3	22.4 - 94.1
Siliqua	0	--	1	5.2
Mya	1	3.3	1	0.1
Fragments[b]	1	14.4	3	5.0 - 9.8
Crustaceans	1	0.7	1	0.1
Holothureans	1	0.4	0	--

[a] For full details of findings in each specimen, see Appendix I.

[b] Fragments mainly of bivalve parts, not assignable to genus due to partial digestion.

Table 8. Composition of combined stomach contents from four walruses taken in the proposed clam fishery zone, April 1981.

Prey taxon	No. of individuals		Wet weight	
	Number	% of total	Grams	% of total
Hydrozoans	16	0.5	1,806	8.8
Polychaetes	5	0.1	4	<0.1
Echiurids	1	<0.1	6	<0.1
Gastropods	55	1.6	146	0.7
Bivalves:				
Serripes	6	0.2	54	0.3
Tellina	2,209	66.0	2,921	14.2
Spisula	1,013	30.2	12,635	61.4
Siliqua	20	0.6	219	1.1
Mya	15	0.4	368	1.8
Fragments[a]	--	--	2,219	10.8
Crustaceans	6	0.2	75	0.4
Holothureans	3	0.1	41	0.2
Total	3,349	100.0	20,589	100.0

[a] Mainly fragments of bivalves, not assignable to genus due to partial digestion.

in May 1962 and 1963; near Port Heiden in June-July 1979; and in the vicinity of Port Moller in April 1968, "summer" 1976, April-May 1979, and May 1980 (F. Fay and L. Lowry, unpubl.). The only report of substantial numbers of walruses in the zone outside of the March to July period was of about 200 walruses hauled out at the west side of Port Moller in January-February 1969 (J. Hemming, pers. comm.).

In recent years, large numbers of walruses have been seen hauled out near Cape Seniavin in spring. They were first reported there in April 1978 and April-May 1979 (J. Sarvis, pers. comm.). Numerous sightings were made during 1980 and 1981 (Table 9). These sightings indicate a peak in numbers in early to mid-April. While it is possible that our monthly surveys may have missed the annual peak of walrus numbers, results of the surveys (Table 3) indicate at least 14,000 animals in the clam zone in 1980 and 5,000 in 1981. In 1980, walruses hauled out at Cape Seniavin until late May, while in 1981 the latest sighting was made on 12 April.

Results of our surveys (Table 3) indicate a marked reduction in the number of walruses in the clam zone in May and June. No walruses were seen in the clam zone during the June 1980 survey (Fig. 9), and this was confirmed by the lack of sightings during the unsuccessful walrus collecting trip in that month (Fig. 19). Furthermore, J. D. Hall (pers. comm.) reported seeing no live walruses while fishing in the zone during July-August 1980, and no reports of walruses in that area were received at the King Salmon Fish and Game office during that summer (C. Smith, pers. comm.). In some years, however, walruses have been seen in the northeastern portion of the clam zone in June and July. During the clam fishery resource assessment cruise in June-July 1978, 16 walruses were seen in the northeastern extreme of the clam zone on 5 July (Fig. 21). J. Sarvis (pers. comm.) reported about 40 walruses hauled out at Port Heiden on 30 June and 16 July 1979. On 27 June 1979, fishermen on a crab boat from Dutch Harbor reported about 3,000 walruses in the water 18-20 miles offshore from Ugashik (R. Tremaine, pers. comm.). We are unable to determine if the animals in the latter sighting were actually in the clam zone.

Walruses are present in Bristol Bay outside of the clam zone throughout the year. We saw walruses on or near Round Island on every survey except in January and March 1981. We saw none in the northeastern part of the Bay, although they have occasionally been seen in Kvichak and Nushagak bays (C. Smith, R. Nelson, pers. comm.). Sightings were scattered throughout the western portion of the Bay and were particularly numerous in the area 45-90 km south and south-southeast of Round Island.

Our surveys yielded very variable estimates of the number of walruses in Bristol Bay outside of the clam area. Based on observations at Round Island from 1978 to 1980, about 20,000 walruses have been estimated to use the Round Island hauling area during summer months (C. Smith, pers. comm.). Our results indicate a comparable number of animals in Bristol Bay in April and August 1980 and in May 1981 (Table 3). Our low estimate of abundance for June 1980 may indicate that animals

Table 9. Summary of observations of walruses at Cape Seniavin in 1980 and 1981.

Date	Number of walruses 1980	1981	Source
Late March	many	--	C. Smith
5 April	600	--	J. Sarvis
7 April	500-600	1,500-2,000	S. Reynolds, L. Lowry
8 April	--	0	F. Fay
9 April	--	60-100	F. Fay
10 April	50	100	S. Reynolds, F. Fay
11 April	--	40	F. Fay
12 April	--	34	F. Fay
13 April	0	--	J. Sarvis
14 April	0	--	J. Sarvis
16 April	1,000-1,500	--	F. Fay
18 April	383	--	C. Smith
23 April	--	0	R. Sellers
7 May	--	0	L. Lowry
15 May	200	--	C. Smith
20 May	1	--	L. Hood
21 May	2	--	L. Hood
22 May	100	--	L. Hood
23 May	130	--	L. Hood
27 May	0	--	L. Lowry
23 June	0	--	F. Fay

