Volume 1. Marine Mammals

Principal Investigators' Reports
for the Year Ending March 1976

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Annual Reports from Principal Investigators

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Environmental Assessment of the Alaskan Continental Shelf

Volume 1. Marine Mammals

Fourth quarter and annual reports for the reporting period ending March 1976, from Principal Investigators participating in a multi-year program of environmental assessment related to petroleum development on the Alaskan Continental Shelf. The program is directed by the National Oceanic and Atmospheric Administration under the sponsorship of the Bureau of Land Management.

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NO REPORT SUBMITTED

Icebreaker was unavailable for studies during 1975 field season.

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QUARTERLY REPORT

ANALYSIS OF MARINE MAMMAL REMOTE SENSING DATA

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1 April 1976

Note: According to notification by the Fairbanks OCS Arctic Project Office on 29 March 1976, an Addendum to this report will be added during the month of April for the purposes of an Annual Report.

I. Task Objectives

The objectives given below are from our Work Statement. Note that our contract includes only analysis of data, not collection of data or processing costs, and that we have been working under this contract for only about 4 months (our contract dates 1 July 1975 - 30 September 1976, but was not executed until 16 November 1975).

> Tasks: We will analyze remote sensing data obtained from aerial surveys of walrus populations in the Bering, Chukchi and Beaufort Seas with particular emphasis on: (1) walrus presence in an area and the ice characteristics; (2) the degree to which walrus movements are influenced by ice dynamics; and (3) the behavioral, ecological and meteorological conditions influencing walrus hauling-out behavior. Walrus can only be sensed when they are hauled out.

This is not an assessment project strictly speaking. It can provide assessment data, but is aimed principally towards natural history and behavioral information which will, we hope, contribute towards a reevaluation of assessment techniques and lead to more accurate results.

We have provided background to the project in Ray and Wartzok (1974), wherein we emphasize the target question/target species concept; i.e., we concentrate on ice dynamics and visibility factors for a few species of promise. This approach is proving productive because: (1) ice dynamics have a clear bearing on the distribution of Alaska's ice-inhabiting marine mammals (*cf*. Burns, 1970: Fay, 1974); (2) the walrus presents an exceptionally large and contrasting image; (3) both ice and walrus are well-suited to our techniques; and (4) the walrus is of high national and international interest, a feature which provides both a large amount of correlative information and a body of co-workers.

The walrus, *Odobenus rosmarus*, is the major, but not only, species of our choice. We also have chosen the bowhead, *Balaena mysticetus*, and the belukha, *Delphinaptarus* leucas for emphasis, but for them, we fall more clearly into an R & D effort, both scientifically and technologically.

II. Field and Laboratory Activities

A. Field trip schedule.

Under support of the National Aeronautics and Space Administration's Ames Research Center, we have been conducting remote sensing flights aboard their Convair-990 four-engine, jet aircraft. This is probably the most sophisticated remote sensing platform in existence. In order to assess this aircraft's potential, we were invited aboard during BESEX (USSR/USA Bering Sea Experiment) during February-March 1973. As a result, BESMEX (Bering Sea Marine Mammal Experiment) was initiated (Ray and Wartzok, 1974).

Initial BESMEX flights were in September 1974 aboard NASA/ Johnson Space Flight Center's NP-3, a propeller-driven aircraft, as the CV-990 was unavailable at that time. Subsequently, we have joined in close collaboration with AIDJEX (the Arctic Ice Dynamics Joint Experiment) and have enjoyed three flight periods in 1975 -- April, August, and October -- which provide a perspective of the full seasonal cycle for our work. The flight schedule to date is presented in Table 1.

