9

AERIAL SURVEY OF WALRUSES IN NORTHERN BERING SEA

23 February to 2 March 1960

by

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CONTENTS

INTRODUCTION

Purpose

The walrus survey was undertaken to obtain information on the population size, distribution and, if possible, breeding habits of the Pacific walrus herd.

Itinerary

19 February	-	Seattle to Anchorage
23 "	-	Anchorage to Bethel (brief walrus aerial survey north corner Kuskokwim Bay)
25 "	-	Aerial survey-Nunivak Island, St. Matthew Island, St. Lawrence Island and return to Bethel
26 "	-	Aerial survey-Area south of Nunivak
1 March	-	Aerial survey-Area south and southwest of St. Lawrence to St. Matthew Island
2 "	-	Aerial survey-Kuskokwim Bay, northern Bristol Bay and trip to Cold Bay

Personnel

Theron A. Smith, pilot, Aircraft Supervisor, BSFW, Anchorage, Alaska; David L. Spencer, copilot, Refuge Supervisor, Kenai, Alaska; James W. Brooks, walrus observer, Chief, Division of Game, Juneau, Alaska; Francis H. Fay, walrus observer, Department of Health, Education and Welfare, Anchorage, Alaska; Karl W. Kenyon, walrus observer, BSFW, Seattle, Washington; Roy Lindsley, Soviet ship observer, BCF, Western Area Supervisor of Fishery Management, Anchorage, Alaska; Dale W. Rice, whale observer, BCF, Seattle, Washington (fig. 1).

Survey Time

Time required for walrus survey - 23 February to 2 March 1960

	Hrs.	Min.
R4D (DC3) charter aircraft flight time on actual walrus survey	18	54
" " charter aircraft flight time transportation to survey area	12	47
Total	31	41

THE SURVEY

Operating Conditions

The village of Bethel was selected as our survey base because it offers ideal facilities for the R4D aircraft and living quarters. It is also centrally located in relation to the part of the Bering Sea surveyed and offers better weather conditions for flight operations than other possible places, such as Nome.

Direct radio contact with U. S. Weather Bureau stations at Bethel and Anchorage was maintained constantly. Flights were undertaken only when a reasonable chance of good weather was forecast. Fog, rain and snow squalls prevented operations on 22, 24, 27, 28 and 29 February. Areas of fog interfered with surveys to some extent on 25 and 26 February. Our best surveys were conducted on 1 and 2 March, which were mostly bright and clear.

We were informed by the Weather Bureau that the 1960 season was unusual in that a southerly circulation over the Bering Sea had prevailed during the winter season when northerly circulation was usual. Low pressure centers moving through the Aleutians in a northwesterly direction brought warm air to the Bering Sea causing fog and precipitation. Unseasonably warm temperatures--the daytime temperature at Bethel remained above +40°F. during our stay

there--prevailed during our entire operation. We were fortunate that snow and ice on the aircraft held us up on only one occasion (fig. 2). Because of the unusually warm winter Bering Sea weather in 1960 and the prevailing southerly circulation, the ice pack was farther north during the survey period than it normally would be. This condition had the advantage of concentrating the walrus population in the area which we surveyed.

Aircraft maintenance was excellent. The R4D aircraft has two auxiliary wing tanks giving a flight range of 12 hours at a cruising speed of 120 to 125 knots. The aircraft was found highly satisfactory for this survey. Engines, radios, etc., operated perfectly throughout the entire trip. The Bureau of Land Management, from whom the aircraft was chartered, and the Fish and Wildlife Service maintenance crews share responsibility for this high standard of performance.

Methods

Walrus counts were made by two observers, standing on each side of the aircraft directly behind the pilot and copilot (fig. 3). When large numbers of walruses were seen a recorder transcribed the observations relayed to him by the observers. Flight speed was

maintained at about 120 to 125 knots (nautical miles are used throughout this report) and flight altitude at from 500 to 800 feet, usually 750 feet. An attempt was made to record all walruses within a 1-mile strip (.5 mile on each side of the aircraft). Under ideal conditions the survey should cover a predetermined route over sample geographical areas. Weather conditions did not permit such a procedure. Also variations from a direct route were occasionally made so that large groups of walruses could be photographed.

Computations of the total walrus population were made by extending our counts, on a walruses per square mile basis to areas judged to have a population of walruses similar to the areas surveyed. Data published by Russian biologists (Nikulin, 1941) and that assembled by U. S. Navy icebreakers (Ryder, in lit.) gave some idea of the limits of the areas occupied by aggregations of walruses for the season of our survey.

Unfortunately, as explained later, computations based on aerial counts and geographical distribution are subject to the judgment of the individual making the computations. Probably each observer would present a somewhat different conclusion as to the total Bering Sea walrus population on the basis of this survey.

Survey Areas

The survey area is illustrated on Chart 1, which shows the track of our aircraft on each survey trip. In general terms the survey area was bounded on the north by St. Lawrence Island, on the west by the international date line, on the south by a line from St. Matthew Island to the western tip of Nunivak Island and curving from there southward to the Togiak Bay area in northern Bristol Bay.