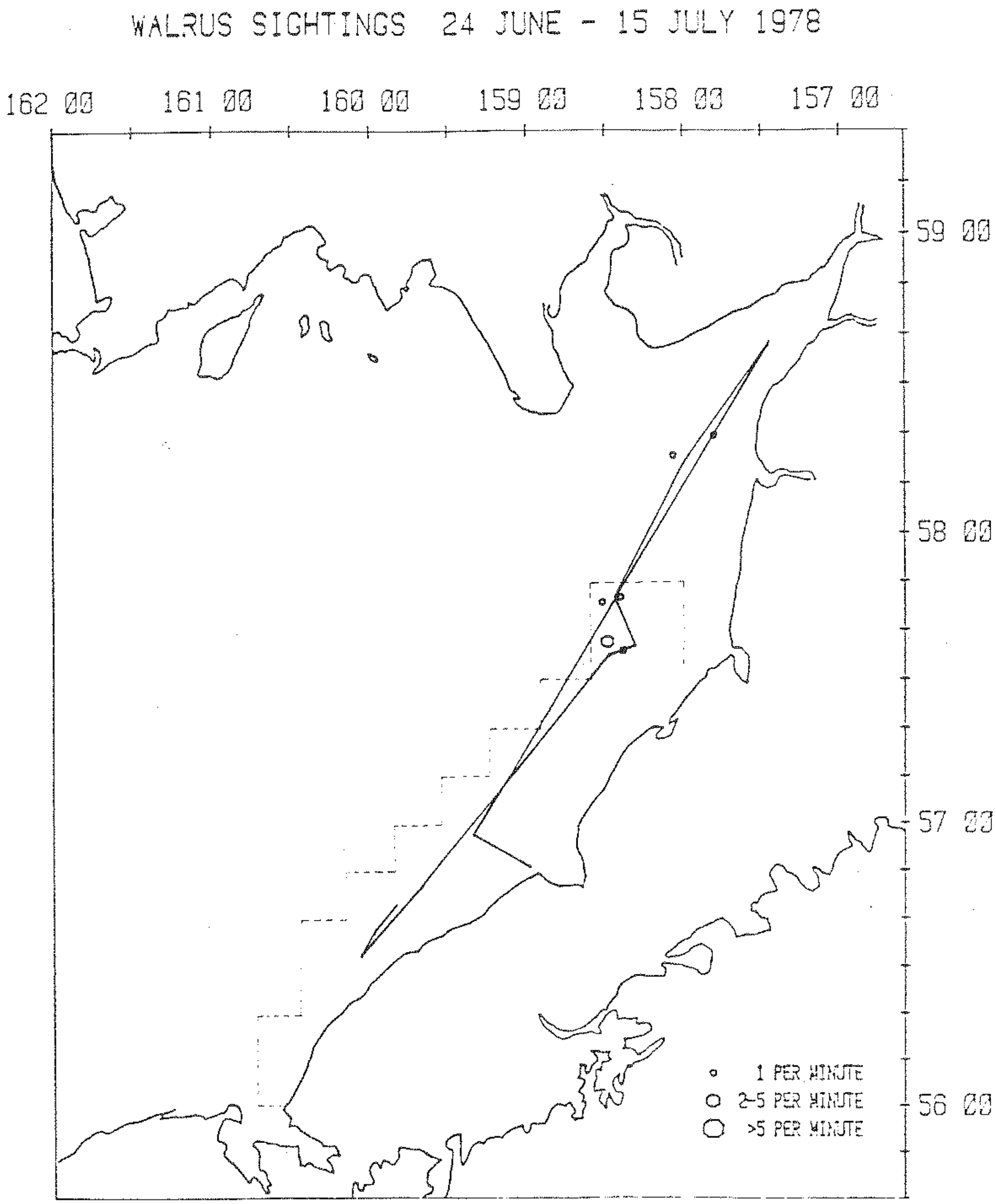

Figure 21. Approximate track lines and sightings of walruses made during the clam fishery resource assessment, 24 June-15 July 1978.

were at sea feeding to the west of the surveyed area. The abundance of animals indicated by surveys declined markedly in September. Based on September and November surveys, 8-10,000 walruses were in the area during that time. Few were seen during October, and the remainder may again have been feeding to the west of the survey area. The very low numbers in the Bay in January to March were probably due to emigration of the male walruses from Bristol Bay to the heavier sea ice to the west, where females were congregated for the breeding season (Fay 1981). During February 1981, the breeding area was in southern Kuskokwim Bay, outside of the surveyed area (Fay 1981).

Our one estimate of abundance that seems inordinately high was derived from the May 1980 aerial survey. On that survey (Fig. 8), walruses were extremely abundant in the water south of Round Island. In one section of a transect, the density of sighted animals was about 5 per km^2. Although it is unlikely that more than 60,000 walruses were in Bristol Bay at that time, the results of both 1980 and 1981 surveys suggest that an annual peak in abundance may occur in the Bay during the month of May.

Based on the results of our surveys and other available data, we have constructed a schematic representation of the seasonal abundance of walruses in Bristol Bay for years when sea ice is not extensive (Fig. 22). This indicates that walruses are abundant in the Bay in most years during April to September. During April, most (about 60%) of the animals are in the clam fishery zone; during the remainder of the year, they are scarce or absent there. Overall abundance declines in September-November, and, except in heavy ice years, walruses are usually scarce in the Bay during January to March. Based on Figure 22, we estimate that about 7% of the annual walrus-days in Bristol Bay in 1980-81 were spent within the proposed clam fishery zone.

Feeding Habits

As in our previous studies of the feeding habits of walruses elsewhere in the Bering Sea (Fay et al. 1977; Lowry et al. 1980; Fay et al., in prep.), we found that the animals in the Bristol Bay region in March and April 1981 had consumed a wide variety of prey, but the bulk of the stomach contents was made up of just a few genera. At least 22 genera of benthic invertebrates were represented in the 19 stomachs analyzed. These included two hydrozoans, three polychaetes, one echiurid, four gastropods, six bivalves, two crabs, one shrimp, two amphipods, and one holothurean. More than 90% of the total biomass of prey in the stomachs, however, was from five genera of bivalves (*Serripes*, *Tellina*, *Spisula*, *Siliqua*, and *Mya*) which have been of primary interest to the potential clam fishery (Hughes et al. 1977, Hughes and Nelson 1979). Of these five, *Tellina* and *Spisula* dominated, comprising more than 75% of the total biomass of food.

Nearly all of the remains of bivalves found in the stomachs were the soft, fleshy parts ("meats"). Only a few chips from the margins