B. Scientific Party.

The BESMEX Principal Investigator (G.C. Ray) has directed, and has been aboard, all flights so far undertaken. The Co-PI (D. Wartzok) has been aboard during April and August 1975, during which time a major component of work was involved with sampling technique and ice dynamics calculations. W.J. Campbell, of AIDJEX and the U.S. Geological Survey, has aided us immensely with ice dynamics and meteorological aspects. All flights have involved additional persons aboard for visual observations, spotting, and aid in in-flight interpretation. Thus, the following have joined us on one or a number of flights. To all, we are grateful for their interest and cooperation: John J. Burns, Alaska Department of Fish and Game; William J. Campbell, U.S. Geological Survey; James Coe, National Marine Fisheries Service (test flight over S. Calif.-porpoise); Thomas P. Dohl, University of California (Santa Cruz); Thomas J. Eley, Jr., Alaska Department of Fish and Game; James Estes, Fish and Wildlife Service; Francis H. Fay, University of Alaska; René Ramseier, Department of the Environment, Canada; Paul Sebesta, NASA/ARC; Larry Shults, University of Alaska; Sam Stoker, University of Alaska. In addition, a number of persons joined us on a guest basis to observe CV-990 operations.

It must be noted that this contract covers costs of none of the above. Rather, it supports only the interpretative work of George H. Taylor, Lab. Technician, at The Johns Hopkins University, who was hired specifically for this task. Mr. Taylor's duties to date are given under Methods below.

C. Methods.

The data-gathering process involves sets of 3 to 5 flights in each of the field periods (see Table 1). This is an insufficient number for a statistically reliable ice dynamics experiment, as outlined by Ray and Wartzok (1974), but it is sufficient for achievement of technological proficiency and for gathering certain information on distribution, group structure, thermodynamics, and sea ice habitat of the target species.

Appendix I gives instrumentation aboard a typical flight. Photography and infrared imagery are our major tools to date, although we will soon analyse further the uses of microwave, SLAR, and laser profilometry for ice dynamics and ice structure.

During a typical flight series, the first flight or flights are dedicated to locate concentrations of animals. We are aided in this task by weather satellite imagery which clearly shows ice distribution and by the frequent presence of co-workers undertaking similar shipboard or aerial tasks at the time. The high speed and range of the NASA aircraft allow considerable aerial coverage during the approximate 6-hour, home-to-home, flight time. In addition, working altitudes over target areas of 3-5000 ft. allow good areal coverage. An average flight of the CV-990, for example, gives 3 hours time on location or approximately a 720 nmi flight time.

Coverage depends, of course, upon field of view. There is no truly precise way to estimate visual field of view from a moving aircraft (Wartzok and Ray, 1975: Appendix II). However, a usual objective is 45^o to either side of the flight line, in which case the track width would be 6000 ft from an altitude of 3000 ft and 10,000 ft from 5000 ft. Such a track implies coverage of from 711 to 1185 nmi^2 during the course of 3 hours. The length of time required to cover an equivalent area during an aerial survey at 500 ft at different survey speeds is given in table II.

We must keep in mind the implication of rapid synoptic coverage. This tends to reduce at least two significant variables which strongly effect the visibility of marine mammals, i.e., circadian behavioral patterns and the influence of weather and/or alterations in ambient thermal conditions. From table II we see that it can require from 2 to 4 eight hour days to cover the same area as covered by the CV-990 in one three hour period. Such extended flight times almost always involve very large animal movements and/or behavioral alterations, both of which grossly influence counts.

Increased height to at least 3000 ft, or possibly 5000 ft, in our experience, does not markedly alter the visual detailability of walrus, bowheads, or belukha. The detectability of walrus from these altitudes is enhanced by the use of IR. Our Texas Instrument RS-310H imager has a 90^o total field of view. However, though it can easily detect walrus from 3-5000 ft, it has a resolution of only about 1 milliradian or 3 ft from a 3000 ft. distance. Thus IR is not satisfactory for counting or for evaluation of group structure. Therefore, we employ photography for high resolution detail in which individuals are clearly discernable. Two cameras are operated continously over animals and on a sample basis (1/30 sec) over other areas. The cameras are a 9" RC-8 with a 6" lens and 73^{o} field of view for synoptic coverage and a 5" KS-87 with a 12" lens and 21^{o} field of view for details of herd structure. SLAR and microwave are continously in operation as well, for certain non-visible ice structural information not requiring high resolution.