For the purpose of computing an estimate of the total walrus population from the sample areas where counts were made the survey area is divided for convenience into two general areas: (1) the northern area comprising the ice pack south and west of St. Lawrence Island and north of a line between Nunivak and St. Matthew Island; (2) the southern area comprising the pack ice extending from Nunivak Island through Kuskokwim Bay into northern Bristol Bay. These general areas are further subdivided into areas having similar population densities of walruses.

Distribution of Walruses in Winter

Icebreaker data

Dr. Francis H. Fay has requested and received the cooperation

in recording walrus observations from U. S. Navy icebreakers operating in the Bering Sea in February and March of 1953 and 1954. As plotted on Chart 2, the Navy observations indicate that walruses are concentrated in two areas (1) south and southwest of St. Lawrence Island, and (2) south and east of Nunivak Island. Our surveys confirmed that these areas are the primary wintering grounds of the walrus herd. Walrus distribution is, of course, closely related to the location of the ice pack and therefore changes as does the ice in different years and in various periods within any given year.

Chart 3 represents our hypothetical concept of the areas covered by the ice pack and the distribution of walruses at the time of our population estimate. This is a composite picture made up of observed ice limits found on the flights of 25 February and 1 and 2 March 1960.

Ice conditions and walrus distribution

A classification of different kinds of ice is given by Armstrong and Roberts (1956). We found that the distribution of walruses was not strictly correlated with any one type of ice (figs. 4 to 10). South of St. Lawrence Island they usually rested on light floes near leads (figs. 4 and 5). Large numbers were seen on "very close pack ice" (fig. 6) and close pack ice (fig. 7) southwestward of St. Lawrence.

In some areas the water between the larger floes had frozen solid. Walruses frightened by the passing aircraft were seen to dive through small open holes near their resting places. Judging from the soiled ice around these holes they had been used for sometime. Along ice edges, predominantly zones of "brash ice," 1 to 10 walruses often rested on the larger floes (fig. 8). In summary, the greatest walrus concentrations were seen on "very close pack ice," often near leads. The next largest numbers were seen on the larger floes among brash ice along the ice edge zone. Some were seen near open leads among vast fields of large floes. Walruses were very scarce, however, on this type of ice in the area 40 to 120 miles southwest of Southeast Cape, St. Lawrence Island on 25 February. None was seen near the outer edges of ice that adhered to land.

In Kuskokwim Bay a group of about 50 walruses was seen in open water about .25 of a mile from the ice edge. Another was seen near Hall Island about 50 miles from the ice edge on 1 March and a group of three and another of two animals was seen in Bristol Bay 8 and 15 miles respectively south of the ice edge on 2 March. (Small groups, more than a mile from the ice, have been excluded from the general population computation.)

Computation of Pacific Walrus Populations

Sources of error

A calculation of an entire wild population from sample counts involves many uncertainties. In the case of the walrus many of the unknowns are important. The sources of error are detailed below:

Area occupied. --The limits of areas occupied by the walrus herd at any moment in time ~~is unknown and almost unknowable~~ could not be determined. At the time of the February-March survey flights, as far as known, the majority of Bering Sea walruses were confined to the ice pack. The area occupied was probably mostly south of St. Lawrence Island. From day to day the area covered by the ice pack varies in size (see Chart 1). Therefore, a computation of the size of the herd from counts in sample areas is difficult. In addition, available time and aircraft range did not give us an opportunity to ascertain the absolute limits of ice areas most heavily populated by walruses. Since we found walrus concentrations where previous observations indicated them for past seasons, we have some confidence in assuming certain general areas of concentrations for our calculations.

Underestimates of large groups. --Although walruses may be scattered singly or in small groups over extensive areas they may also be concentrated in large closely packed groups of up to several hundred animals (see table 1). Photographs were taken of some of

these groups (figs. 5 and 6), but because of the large number of groups seen no correlation can be made between groups photographed and our recorded estimates of their size. After prints were made, an estimate of the number of animals shown was made; then the animals visible were carefully counted. In every large group the estimated number was less than the total counted in the group. This would tend to make our total computation conservative. It would be difficult to assign a percentage of underestimation because the error probably increased with the size of the group. It is probably safe to say that our total recorded count may be from 10 to 25 percent below the actual number of walruses within the area surveyed. No correction factor to account for this underestimate has been introduced into the calculation. It has been considered that the conservative "count" figures used will to some degree compensate for the possibility that the areas of high walrus concentration were overestimated. The net result is, I believe, a conservative figure.

Distance estimates.--It was necessary to estimate a distance of .5 of a mile on each side of the aircraft within which strip we counted all walruses. As an aid to accuracy, sighting on the horizon and using triangulation gave a rough estimate of this distance. Known distances on the ground (air strips) were looked at and used

as a gauge for later distance estimation. Undoubtedly a few animals outside the 1-mile strip were recorded as within it. However, such errors would to some extent be compensated for by underestimates of large groups.

The survey track.--Ideally, a predetermined track over the ice should have been laid out and followed without variation. However, weather conditions would frequently interfere with such a plan. In addition, the temptation to investigate and photograph a large group of animals somewhat off the direct track caused us to vary our course at times. However, I believe that such variations as we made do not materially affect our results.