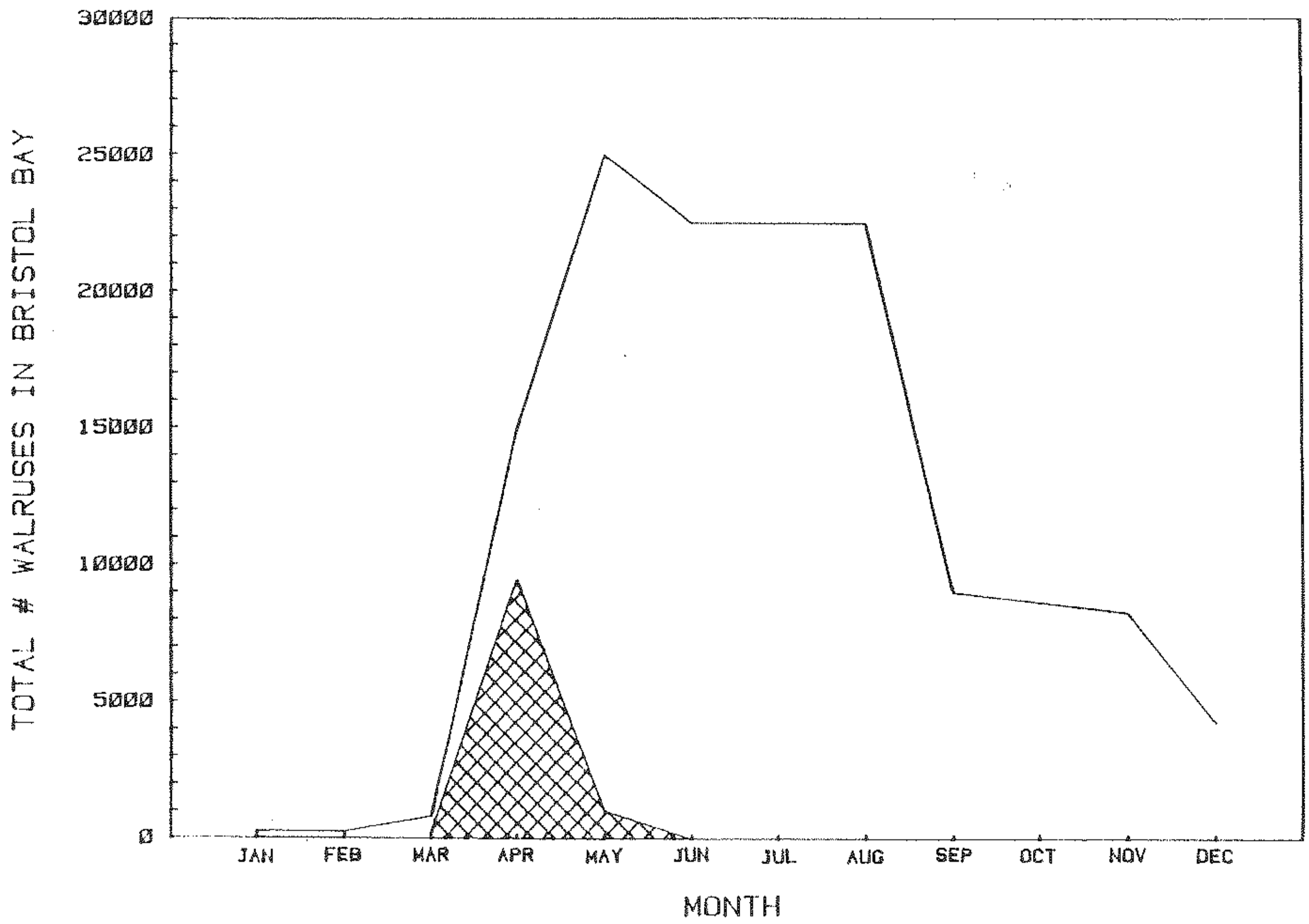

Figure 22. Schematic representation of seasonal abundance of walruses in Bristol Bay, based primarily on results of aerial surveys. Walruses in the proposed clam fishery zone are indicated by crosshatches.

of the shells were present in each stomach. That the rest of the shells had not been consumed is indicated by the fact that these marginal chips made up only 0.2% of the total wet weight of the bivalves, whereas in whole bivalves the shells normally make up 50 to 75% of the total wet weight (Fay et al. 1977, Hughes et al. 1977). This scarcity of shells is typical of the stomach contents of walruses. It is not due to the shells having been digested, for they are more resistant to digestion than are the meats. Even tiny shells no more than a centimeter in diameter survive passage through the entire digestive tract, whereas the meats of bivalves are entirely digested. In the 19 stomachs analyzed here, the largest proportional amounts of shell fragments were found in those contents having the largest proportion of finely divided, partly digested meats (i.e., were most advanced in digestion), yet the actual weights of those fragments were about the same in all stomachs (Table 10).

The effect of digestion on the meats is a point of concern, for the accuracy of the analyses of the stomach contents is affected by digestion. In our analyses, we usually were able to identify only the foot and contiguous visceral mass of the tellins. Occasionally, where the prey had just been ingested, the mantles and other soft parts were identifiable as well. For the cockles and for the surf, razor, and Mya clams, however, feet and siphons often were identifiable and, occasionally, the mantles and adductor muscles as well (Fig. 23). We observed that the feet of the cockles, surf, and razor clams greatly outnumbered the siphons in all instances and that the siphons of the Mya clams greatly outnumbered the feet (Table 11). We believe that these disparities were partially due to digestive breakdown of the "underrepresented" parts. The siphons of the cockles, surf, and razor clams are much smaller and have more surface area in proportion to their mass than do their feet, hence should be expected to digest more swiftly. The feet of these bivalves, being much larger and more solid, appear to digest very slowly and to persist as identifiable objects for a much longer time than the siphons. Conversely, the foot of Mya is very small and the siphon much larger, more solid, and better protected (by periostracum) than is the foot; hence, the siphon of Mya probably persists much longer than the foot in the stomach contents. For these reasons, and because we could sometimes identify all of the parts of bivalves in newly ingested contents, we believe that the walruses often ate the entire meats of these organisms and were not always selectively removing the larger, fleshier parts as previously supposed (Vibe 1950, Fay et al. 1977).

Digestion also appears to have had an influence on our assessment of composition, in that the smaller organisms were digested more rapidly than the large ones. This is indicated by the comparative proportions by weight of tellins and surf clams, in relation to the proportion of fragmented, partly digested clam meats (i.e., stage of digestion) per stomach (Fig. 24). In the sample of walruses collected on the ice (March), the percentage of tellins was consistently higher in newly ingested contents than in those far advanced in digestion; the reverse was true of the surf clams. The tellin feet, being about one-fifth the

Table 10. Amounts of bivalve shell fragments per stomach in relation to stage of digestion (as indicated by the proportion of the stomach contents made up by partly digested clam meats) in 19 walruses taken in the Bristol Bay region, March-April 1981.

No. of stomachs	% contents made up of partly digested meats		Bivalve shell fragments			
			% of total bivalves		Weight (g)/stomach	
	Range	Mean	Range	Mean	Range	Mean
7	4.9 - 7.9	6.59	<0.1 - 0.3	0.11	1- 7	3.7
6	8.9 - 13.9	8.19	0.1 - 0.5	0.23	1-20	7.0
6	19.8 - 44.3	21.12	0.1 - 2.8	0.59	1- 6	2.4