Over the past year and a half, we have been encouraged by the applicability of these techniques to the walrus and belukha, in particular. There is no implication intended that these same techniques will work for all species. Survey methods must obviously be species-specific. We have doubts that visual surveys are sufficiently accurate under any circumstance for achievement of reliable assessment data (cf. Wartzok and Ray, 1975, Appendix II). However, the use of visual methods must continue for other purposes. Remote sensing implies the replacement of highly subjective and only grossly accurate visual means by methods which produce accurately quantifiable, permanent data records. Ray and Wartzok (1975: Appendix III) point out synergisms between IR and photography in remote sensing, namely that the use of these sensors, together, yields detection and quantification techniques which neither, used alone, can provide. This use of several sensors in unison is a vital point, often missed by those seeking single solutions or unwisely applying a "what's best" or false dichotomy approach.

During all flights, two computer-recorded logs are kept. The first is simply a recorded spoken dialogue (Appendix IV provides a sample). All observers and data recorders are on an intercom, providing great ease in visually-obtained data retrieval and onsite validation between observers. Second, the CV-990's sensors and navigational systems provide continuous data of many sorts on weather, position, pitch, roll, speed, etc. (see Appendix V for a sample), which are invaluable for correlation with other data obtained.

It has been necessary to provide the above information here in order to give perspective to the work supported by this contract, which is solely analytical. At the present time, we have gathered data in the form of 15 rolls of 9" color film, 16 rolls of 5" color film, 6 rolls of 9" false color IR film, 6 rolls of 5" false color IR film, 8 rolls of 70 mm black and white film, 6 rolls of 70 mm IR imagery, 2 rolls of 70 mm UV imagery, and 24 miles of magnetic tape containing IR data. Mr. Taylor, our analyst has been examining all film with the aid of a Richards 918LW light table and Olympus SZ-IV, variable-power dissecting microscope. He is logging the film in a cursory fashion at this time, noting length of each data run, start and stop times and locations, altitude of aircraft, quality of photography, extent of ice coverage, ice type, and presence of animals and walrus hauling out areas. This preliminary view is necessary in order that we most efficiently may return to certain sections at a later date for detailed visual and other analyses. Mr. Taylor expects to finish his preliminary examination by approximately the end of May 1976, not including, of course, materials from the April 1976 flights.

There are also analytical procedures which are being carried out elsewhere, the results of which are stated very briefly below. It is obvious that one can accumulate vast quantities of data by the means described and that visual or manual examination is very time consuming. Therefore, we are seeking digital means for analysis. Contracts have been let to various corporations by NASA/Ames Research Center for IR tape analyses. The methods used are costly at present, so that we must carefully choose which data we wish to use for initial examination. This is the primary reason for the preliminary examination. That is, choice of samples for digital processing, enhancement, or computerization will depend upon work carried out under this contract.

D. Localities.

Our area of interest is not divisible according to the OCS plan. That is, the populations of concern inhabit the entire Beringean region -- the Bering Sea in winter and including the Chukchi and Beaufort Seas in warmer seasons. Thus, flights are conducted according to animal distributions. Table 1 provides a summary of these. More detail will be provided at a later date, after completion of preliminary analysis.

E. Data collected.

We have given, above, a statement on tapes, film, and computer records collected to date. We did not include microwave, SLAR, and laser data, presently in the hands of others, and to which we have access (see Appendix I), but which we have not yet examined. The limitations of time and manpower do not yet allow us to state when we will be able to acquire these data or examine them. To date, we have attempted correspondence with the investigators involved, but in doing so, we are depending on the good will and time available to others. Obviously, this approach is not ideal.

III. Results

The high cost of reproduction of photographic and other of our materials precludes incorporating these in a report of this kind. Therefore, statements about results must suffice until work is more advance, until funds for photographic reproduction are provided, or until more formal publication is possible. As before stated, our contract does not provide for reproduction of raw data, but only for analysis, and though we have many sample materials on hand, work now underway will soon provide more complete samples and coverage.

Certain visually-obtained results of surveys may now be stated, but on a sample-of-data basis, as full analyses of these also depends upon remote-sensing analysis. Results fall into two categories, ecological and technological.