Walruses not seen.--Only a guess can be made to account for the number of walruses that were in the survey area that were not seen. Undoubtedly almost all of those in the water were missed (fig. 9). When walruses rest for sometime on ice floes, depressions are made that are visible from the air; around such resting places the ice and melt water are stained by brown excrement (figs. 4 to 6). A number of deserted floes were seen showing signs of recent occupation by walruses and indicated that some percentage of animals were in the water and not counted. This source of error, plus our underestimations of large groups, I believe contributes to making

our final results conservative. For our final figures we have assumed a correction factor that between 25 and 50 percent of the walruses in our survey area were missed while in the water.

Weather as an influence on behavior. --Weather as a factor causing walruses either to haul out on ice or remain in the water is unknown. From experience gained in watching other pinnipeds I would assume that more walruses haul out in clear calm sunny weather than during windy weather or when precipitation is falling. Our aerial observations of walruses during a considerable range of weather conditions tended to confirm the above assumption. Therefore our observations of 25 and 26 February, when wind, fog and precipitation were encountered, probably resulted in minimal counts in the areas surveyed.

Population Computations

Northern area

1. Areas south and southwest of St. Lawrence Island.

Walruses were recorded along an irregular course in the area directly south of St. Lawrence Island. About 200 miles were covered along our track and 1,073 walruses or 5.36 per square mile were recorded. If we consider that this area of concentration is roughly 100 miles long by 10 miles wide then the

estimated number of walruses there is 5,360. If we consider the area is 20 miles wide the total becomes 10,720. Since our course was not direct (we purposely passed over several concentrations that were seen at a distance), the lower figure is probably more realistic.

A nearly direct course was held southwest from Northwest Cape, St. Lawrence Island for 170 miles to the southern edge of the ice and additional courses were taken in a northerly and easterly direction in the area of walrus concentration for an over-all distance of 302 miles (see Chart 1). The total walruses counted along this route in a 1-mile wide strip was 2,598 or 8.6 walruses per square mile. Our observations indicated that, in the southern area at least, this zone of concentration was at least 70 miles wide. Large concentrations of walruses could sometimes be seen at an estimated distance of 3 to 5 miles on each side of the aircraft.

We have estimated that the northern part of this area of concentration measured approximately 10 by 100 miles and that the southern part of the concentration area may have measured 70 by 70 miles for a total of 5,900 square miles and a total estimate of (8.6 x 5,900) 50,740 walruses. If an additional area of 3,100 miles is added for a total area of 8,000 square miles then a maximum estimate of 68,800 walruses is obtained.

This westernmost area covered by our survey certainly was occupied by the majority of the Pacific walrus herd.

2. Ice pack edges.

The southern and eastern edges of the ice pack in the northern area were considered to be about 300 miles long on 1 March (excluding areas included in the previous section). A total of 190 miles of ice edge was covered in the northern area (25 February, 90 miles; 1 March, 100 miles) and a total of 22 walruses were seen along our 1-mile wide counting strip or .116 walruses per square mile. The area properly classified as "edge of the pack" probably averaged about 5 miles wide, consisting of considerable expanses of brash ice which projected in sinuous tongues from the main ice pack (fig. 10). With an ice edge width of 5 miles the total walruses in the edge zone would be 300 x 5 = 1,500 square miles x .116 or 174 walruses. It is possible that this zone was actually more than 5 miles in width; to obtain a maximum estimate it is assumed to be 10 miles wide and the estimate becomes 248 walruses.

Walruses were very sparsely scattered in certain zones away from ice edges and the western area of concentration. Along 210 miles of such ice 10 walruses were counted--or .0476 per square mile. If an area about 50 miles wide and 70 miles long southeasterly of St. Lawrence has walruses in this concentration

then 3,500 x .0476 = 166.6. If the area is taken as 130 x 60 a maximum estimate of 371 walruses is obtained.

Southern area

1. Nunivak Island-Kuskokwim Bay-Bristol Bay Area.

The area includes the ice pack south of Nunivak Island which covered Kuskokwim and northern Bristol Bay. On 26 February our objective was to count walruses in the area south of Nunivak Island where reports from icebreakers indicated a possible walrus concentration area (see Chart 2). Fog patches reduced visibility and also caused us to discontinue the survey before we were completely satisfied that we had properly covered the area. However, a count of 28 walruses was obtained along a track of 160 miles (.175 walruses per square mile). The animals were scattered among loose ice floes. The minimum area estimated to be occupied by walruses in this region is about 60 x 60 or 3,600 square miles for an estimated minimum of 630 walruses. The maximum estimated occupied area is 7,200 square miles (60 x 120 miles) giving an estimate of 1,260 walruses.

The ice edge in Kuskokwim and northern Bristol Bay was found a productive counting area. On 2 March, along a track of 178 miles a total of 183 walruses were counted, or an average of

1.03 walruses per mile. If the ice edges on this date may be assumed to be approximately 300 miles in length (this excludes the northwestern edge area which is included in the calculation above), and the width of the edge area occupied is considered to be a minimum of 5 miles the minimum number of walruses along the ice edge becomes 5 x 300 x 1.03 = 1,545. If a maximum zone 10 miles wide is considered the estimate becomes 3,090 walruses.