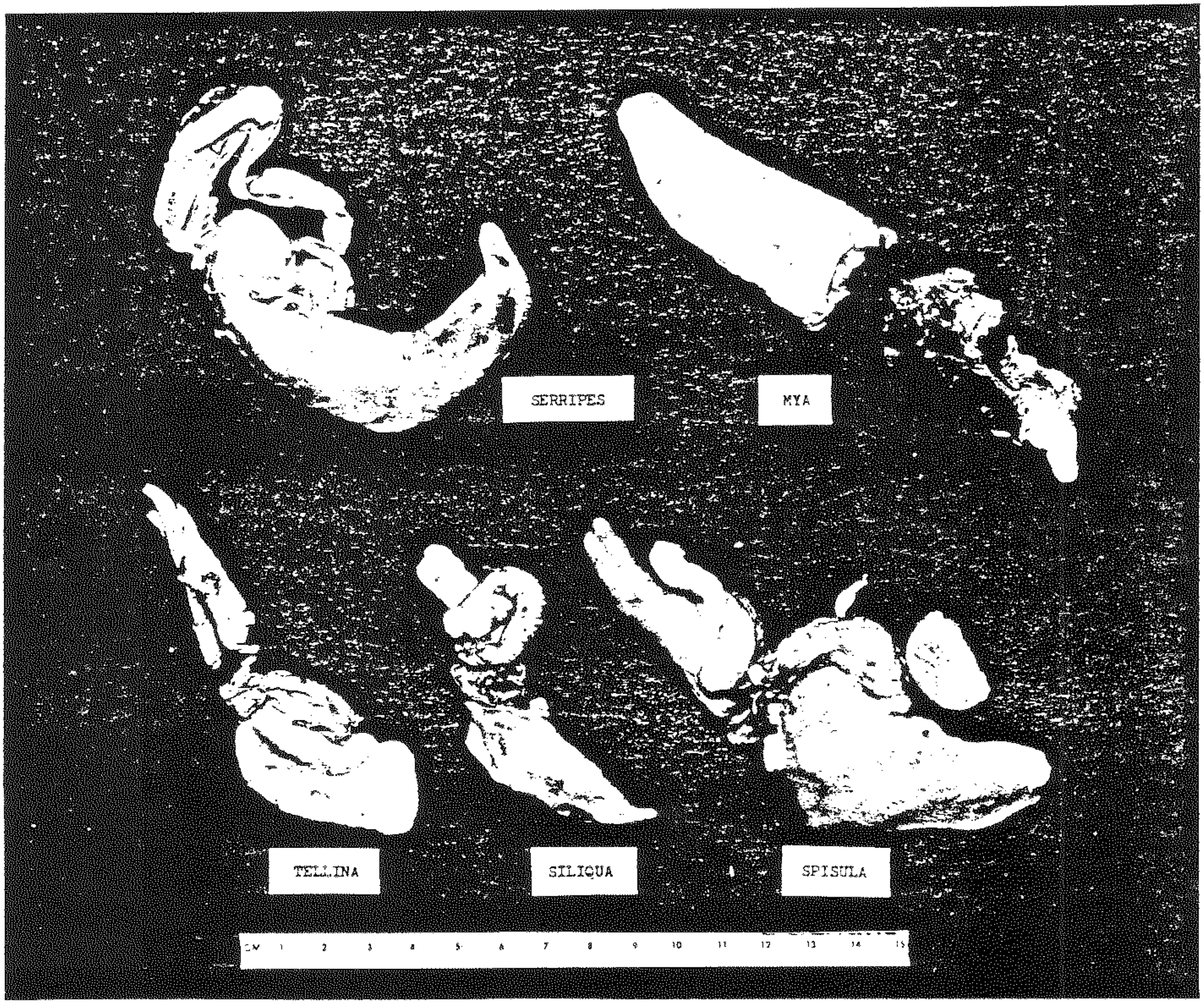

Figure 23. Clam meats from walrus stomachs. For each genus, the foot is at lower right, the siphon at upper left.

Table 11. Comparative numbers of siphons and feet of certain bivalve mollusks found in the stomach contents of walruses taken in the Bristol Bay region, March and April 1981.

Bivalve genus	Numbers of parts		Number of siphons/foot
	Siphons	Feet	
Serripes	42	167	0.25
Spisula	603	1,296	0.46
Siliqua	85	249	0.34
Mya	13	6	2.17

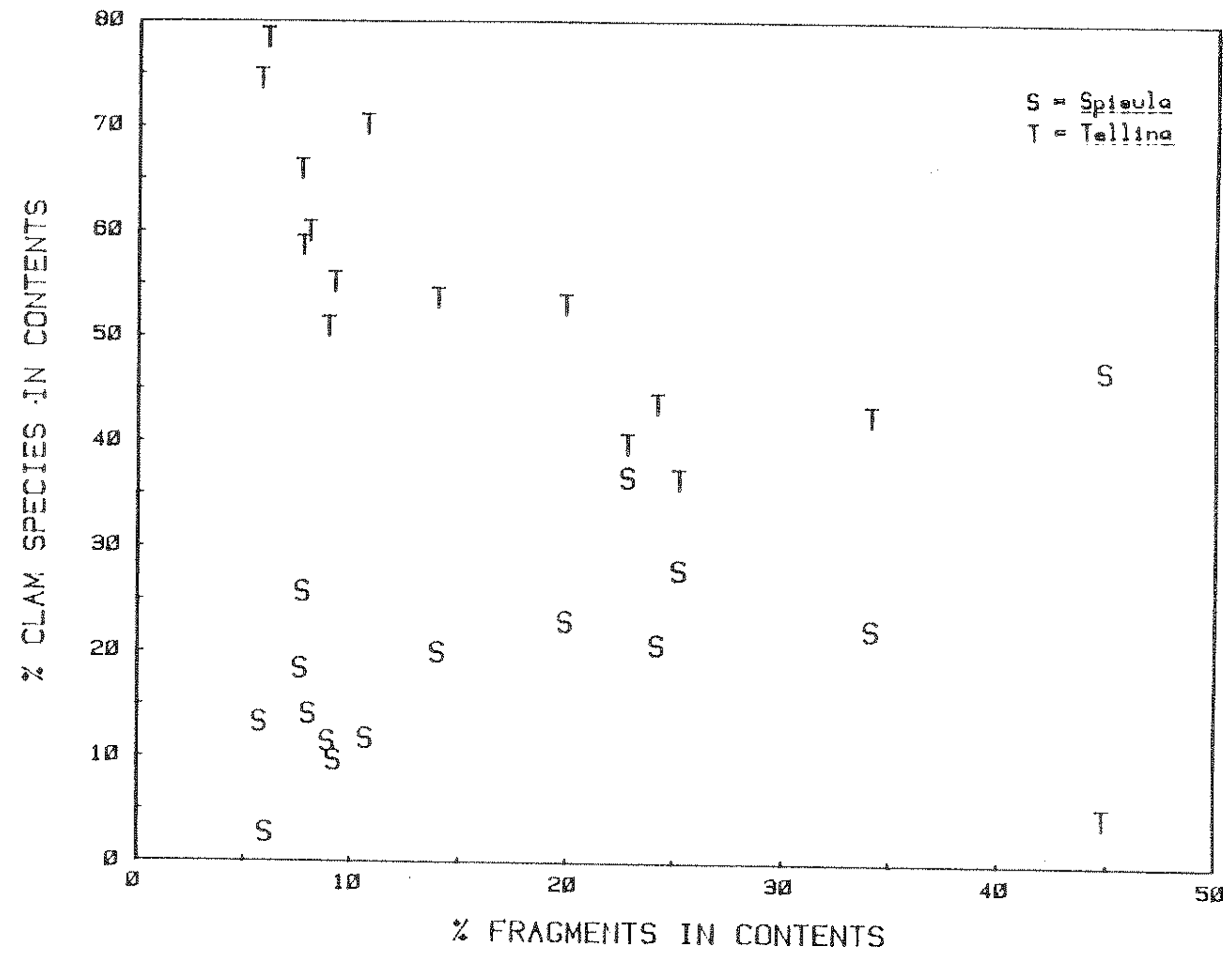

Figure 24. Relationship between the percent of fragments and the percent of *Spisula* and *Tellina* in stomachs of walruses collected on the ice in southern Kuskokwim Bay.

size of those of the surf clams, evidently were digested more rapidly and were less easily identified after partial digestion than were the surf clam feet. This difference apparently led to inaccurate assessment of both types of bivalves in that sample, the surf clams being overestimated and the tellins underestimated as digestion advanced. In the April sample of animals collected in the water, that relationship did not exist; the percentage of partly digested fragments for these ranged from 5.0 to 14.5%, which indicated recent feeding by all four animals.