1. Ecological Data.

On two occasions, we have been able to fly replicate sample grids for determination of variance under different conditions over time. These occasions occurred in April and August 1975. The latter must await infrared analysis for determination of results. For the former, count differences were most striking, as a reflection of walrus hauling-out behavior. An explanation and diagram is in Ray and Wartzok (1975: Appendix III). On 6,7, and 8 April weather became increasingly favorable in the Bering Sea following a period of storms. Previously, we had found a concentration of walrus in the central Bering Sea, approximately 45 nmi NNW of St. Matthew Island. On 6 April we visually counted 427 animals in an area about 10 nmi in diameter. During the two successive days, we computed ice movement by a wind stress model (Reed and Campbell, 1969) to the SE and counted 1200 and 9479 animals, respectively. We are certain that we found the same area on all three days because of the recognizeability of certain structures and leads. Further, the number visible was not a reflection of movement to and from the 32x28 nmi area, as walrus presence was easily detectable by means of breathing holes which they make in new (grey) ice. This not unexpected finding, a more than 20 fold difference in animals visible from day 1 to day 3, illustrates precisely why the causes for such behavior must be investigated for assessment purposes. To that end, we have constructed a heuristic model of walrus hauling out behavior.

Figure 1 presents this model. By way of explanation, we know that the hauling-out patterns of walruses during winter will be dependent on whether they are part of a breeding herd or not. Within the breeding herd, the mature males will have a different hauling out pattern than the other animals. We believe that these three categories of walrus will each require a different set of parameters in the model. Therefore, the model attempts to predict the proportion of each of these walrus groups hauled out, according to three quantifiable factors: animal surface temperatures; diurnal hauling-out patterns; and previous weather history. Each of these three factors, after operating through an associated transfer function, results in a value between 0 and 1 which indicates the fraction hauled out when the other two factors are considered to be constant.

Considering thermoregulatory behavior, we can measure surface temperature (T^s) directly by IR imagery, so we will work with this parameter, rather than "effective temperature" (T^e). The transfer function for the surface temperature has a theoretical value of 0 when the surface temperature is 0^oC. Obviously, a value of 0 says that no animals are out so that we cannot measure surface temperature under those conditions. However, Ray and Fay (1968) Zoologica, 53:19-30, indicate some relationship between T^s and T^e. So we propose that if we sense very warm surface temperatures, the maximum fraction of the herd will be hauled out which is represented by parameter "A". The rate at which the fraction hauled out increases with increasing surface temperature is controlled by "a".

The transfer function for the haulout patterns was derived from Figure 2 of Fay and Ray (1968). The function sin (x) +sin (5x) produces approximately the same shape curve over the interval $\pi/6$ to $5\pi/6$. This curve is the fraction active. We want the fraction hauled out which can be modelled by this same function over the interval $7\pi/6$ to $11\pi/6$. The argument of the sine functions (e.g. $\frac{(T+42)}{36}\pi$) has been chosen so that the latter values are obtained at 0000 hr and at 2400 hr respectively. Constants B and C set the relative magnitudes of the peaks and valleys in that curve. Constant G moves the entire curve up and down setting the absolute value for the peak of the fraction hauled out in the early afternoon.

Weather history disrupts "normal" diurnal behavior and is modelled on the assumption that following a period of bad weather, a large fraction of the animals will be hauled out, presumably to rest, on the first "good" day. We may define "good" for the moment as a T^e of -10^oC or a bit less. How large this fraction is will depend on how long a time the weather has been bad. This is reflected in the reset impulse transfer function. This reset is activated only on the first good day after a storm. How this fraction is effected by the duration of a storm is indicated by the parameter "b". The damped oscillatory transfer function reflects the probable course of events after a storm. On the first good day a large fraction of the animals is hauled out. After a day or two (as reflected by the parameter "r") the animals will be rested and they will return to the water, presumably to feed intensively, so that a smaller fraction may be hauled out than normally would be under identical conditions after effects of the storm have disappeared; i.e., the parameter "E" indicates the fraction hauled out long after the perturbation caused by a storm has died away. How rapidly the perturbation dies away is determined by parameter "s". Finally, parameter "D" indicates the maximum fraction that will haulout on the first good day after a major, lengthy storm.