Recapitulation of Population Computations

Northern area	walrus/ sq. mi.	Area occupied square miles min.	max.	Walrus population min.	max.
Area adjacent to south shore of St. Lawrence Island	5.36	1,000	2,000	5,360	10,720
Area south and west of St. Lawrence Island to southern edge of ice	8.6	5,900	8,000	50,740	68,800
Ice edges	.116	1,500	3,000	174	248
Interior of ice pack	.0476	3,500	7,800	167	371
Sub-total		11,900	20,800	56,441	80,139
Southern area					
Area south of Nunivak	.175	3,600	7,200	630	1,260
Ice edge; Kuskokwim, Northern Bristol Bay	1.03	1,500	3,000	1,545	3,090
Sub-total		5,100	10,200	2,175	4,350
Grand total		17,000	31,000	58,616	84,489
If 25 percent overlooked				78,154	112,652
If 50 percent overlooked				117,232	168,978
Totals rounded				78,000	113,000
				117,000	170,000

Although the total ice surface in our survey area has been estimated at about 40,000 square miles, the total minimum and maximum areas of population computation include only 17,000 and 31,000 square miles respectively. This discrepancy represents the considerable expanses of ice within the total area where walruses are presumed very scarce or absent.

Evaluation of computations.--It is impossible in a population estimate of the type presented in this report to eliminate subjective treatment. Estimates of distances, of areas, of numbers of walruses in groups and of animals missed compose the basic material with which we must work. We can only hope that, to some degree, the errors are compensatory. In my judgment, we tended to underestimate numbers of walruses seen and probably more than 25 percent were in the water and not seen. On the other hand we may have overestimated the areas of highest walrus concentration.

Although a total of 4,382 walruses were counted it will be noted that only 3,914 were used in the population computations. The remaining 468 were considered outside the 1-mile wide counting track on the ice or else were in the water more than 1 mile from the ice edge.

Only further surveys can narrow the extreme estimates of from 78,000 to 170,000 walruses to a figure in which more confidence

may be placed. For the present an estimate of from 78,000 to 113,000 walruses appears reasonable. At least I feel quite confident that former estimates placing the population at 40,000 to 50,000 (Fay, 1957) are too low.

Alternative computations considered. --If the mean of walruses per square mile in the various areas surveyed and computed separately is taken the figure obtained is 2.5542. If during the survey period the approximate area occupied, in some degree, by walruses was 40,000 square miles an estimate of the total population is about 102,000 walruses. This may be raised to 136,000 if it is considered that about 25 percent of the walruses were not counted during our sample counts.

Approximately 40,000 square miles of ice surface were within the survey area. Our five survey flights over the ice covered a track representing approximately 1,550 square miles, which is about 4 percent of the total survey area. It would be wrong to apply this 4 percent to the total count of walruses (about 4,000) to give a total population figure of 100,000 walruses because the distribution of walruses within the survey area was not at all uniform. The same distance might have been covered and only a fraction of our total count obtained if we had not purposely chosen to survey known areas

of walrus concentration. Therefore it is a coincidence that the figure obtained by this method is the same order of magnitude as calculated by a more detailed analysis of various areas and the counts obtained in them.

Natural history observations

Grouping of walruses.--During our survey of the greatest walrus concentrations on 1 March, the estimated number of walruses in each group seen was recorded individually whenever possible. When the individuals and groups were numerous, as they were in certain areas, one recorded count might include many groups. Excluding these lumped counts, our records indicate that 35 percent of the animals seen were in groups of 10 or less while 65 percent were in groups of 11 to 200 (table 1).

Table 1.--Grouping of Walruses
1 March 1960

Group size	No. of groups counted	Total animals	Percent walruses in each category
1	102	102	3
2	114	228	6
3	60	180	5
4	31	124	3
5	37	185	5
6-10	57	463	13
11-25	26	464	13
30-100	17	1,000	28
125-200	5	875	24
Total	449	3,621	100

Reproduction, sex, and age distribution. --Although many groups of walruses were seen no grouping that could be interpreted as a harem structure could be observed. It was not possible to ascertain whether or not mating activity was taking place.

Young of various sizes, judged to be yearlings, 2-year-olds and older, were frequently seen in all areas of concentration. That births were taking place on 1 March was shown by clearly visible blotches of blood on at least two areas from which females were frightened. In one instance a very small calf, probably newborn, was clasped by its mother as she plunged into the water. Four other calves, presumed to be newborn, were seen.

Generally it appeared that the adults were not segregated by sex. However, it was difficult to distinguish between the sexes. It was definitely noted that several solitary animals were adult males.

SUMMARY AND CONCLUSIONS

1. An aerial survey of the Pacific walrus was conducted over the Bering Sea ice pack south of St. Lawrence Island and east of the international date line. Between 23 February and 2 March 1960 a total of 18 hours and 54 minutes were spent flying over the Bering Sea ice pack and approximately 1,550 square miles were surveyed.