Differential digestion rates in relation to size of organisms probably also tended to result in underestimation of quantities of small individuals within each genus of bivalves. Nonetheless, we did find a wide range in size of both the tellin and the surf clam feet in some of the stomachs. Individual feet of the tellins, after fixation in formalin, ranged in length ("heel-toe") from 10 to 45 mm and in weight from 0.2 to 9.0 g. Feet of the surf clams were from 13 to about 75 mm in length and weighed from 0.2 to 51.0 g. These wide ranges indicate that the walruses were not preying solely on the largest, oldest age classes but were taking many of the very small, young individuals, as well. In an effort to estimate the relative predation on the different age classes of surf clams in the clam fishery zone, we ranked the Spisula feet from the April sample according to their length (Table 12). We then estimated the shell lengths for these "foot-classes," using as our guide the shell/foot length of one preserved, whole specimen (ratio about 1.6:1). A range of ages in years was then assigned to each foot-class on the basis of the age/shell length data presented by Feder et al. (1978). Although the smaller feet probably were underrepresented in this sample, because of their being digested more rapidly than the large feet, the resultant estimate of age composition (Fig. 25) suggests that the walruses' predation was heavy on the young age classes and may have been proportional to the relative abundance of each age class from about 3 years to old age. Unfortunately, we did not preserve all of the surf clams from the Kuskokwim Bay sample for comparison, but a general comparison is possible from the overall unit-weights.

As a whole, the tellins, cockles, and surf clams appear to have been somewhat larger and the razor clams considerably smaller in the March sample of walruses from southern Kuskokwim Bay than they were in the April sample from southern Bristol Bay (Table 13). These unit-weights for each genus include all identifiable parts, rather than the foot alone. Because of the generally more advanced digestion in the March sample, we suspect that the actual differences in size were even greater than the data suggest.

Evaluation of the Impact of Walruses on the Surf Clam Stock

Walruses were present in the clam zone from March to early June 1980 and from March to early May 1981. Each year the largest numbers were present in April. Past records suggest that their occupation of

Table 12. Numbers of individuals per size class of surf clams, *Spisula polynyma*, in stomach contents of walruses in the Bristol Bay proposed clam fishery zone.

No. of individuals	Average unit weight (grams)	Length (mm) of foot	Estimated length (mm) of shell[a]	Approximate age (years)[b]
102	0.4	13 - 20	20 - 32	3 - 4
67	0.9	21 - 25	33 - 39	4 - 5
68	1.7	26 - 30	41 - 47	4 - 5
57	2.9	31 - 35	49 - 55	5 - 6
69	4.6	36 - 40	57 - 63	5 - 7
84	7.7	41 - 45	65 - 71	6 - 8
102	10.7	46 - 50	72 - 79	7 - 9
335	20.7	51 - 75	80 -118	8 -16

[a] Shell/foot length ratio 1.575 in preserved specimen.

[b] Based on age/shell length in Feder et al. (1978).

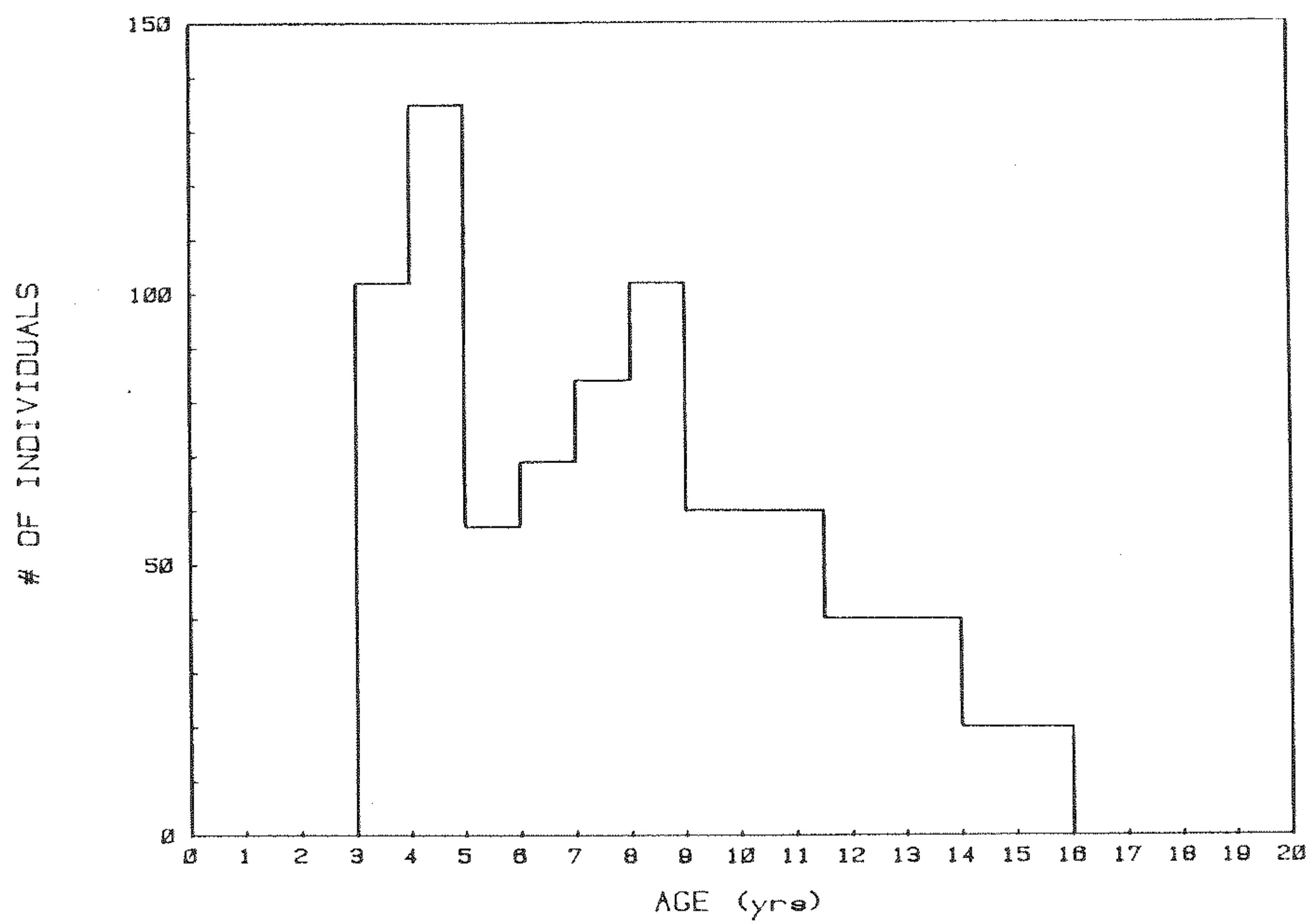

Figure 25. Estimated age composition of surf clams (*Spisula polynyma*) preyed on by walruses in the Bristol Bay proposed clam fishery zone, April 1981.

Table 13. Comparative unit-weights of the principal prey of walruses taken in southern Kuskokwim Bay in March and southern Bristol Bay in April 1981.

	March sample			April sample		
Genus of prey	No. of individuals	Total weight	Unit-wt (g)	No. of individuals	Total weight	Unit-wt (g)
Serripes	162	2,221	13.7	6	54	9.0
Tellina	4,839	20,184	4.2	2,209	2,921	1.3
Spisula	283	5,352	18.9	1,013	12,635	12.5
Siliqua	229	985	4.3	20	219	11.0
Total	5,513	28,742	5.2	3,248	15,829	4.9

that area has followed a similar trend for several years and that their presence there in other seasons is infrequent and highly irregular. In years when heavy ice fills Bristol Bay, tens of thousands of walruses may reside in the Bay throughout the winter but apparently seldom invade the clam zone itself.