Other sorts of ecological information are provided by various remote-sensing techniques. Infrared imagery may be density sliced for walrus (hotter) and ice (colder) to yield very different pictures which, when superimposed, give a complete view of walrus vis-à-vis ice structure. It has long been supposed that walrus require heavy ice for hauling out and leads or polynyas for access to and from the water. Areas of high ice activity, always with some dispersive forces, are implicated, but it appears that only by remote sensing means may this supposition be tested and quantified. Some initial analyses indicate that walruses prefer to haul out where leads of compression and dispersion converge and where sea ice is composed of moderate, fractured floes, both old and new. We will need further IR analyses to quantify this.

We have stated that we do not emphasize assessment per se. Nevertheless, our imagery can be analyzed for density and abundance figures of visible animals and for certain group structure information. Detailed such analysis must follow Mr. Taylor's preliminary work. A sample of such data, compiled by Mr. Thomas J. Eley, Jr., from our photographic imagery, is presented in Table III.

2. Technological Data.

One of the foremost tasks facing any remote sensing project involves the acquisition of "signature". Walrus are fairly unique in their habitat in some ways, to the naked eye. Yet they may be easily confused with brown ice (multiyear or diatom-covered) or abandoned haulout areas, making counting and detection very difficult at times except at such close ranges that aircraft frighten them into the water.

First, we dismiss the utility of UV, so successful for polar bears and seals, (Lavigne and Øritsland, 1974a, 1974b) for the target species here, although we have not been able to give it a thorough test. Analysis of multispectral data from the NP-3 flights has revealed a walrus signature. Walrus groups appear as orange patches against dark green ice flows in the synthesized imagery. Haulout areas, visually nearly the same color as walrus, do not appear. This separation results from a color additive process. The synthesized image is formed when black and white negatives obtained from the multispectral scanner in the 560 $\pm$ 40 nm (yellow-green) band and the 1015 $\pm$ 90 (near IR) band are illuminated with red and green light respectively and then optically superimposed.

A second signature concerns infrared in the 8-14 nm band. We are now able to detect and measure walrus surface temperatures from 5000 ft. The results of sensing may be presented in a false color image. Each pixcel on the print approximates

7.5 ft square and over each the temperature is integrated. The temperature range covered by all the pixcels on the print is divided into 255 temperature levels. Since $2^8 = 256$, all heat levels can be uniquely represented by 8 binary digits or equivalently by combinations of 8 different colors. Computer analysis then allows not only the distribution of heat to be quantified, but also a total walrus area to be calculated. This represents not merely a potentially powerful assessment tool, but also a means for gathering thermoenergetics information as well.

Lastly, we have achieved an improvement in photographic proficiency through the combined use of synoptic or wide angle and slightly telephoto lenses operating on 2 cameras simultaneously (see Methods). We are now able to make some structural analyses of walrus herds, to identify belukha and bowheads, and to measure sizes of whales from altitudes somewhat in excess of 3000 ft. We are looking into enhancement and intensification processes for improvement in resolution. These results have not been achieved easily. The best cameras for the work are extremely expensive or not available (panoramic types). Aerial cameras must be retuned for low altitude work. Light levels do not permit the use of the finest grained film.

For all of the above, the identification of the best test frames and data samples by Mr. Taylor is a key to future improvement of results. Shortly, in mid-April 1976, we will have three CV-990 flights over the central Bering Sea. Our objective will specifically be to gather remote-sensing data, especially IR and photographic, which will yield distributional and group structure information and habitat correlation, and which will further develop the techniques briefly described here.

IV. Preliminary Interpretation of Results

We have operated under severe technological, financial, and operational constraints, but we are able to state the strong contrast between the potential and realized value of remote sensing. As remote sensing relies upon a comprehension of physics, its value is not nearly as well understood in the biological community as in the physical, meteorological and oceanographic sciences, with a few notable exceptions (cf. the work of the Canadians on remote sensing of marine mammals and that of Shapiro, Burns, and Fay on ice structure vis à vis seal distribution.)

One factor is clear; the visual, low altitude survey methods which currently dominate "assessment" are not satisfactory. The "principal of uncertainty" and such works as Miller and Botkin (1972) provide clear warnings that "gross estimates" and "order of magnitude" estimates, phrases which appear all too often in marine mammal assessment reports, form dangerous operational frameworks. Cost analysis is often brought into the argument for comparison of methods, but one must ask "what is the true cost of unreliable data?"