2. An R4D aircraft having two auxiliary wing tanks of 150 gallon capacity each, giving a maximum of 12 hours flight time, was found highly satisfactory for the survey work. The cruising speed during surveys was about 120 knots and the survey altitude averaged about 750 feet.

3. Walruses were recorded by two observers who stood behind the pilot and copilot each counting all walruses seen in a .5 of a mile strip on each side of the center line of the flight track. In this 1-mile strip 3,914 walruses were recorded.

4. Icebreaker observations indicating the approximate distribution of the walrus herd in February and March assisted us in finding the primary wintering areas of the walrus.

5. The greatest concentrations of walruses were found on close and very close pack ice. Many were also found on the larger floes among brash ice near edges of the pack. Few were found among extensive ice fields that had few leads and none was seen on ice shelves attached to land. Several were seen in the water from .25 to 50 miles from the southern edge of the ice.

6. The majority of the Pacific walrus population was found concentrated in areas south and southwest of St. Lawrence Island. A lesser number was found along the edge of the ice pack. A considerable number was found in the ice pack south of Nunivak Island.

in Kuskokwim Bay and in northern Bristol Bay.

7. Estimates of the size of areas occupied, areas surveyed, numbers of animals in tightly packed masses, and the number of animals in the survey area not seen introduce unknowns difficult to evaluate in a total population computation.

8. Computations of the total walrus population from sample counts along a 1,550 mile track and on a walrus per square mile basis were made for individual areas having different concentrations of walruses.

9. The total walrus population is considered to be between 78,000 and 113,000, it may conceivably be as high as 170,000.

10. Alternative methods of computation using total areas involved and mean of the over-all count tend to confirm an estimate of about 100,000 walruses but are not considered satisfactory methods of computation.

11. Sixty-five percent of walruses observed on 1 March were in groups of more than 10 animals, while 35 percent were seen singly or in groups of less than 10 animals. Counts of walruses on photographs indicate that numbers in large groups were underestimated by 10 to 25 percent.

12. No harem structure was observed.

13. Blood spots on ice and the sighting of small calves indicate that some walruses were born on, and perhaps a few days before, 1 March.

14. Although old males were seen singly, no quantitative information on segregation or mingling of the sexes at this season was obtained.

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Chart 1.--The 23 February to 2 March 1960 aerial survey tracks and the approximate locations of walruses counted are shown in relation to ice fields as they were observed on the respective flights.