Judging from our observations, the animals using the clam zone are virtually all adult males, which move into the area after the mating season. At that time, the females and young begin their migration northward to summering grounds in the Chukchi Sea. At the end of the mating season, these adult males are extremely lean, apparently having fasted for much of the winter. In order to recuperate from their depleted condition, they probably feed more intensively than at other times during the year. Adult males taken in the northern Bering Sea in spring tend to have food in the stomach more than twice as often than do the females and young (Fay, in press).

Judging from the stomach contents of the bulls collected within the clam zone in 1981, their principal prey there is the surf clam. To estimate the intensity of that predation, we have assumed that the animals were continuously foraging in the clam zone between the time of first and last sightings there (i.e., early March to late May 1980 and early March to early May 1981). Presumably, in those periods, they were using only the Cape Seniavin haul out as a place to rest between feeding forays. Based on our estimates of numbers there during April and May 1980 and March to May 1981 (Table 3), and assuming that the highest estimate each year was the peak number in the zone that year, we constructed smoothed curves of the possible numbers of walruses per day in the clam zone for each year (Fig. 26). Taking the sum of the interpolated daily values from each curve as the best estimate of the total number of "walrus-days" per year in the zone, we calculated the total wet weight biomass (WWB) of food eaten by the walruses as:

$$\text{Food WWB} = \left(\sum_{i=1}^{n} W_i\right)(\text{TBW} \cdot r)$$

where W_i = the number of walrus in the clam zone on day i

n = total number of days walruses occurred in the clam zone

TBW = total body weight per walrus. The mean for adult males is 1,210 kg (Fay, in press), which in this case we rounded to 1,200 kg.

r = feeding rate in relation to TBW. Fay (in press) estimated the daily intake of food by a 1,200-kg wild walrus as 0.055 TBW, based on feeding rates of captive walruses and the nutrient content of normal foods.

Assuming that the stomach contents of the four specimens taken in the clam zone in April 1981 were representative of the foods eaten there

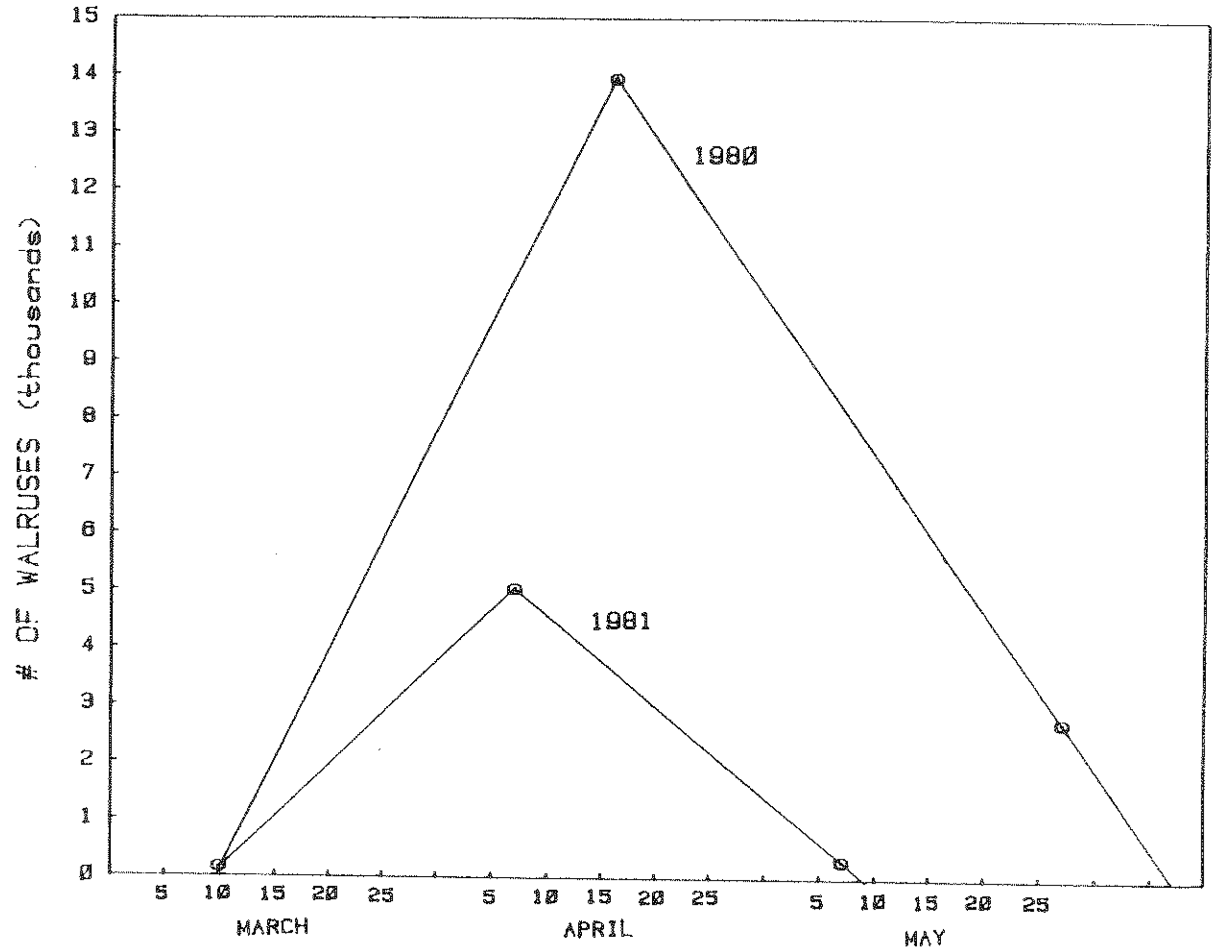

Figure 26. Interpolated numbers of walruses per day in the clam fishery zone. Circled points indicate numbers estimated from aerial survey data.

by all of the walruses, we then estimated the quantity of surf clam meats as 69.8% of the total food biomass (mean, 61.4% of identified remains, plus 8.4% from the partly digested fragments). Based on data given by Hughes et al. (1977), the round weight of those clams would be 2.725 times the weight of the meats. The results (Table 14) suggest that the walruses using the clam zone as a feeding area in March to June 1980 could have consumed about 17 to 33% of the total biomass of harvestable surf clams in that area, or about two to four times the estimated (by Hughes and Nelson 1979) annual sustained yield. In 1981, the impact was considerably less because of the smaller number of animals using the area. Nevertheless, about 5 to 11% of the harvestable biomass (i.e., all or most of the sustained yield) could have been removed by the walruses.

We suspect that these estimates are very conservative and that the actual impact in 1980 could have been at least twice the amount estimated. We also suspect that the walruses returned in smaller numbers and stayed for a shorter time in 1981 because they found the food supply depleted as a result of their incursions in the previous year.