Previous work of two kinds may be cited to illustrate the evolution of our methods, first, on assessment of the sea ice habitat of marine mammals and, second, on the detection and enumeration of the animals themselves. This is done in order that we may contrast these methods with those of more traditional use.

One of the OCSEP goals is a classification of ice structure for data-logging purposes. Several workers have pointed out the difficulty of detecting the thickness, age, and structure of sea ice by any single method. A report of the Raytheon Company (1970) deals with the establishment of a data base for sea ice evolution, employing the integrated use of SLAR, infrared scanning, photography, laser profilometry, and, accurate navigational instrumentation. Fischer and Lathram (1973) point to the "unique synoptic perspective of the satellite" which "yields information either not readily identified, or not perceived at all by conventional methods." Kuhn, Stearns, and Ramseier (1975) demonstrate the power of infrared imagery in measurement of sea ice thickness. Campbell, Gloersen, Nordberg, and Wilheit (1974), in an analysis of sea ice, state that their study "illustrates how a variety of surface based, aircraft and satellite observations can be combined and jointly analysed to yield new findings which would not have resulted if the data were treated separately."

Perhaps it is this latter statement, more than any other which provides a <u>raison d'etre</u> for our methods -- a combination of sensors, used together, to describe a common goal,namely the description of the dynamics of marine mammals of the seasonally ice-covered Alaskan seas with relation to their sea ice habitat. Siniff and Kuechle (1974) state our conclusion: "Clearly, space technology could aid greatly in the evaluation of the Antarctic biological resource." We believe this to be true for the Arctic as well. Clearly, evaluation of ice habitat is essential in all studies of associated marine organisms. The above statements tell us that <u>it is impossible to evaluate ice habitat other than by integrated ground-to-satellite means</u>. Gross visual accounts are likely to introduce both inaccurate and misleading data, no matter how simple the classification scheme.

Sensing of animals within habitat demands: (1) higher resolution and (2) a signature which differentiates animals from their background. Heyland (1974) has used visual spectrum photography to great success on belukha. Lavigne and Oritsland (1974b) turn to ultraviolet to differentiate polar bears. We turn to infrared to detect walrus from their background (Ray and Wartzok, 1974). These latter spectra can be used to sense animal presence far more successfully than the human eye, but it is essential to note that methods are highly species-specific. These methods are new, but not unproven. They are in marked contrast to traditional methods which cannot provide data suited to the demand of assessment of environmental impact on an ecological basis.

In conclusion, it is abundantly clear that older methods need amplification in new directions, but it is not yet certain what the extent and direction of that amplification might be. Remote sensing surely provides one direction, but the synoptic view provided cannot solve the problem of proportion of animals visible. That proportion will probably best be discovered through a combination of radio tracking and detailed *in situ* behavioral and natural history studies. If the walrus turns out to be an "indicator" or "keystone" species, as we suspect it will, the importance of detecting its numbers and movements in a highly accurate fashion cannot be overestimated.

Thus, while it is too early in our project to make a critical evaluation or interpretation of results, we do believe that the sample results given above provide an encouraging basis for further work.

V. Problems Encountered/Recommended Changes.

A severe constraint has been the decision, made early in this program, to give little support to R and D efforts such as this one. New goals require new methods, most often, yet remote sensing of animals receives little attention from user agencies, with the result that NASA has devoted a minimum of support to efforts such as those outlined in their Wildlife Monitoring Program Plan (NASA, 1974).

Further problems involve instrumentation, insufficient funds and manpower for analysis, the time-consuming and costly nature of the work at present, and certain difficulties in integration of the efforts of all those with similar tasks to devote attention to certain key species and areas. Further, the technological counterpart to remote sensing, namely radio tracking, is receiving no encouragement at all under this program. This is in spite of the fact that it is the only known way to achieve a continuous record of marine mammal movements in the hostile (to us) Beringean region.

The best solution would appear to be a further commitment of OCSEP to this sort of work and interchange of task questions and methodology between workers. When this interchange occurs, a great deal of information on problem areas may be detailed and tasks specified to which these technologies are applicable and to which they are not.