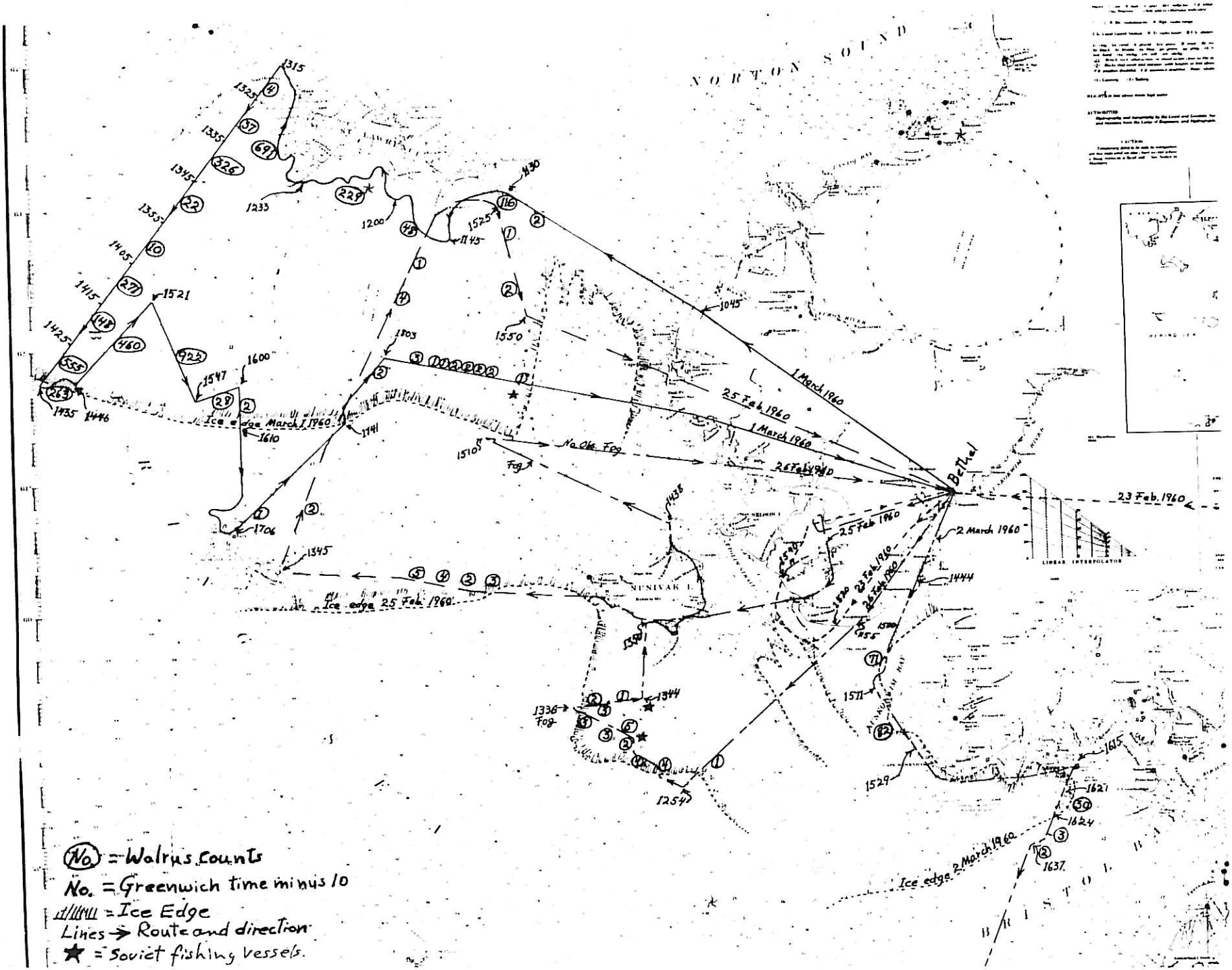
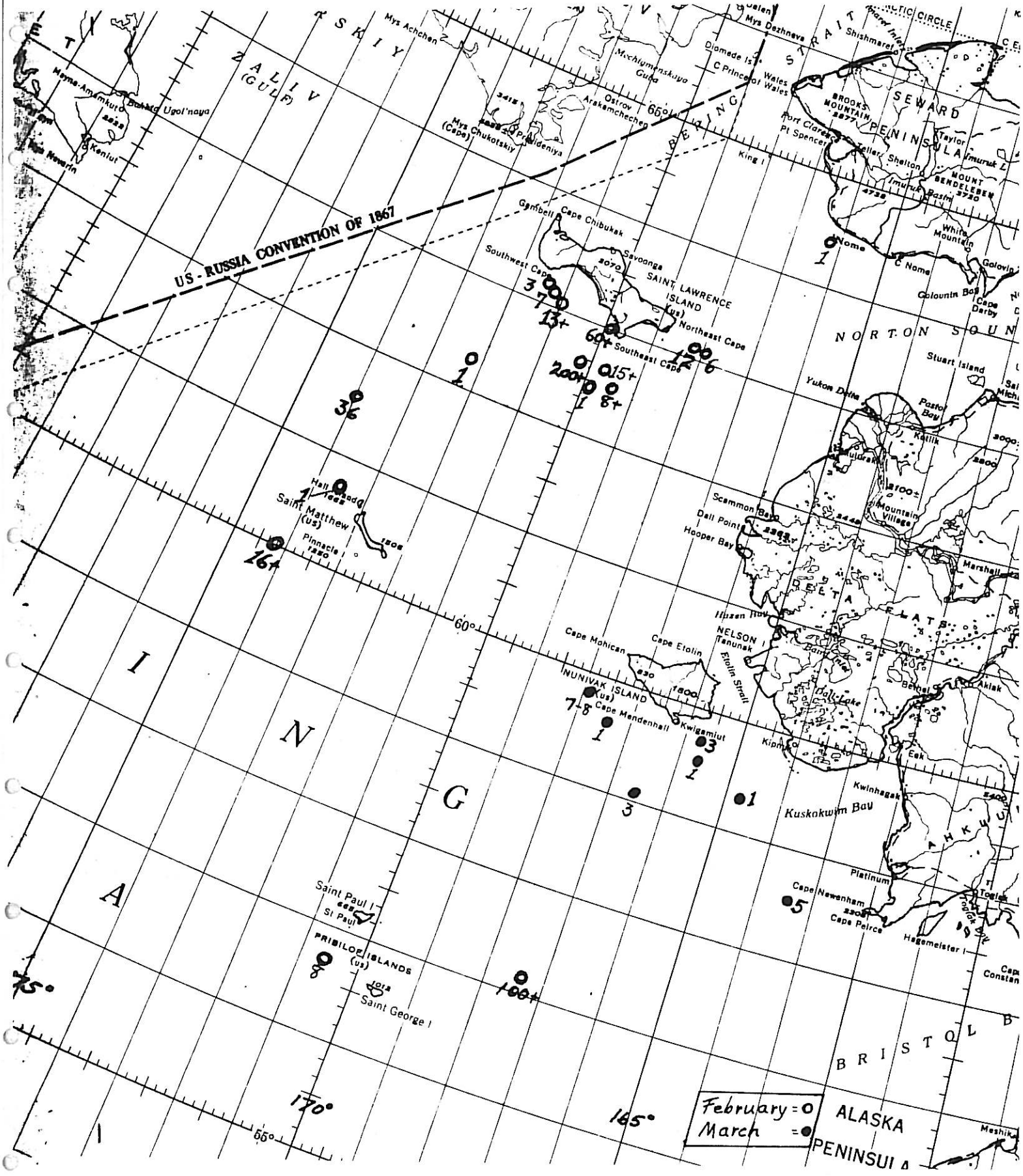

NORTON SOUND
Bethel
Ice edge March 1 1960.
Ice edge 25 Feb. 1960.
Ice edge 2 March 1960.
1 March 1960
25 Feb 1960
1 March 1960
26 Feb 1960
No Obs Fog
Fog
23 Feb. 1960
25 Feb 1960
2 March 1960
(No) = Walrus Counts
No. = Greenwich time minus 10
= Ice Edge
Lines → Route and direction
★ = Soviet fishing vessels.