Assuming that a) an average of at least 15,000 bull walruses inhabit Bristol Bay each year, b) the bulls feed for about 10 months per year and fast for 2 months during the mating season, and c) our estimates of their consumption of food in the clam zone in 1980 and 1981 are reasonably close to the normal range of amounts consumed, then these bulls could eat a total of about 297,000 mt of food per year, 3 to 17% of which would be drawn from the clam fishery zone.

CONCLUSIONS

1. Walruses inhabit Bristol Bay throughout the year. These are primarily adult males. In winters with light to medium ice cover, almost all animals leave the Bay for 3 to 4 months to join with the females and young farther west. In winters with heavy, extensive ice cover, the females and young may come into the Bay and join the males.

2. Within the Bay, the resident males (about 20,000 individuals) range out mainly from Round Island to forage. For the past several years, a large proportion of them has resided in the proposed clam fishery zone, but only from March to May or June of each year. There, they apparently have used various sites, particularly Cape Seniavin, along the adjacent coast as haulouts, rather than return to Round Island between forays.

3. While in the clam fishery zone, walruses feed on surf clams, *Spisula polynyma*, and on other bivalves and other benthic invertebrates. Judging from the walruses collected there, about two-thirds (by weight or volume) of their food consists of surf clams, ranging in age from about 3 years on up.

Table 14. Estimated amounts of surf clams eaten by walruses in the proposed Bristol Bay clam fishery zone in 1980 and 1981.

Year	Total walrus-days in clam zone[a]	Wet wt biomass of food consumed (mt)[b]	Biomass of surf clams eaten: Meats (mt)	Biomass of surf clams eaten: Round wt (mt)[c]	Total harvestable biomass (mt)	Annual sustained yield (mt)
1980	517,460-724,942	34,152-47,846	23,838-33,397	65,955-90,999	277-381,000[d]	24-32,400[d]
1981	123,251-181,449	8,135-11,976	5,678- 8,359	15,471-22,776	202-343,000[e]	17-29,200[f]

[a] Sum of interpolated values from Fig. 26, with range equivalent to 95% confidence limits of highest estimate from survey data (1980: ± 16.7%; 1981: ± 19.1%).

[b] Walrus-days x 0.066 mt, the mean daily intake by a 1.2 mt walrus.

[c] Meats = 36.7% of whole, round weight (Hughes et al. 1977).

[d] From Hughes and Nelson (1979).

[e] 1980 biomass, less amount eaten by walruses in 1980, plus 8.5% recruitment.

[f] 8.5% of total biomass (Hughes and Nelson 1979).

4. In 1980 and 1981, the animals using the clam zone probably consumed at least the annual increment of the surf clam population each year and possibly several times that amount.

5. The walruses would be a major competitor of a surf clam fishery in this area, probably to the extent of periodically depleting the surf clam stocks below the harvestable level. The fishery, in turn, could be a significant competitor of the walruses, which appear to depend on the clams in this area for perhaps 7 to 10% of their annual intake of food. The walruses, however, are highly mobile and probably could forage elsewhere if their food supply here were impacted by the fishery.

REFERENCES

Braham, H. W., R. D. Everitt, B. D. Krogman, D. J. Rugh, and D. E. Withrow. 1977. Marine mammals of the Bering Sea: a preliminary report on distribution and abundance, 1975-76. Processed Rep., NOAA/NMFS, Northwest and Alaska Fish. Cent., Seattle, WA. 90pp.

Brooks, J. W. 1954. A contribution to the life history and ecology of the Pacific walrus. Spec. Rep. 1, Alaska Coop. Wildl. Res. Unit, University of Alaska, Fairbanks. 103pp.

Burns, J. J. 1965. The walrus in Alaska, its ecology and management. Processed Rep., Alaska Dept. Fish and Game, Juneau. 48pp.

__________. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51:445-454.

__________, and S. J. Harbo, Jr. 1977. An aerial census of spotted seal, *Phoca vitulina largha*, and walruses, *Odobenus rosmarus*, in the ice front of Bering Sea. Pages 58-132 *in* Environmental Assessment of the Alaskan Continental Shelf, Quarterly Reps. of Principal Investigators, April-June 1977, Vol. 1. NOAA Environmental Res. Lab., Boulder, CO.

__________, L. H. Shapiro, and F. H. Fay. 1980. The relationships of marine mammal distributions, densities, and activities to sea ice conditions. Final Rep. RU #248/249, Outer Continental Shelf Environmental Assessment Program, NOAA Environmental Res. Lab., Boulder, CO. 172pp.

Chapskii, K. K. 1936. The walrus of the Kara Sea. Trudy Vsesoiuz. Arkt. Inst. (Leningrad) 67:1-124.

Estes, J. A., and J. R. Gilbert. 1978. Evaluation of an aerial survey of Pacific walruses (*Odobenus rosmarus divergens*). J. Fish. Res. Board Can. 35:1130-1140.

Fay, F. H. 1981. Modern populations, migrations, demography, trophics, and historical status of the Pacific walrus. Annu. Rep. RU #611, Outer Continental Shelf Environmental Assessment Program, NOAA Office of Marine Pollution Assessment, Juneau, AK. 38pp.

__________. (In press). Ecology and biology of the Pacific walrus. Odobenus rosmarus divergens Illiger. North American Fauna, No. 74. U.S. Fish and Wildl. Serv., Washington.

__________, Y. A. Bukhtiarov, S. W. Stoker, and L. M. Shults. (In prep.). Food of the Pacific walrus in the winter-spring period in the Bering Sea. Soviet-American Cooperative Studies on Marine Mammals, Vol. 1. Pinnipeds.

__________, H. M. Feder, and S. W. Stoker. 1977. An estimation of the impact of the Pacific walrus population on its food resources in the Bering Sea. Final Rep., U.S. Marine Mammal Commission, Contract Nos. MM4AC-006 and MM5AC-024, Washington. 38pp.

Feder, H. M., A. J. Paul, and J. M. Paul. 1978. The pinkneck clam Spisula polynyma in the eastern Bering Sea: growth, mortality, recruitment, and size at maturity. Sea Grant Rep. 78-2, University of Alaska, Fairbanks. 26pp.

__________, K. Haflinger, M. Hoberg, and J. McDonald. 1980. The infaunal invertebrates of the southeastern Bering Sea. Final Rep., Outer Continental Shelf Environmental Assessment Program, NOAA Office of Marine Pollution Assessment, Juneau, AK. 399pp.

FWS. 1972. Bristol Bay waterbird survey. Operation Rep. 1972, U.S. Fish and Wildl. Serv., River Basin Studies, Anchorage, AK. 8pp.

Hughes, S. E., and R. W. Nelson. 1979. Distribution, abundance, quality, and production fishing studies on the surf clam, Spisula polynyma, in the southeastern Bering Sea, 1978. Processed Rep., NOAA/NMFS, Northwest and Alaska Fish. Cent., Seattle, WA. 31pp.

__________, __________, and R. Nelson. 1977. Initial assessments of the distribution, abundance, and quality of subtidal clams in the S.E. Bering Sea. Processed Rep., NOAA/NMFS, Northwest and Alaska Fish. Cent., Seattle, WA. 43pp.