Chart 2.--Icebreaker walrus observations made in February and March of 1953 and 1954. These records, compared with aerial observations of late February and early March of 1960 indicate that walruses tend to concentrate in late winter primarily south and west of St. Lawrence Island and south and east of Nunivak Island. Unfortunately the courses travelled by the icebreakers when observations were made are not available.



Icebreaker - walrus observations - 1953-54

Chart 3.--Observed limits of the Bering Sea ice fields, the areas in which walruses were found and the possible extent of areas of concentration in late February and early March of 1960 are shown. In order to calculate the walrus population this composite representation of ice limits consists of observations made on flights of 25 February to 2 March.

Ice and walrus distribution - late February - early March, 1960

Figure 1. Survey aircraft and personnel (except Kenyon) From left: Roy C. Lindsley, Francis H. Fay, James W. Brooks, Theron A. Smith, David H. Spencer, and Dale W. Rice. The R4D aircraft, chartered from the Bureau of Land Management, is equipped with Jato and auxiliary wing tanks of 150-gallon capacity each, which give the aircraft a 12-hour flight range. 25 February 1960. KWK 60-4-10.

Figure 2. Brooks removes snow and ice from the aircraft wings. Frost had to be removed from wings before some flights but fortunately the survey was held up only once because of bad icing conditions as shown here. 23 February 1960. KWK 60-3-4.

(Figs. 1, 2, 3, 6, 7, 8, and 10 taken with Super Ikonta camera, 2x2 negative, 1/500 sec. at f11 to f16.
Figs. 4, 5, and 9 taken with Exakta VX, 150 mm. telephoto lens, 1/500 at f11 to f16. All photos on Plus X film).


FAA

Figure 3. The observers obtain an unobstructed view through an arc of 180° by looking through the windshield and adjacent side windows. The two observers are forward of the recorder who transcribed observations when large numbers of walruses were in view simultaneously requiring the entire attention of the counters. 25 February 1960. KWK 60-4-12.

Figure 4. Walruses assembled along leads among large expanses of light floe ice south of St. Lawrence Island. Ice stained brown by excrement is evident where the near group of walruses are taking to the water. 1 March 1960. KWK 60-9-23.

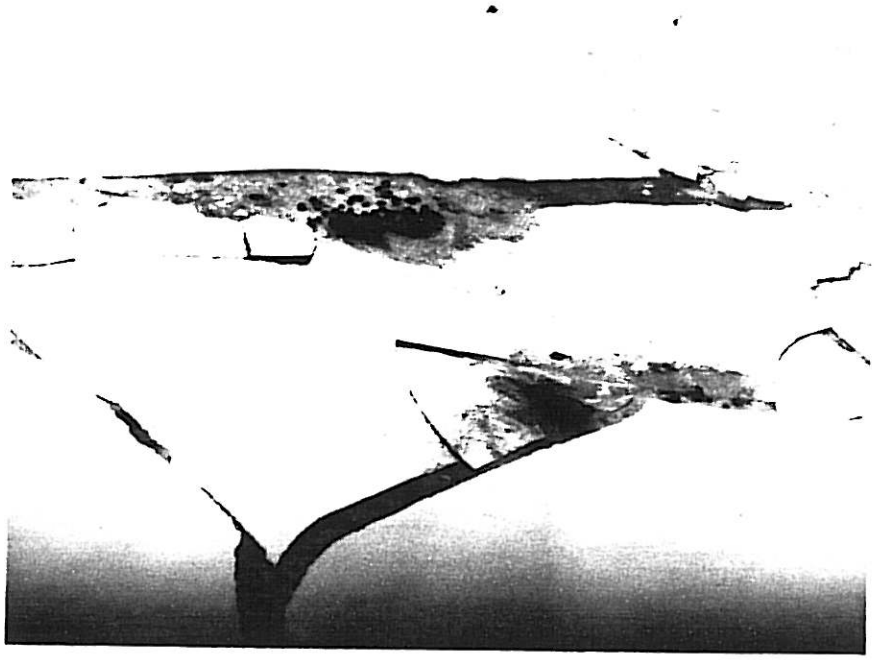


Figure 5. A group of walruses resting in close pack ice near a lead. The melt water where these animals have rested is stained rusty brown by excrement. After visually estimating the number of animals in this photograph, turn page for the exact count. Several calves (yearlings?) are visible. Photographed southwest of St. Lawrence Island. 1 March 1960. KWK 60-9-37.

Figure 6. Walruses on very close pack ice. Open water between these floes appeared to be frozen. Several animals were seen to plunge through open holes near their resting place. Photo taken near international date line southwest of St. Lawrence Island. 1 March 1960. KWK 60-10-5.

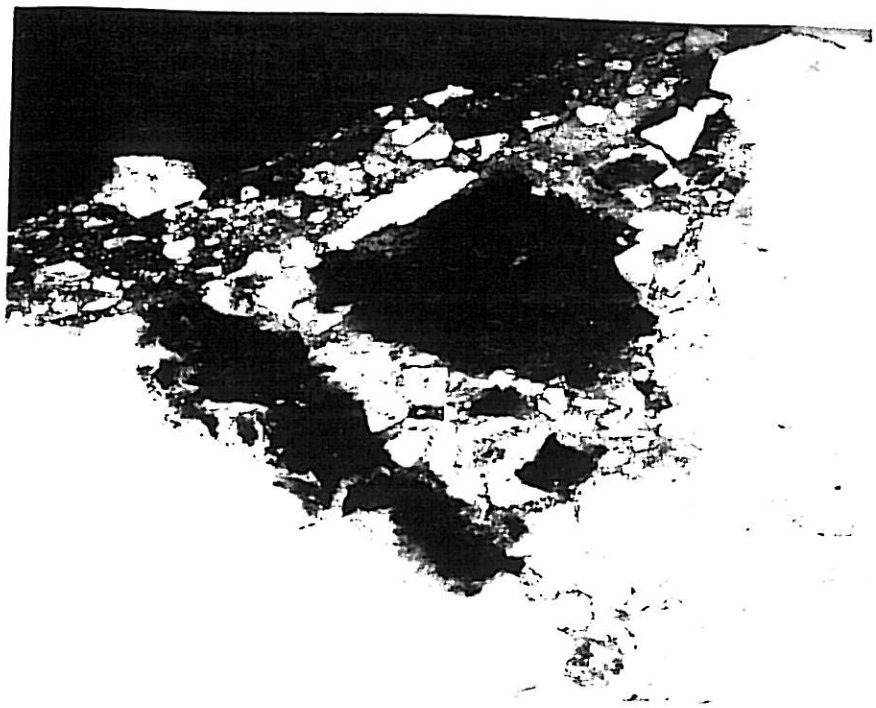


Figure 7. Groups of walruses are visible as dark specks far into the distance on close pack ice. It was estimated that many groups could be seen at a distance of 5 miles on each side of the aircraft. Several deserted floes show signs of recent occupancy by walruses. Photo in greatest concentration area southwest of St. Lawrence Island. 1 March 1960. KWK 60-10-2.

Figure 8. A group of walruses plunge from a floe in a field of brash ice. Spots on the floe to the right of the animals indicate recent occupancy by walruses. Photo taken in ice edge zone. 1 March 1960. KWK 60-10-7.

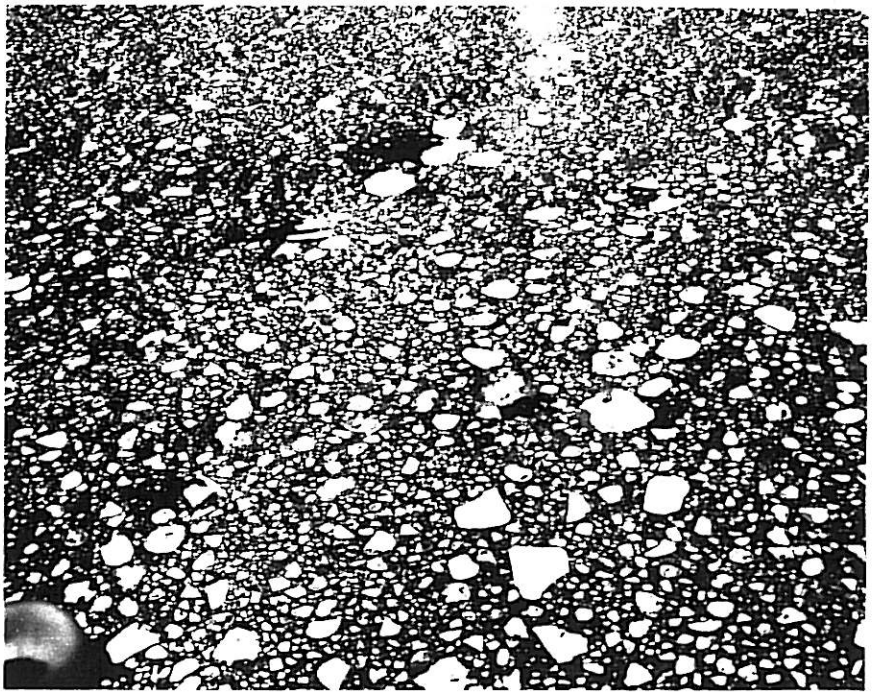


Figure 9. This photograph indicates the difficulty of detecting walruses in the water during an aerial survey. A minimum of 16 animals are visible among light floes, brash and sludge ice in this photograph. Photo southwest of St. Lawrence Island. 1 March 1960. KWK 60-9-8.

Figure 10. The ice edge zone. Patches and sinuous tongues of brash ice extend from the ice pack. In such areas larger floes may be occupied by resting walruses. This ice edge zone was estimated to be from 5 to 10 miles wide. 2 March 1960. KWK 60-10-9.