Kenyon, K. W. 1960. The Pacific walrus. Oryx 5:332-340.

__________. 1972. Aerial surveys of marine mammals in the Bering Sea, 6-16 April 1972. Ms. Rep., U.S. Fish and Wildl. Serv., Bur. Sport Fish. Wildl., Seattle, WA. 79pp.

Krogman, B. D., H. W. Braham, R. N. Sonntag, and R. G. Punsly. 1979. Early spring distribution, density, and abundance of the Pacific walrus (Odobenus rosmarus) in 1976. Final Rep. RU #14, NOAA, Environmental Res. Lab., Boulder, CO. 47pp.

Krylov, V. I. 1965. Determination of age, rate of growth, and analysis of the age structure of the harvest of Pacific walruses. Pages 201-211 in E. N. Pavlovskii, B. A. Zenkovich, S. E. Kleinenberg, and K. K. Chapskii, eds. Marine Mammals. Nauka, Moscow.

__________. 1971. On the food of the Pacific walrus (Odobenus rosmarus divergens). Pages 110-116 in E. S. Mil'chenko, T. M. Andreeva, and G. P. Burov, eds. Investigations of Marine Mammals. AtlantNIRO, Kaliningrad.

Lowry, L. F., K. J. Frost, and J. J. Burns. 1980. Trophic relationships among ice-inhabiting phocid seals and functionally related marine mammals in the Bering Sea. Final Rep. RU #232, Outer Continental Shelf Environmental Assessment Program, NOAA Environmental Res. Lab., Boulder, CO. 76pp.

Mansfield, A. W. 1958. The biology of the Atlantic walrus, Odobenus rosmarus rosmarus (Linnaeus), in the eastern Canadian Arctic. Ms. Rep. (biol.) 653, Fish. Res. Board Can., Montreal. 146pp.

Miller, E. H. 1975. Walrus ethology. I. The social role of tusks and applications of multidimensional scaling. Can. J. Zool. 53:590-613.

__________. 1976. Walrus ethology. II. Herd structure and activity budgets of summering males. Can. J. Zool. 54:704-715.

Nikulin, P. G. 1941. The Chukchi walrus. Izv. TINRO (Vladivostok) 20:21-59.

Scheffer, V. B. 1964. Hair patterns in seals (Pinnipedia). J. Morphol. 115:291-303.

Stoker, S. W. 1977. Report on a subtidal commercial clam fishery proposed for the Bering Sea. Final Rep., U.S. Marine Mammal Commission, Contract No. MM7AD-076, Washington. 33pp.

Tikhomirov, E. A. 1964. On the distribution and biology of pinnipeds of the Bering Sea. Pages 277-285 in P. A. Moiseev, A. G. Kaganovskii, and I. V. Kisevetter, eds. Soviet Fisheries Investigations in the Northern Part of the Pacific Ocean. Food Industry, Moscow.

Vibe, C. 1950. The marine mammals and the marine fauna in the Thule District (Northwest Greenland) with observations on ice conditions in 1939-41. Meddlelser om Grønland 150(6):1-115.

Appendix 1. Number of individuals and wet weight (g) of prey in stomach contents of walruses from the Bristol Bay region, March-April 1981.*

Field no.	Sex	Age (Yrs)	Hydrozoans		Polychaetes		Echiurids		Gastropods		Bivalve molluscs: Astarte		Serripes		Tellina		Mya		Spisula		Siliqua		Fragments	Crustaceans		Holothureans		Total	
			No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
48z	F	4	--	--	13	12	4	27	8	7	--	--	5	86	482	1,850	--	--	12	308	12	58	278	--	--	--	--	536	2,606
49z	F	8	--	--	3	3	tr	--	2	3	1	0.5	--	--	198	761	--	--	20	330	15	49	285	1	1	--	--	238	1,452
50z	M	13	--	--	--	--	--	--	1	2	--	--	4	110	201	654	--	--	15	244	10	38	170	--	--	--	--	231	1,218
51z	F	11	--	--	41	80	7	55	5	6	2	1.0	10	202	569	3,300	--	--	54	1,490	18	94	432	tr	--	--	--	711	5,632
52z	F	±25	4	15	5	7	--	--	1	1	--	--	10	162	745	3,650	--	--	32	590	34	190	281	--	--	--	--	827	4,901
53z	F	20	--	--	9	10	--	--	8	8	--	--	11	145	472	2,000	--	--	28	560	12	82	230	--	--	--	--	540	3,035
55z	F	>25	--	--	--	--	tr	--	2	1	--	--	--	--	118	316	--	--	14	291	--	--	181	2	3	--	--	136	792
113z	F	17	--	--	60	131	65	645	5	12	--	--	51	720	530	2,950	--	--	36	666	30	156	519	3	5	--	--	780	5,800
115z	F	19	--	--	5	2	35	42	--	--	--	--	24	240	341	1,260	--	--	21	296	25	92	167	1	1	--	--	452	2,100
116z	F	21	--	--	--	--	frag	27	12	28	--	--	37	403	400	1,219	--	--	27	215	39	115	205	--	--	--	--	515	2,210
131z	M	4	--	--	5	2	1	3	--	--	--	--	2	17	97	161	--	--	6	123	5	7	111	9	17	--	--	125	441
132z	F	20	--	--	--	--	--	--	--	--	--	--	1	2	5	4	--	--	4	41	--	--	39	2	1	--	--	12	87
133z	F	12	--	--	--	--	tr	--	4	7	--	--	1	7	75	139	--	--	5	66	4	7	11	7	15	--	--	94	318
135z	F	4	--	--	9	7	2	14	4	12	--	--	6	127	534	1,850	--	--	5	65	75	135	141	4	9	--	--	589	2,360
137z	M	16	--	--	--	--	tr	--	1	--	--	--	--	--	74	90	--	--	4	47	2	2	12	--	--	--	--	81	211
1R	M		16	1,806	3	2	1	6	32	136	--	--	2	24	490	1,193	13	364	622	5,910	--	--	1,620	5	74	3	41	1,187	11,176
2R	M		--	--	1	1	--	--	--	--	--	--	--	--	968	846	--	--	11	267	--	--	70	1	1	--	--	993	1,194
3R	M		--	--	1	1	--	--	21	8	--	--	--	--	751	882	--	--	178	2,702	20	219	415	--	--	--	--	964	4,227
4R	M		--	--	--	--	--	--	2	2	--	--	4	30	--	--	2	.4	209	3,756	--	--	200	--	--	--	--	217	3,992

* Numbers 48z to 55z taken on 2 March at 58°51'N, 164°40'W
Numbers 113z to 116z taken on 6 March at 58°37'N, 166°36'W
Numbers 131z to 137z taken on 8 March at 58°45'N, 165°24'W
Number 1R taken on 12 April at 56°33.5'N, 160°11'W
Number 2R taken on 17 April at 57°07'N, 158°58'W
Number 3R taken on 18 April at 57°07'N, 158°53'W
Number 4R taken on 20 April at 57°11'N, 158°50'W