Estimate of Funds Expended

	Allotted	Spent
Salary	$2,609.00	$1,143.75
Personal Benefits	391.00	171.56
Supplies	87.00	-
Duplicating	100.00	-
Services	1,200.00	4.16
Postoffice	30.00	-
Service Agreements	1,500.00	-
Travel	1,300.00	-
Equipment	1,100.00	1,319.00
Telephone	200.00	-
Computer charges	700.00	-
Costs (Indirect @ 31%)	2,783.00	817.93
Total -	$12,000.00	$3,456.40

Bibliography

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

Campbell, W.J., P. Gloersen, W. Nordberg, and T.T. Wilheit. 1974. Dynamics and morphology of Beaufort Sea ice determined from satellite, aircraft, and drifting stations. In: COSPAR Approaches To Earth Survey Problems Through Use of Space Techniques. Eds. P. Bock, F.W.G. Baker, and S. Ruttenberg. Akademie-Verlag, Berlin: 311-327.

Fay, F.H. 1974. The role of ice in the ecology of marine mammals of the Bering Sea. In: Oceanography of the Bering Sea. Proc. Intl. Symp. Bering Sea Study, Hakodate, Japan. Eds. D.W. Hood and E.J. Kelly, Inst. Mar. Sci. Occas. Paper No. 2, Univ. of Alaska: 383-399.

Fay, F.H. and C. Ray. 1968. Influence of climate on the distribution of walruses, Odobenus rosmarus (Linnaeus). I. Evidence from thermoregulatory behavior. Zoologica 53:1-18

Fischer, W.A. and E.H. Lathram. 1973. Concealed structures in Arctic Alaska identified on ERTS-1 imagery. From Oil and Gas Journal, May 28, EROS Reprint 179:1-5.

Heyland, J.D. 1974. Aspects of the biology of beluga (Delphinapterus leucas Pallas)interpreted from vertical aerial photographs. Second Canadian Symposium on Remote Sensing, Univ. of Guelph, Guelph, Ontario. April 29 - May 1, 1974.

Kuhn, P.M., L.P. Stearns and R.O. Ramseier. 1975. Airborne Infrared Imagery of Arctic Sea Ice Thickness. NOAA Technical Report ERL 331-APCL34:1-19.

Lavigne, D.M. and N.A. Øritsland. 1974a. Ultraviolet photography: A new application for remote sensing of mammals. Can. J. Zool. 52:939-941.

Lavigne, D.M. and N.A. Øritsland. 1974b. Black polar bears. Nature 251:218-219.

Miller, R.S., G.S. Hochbaum, and D.B. Botkin. 1972. A simulation model for the management of sandhill cranes. Yale Univ. School of Forestry and Env. Studies Bull. 80: 1-49.

National Aeronautics and Space Administration Ames Research Center. 1974. Wildlife Monitoring Program Plan. Report of 1973 Santa Cruz Summer Study on Wildlife Resources Monitoring: 1-72.

Ray, C. and Francis H. Fay. 1968. Influence of climate on the distribution of walruses, Odobenus rosmarus (Linnaeus). II. Evidence from physiological characteristics. Zoologica 53:19-32

Ray, G.C. and D. Wartzok. 1974. Bering Sea Marine Mammal Experiment (BESMEX) Project Plan. NASA/Ames Research Center Document TM-X-62, 399. iv. + 52 pp.

Raytheon Co. 1970. Data Reduction of Sea Ice Records. Final Report Prepared for Dept. of Transportation, U.S. Coast Guard. DOT-CG-01-800-A.

Reed, R.J. and W.J. Campbell. 1960. Theory and observation of the drift of Ice Station Alpha. Final Report, Task Number N.R. 307-250. University of Washington, 255 pp.

Siniff, D.B. and V.B. Kuechle. 1974. Remote sensing of Antarctic biological resources: Vertebrates. In: COSPAR Approaches To Earth Survey Problems Through Use of Space Techniques. Eds. P. Bock, F.W.G. Baker, and S. Ruttenberg. Akademie-Verlag, Berlin: 65-74.

TABLE I

BESMEX Flight Schedule

Date	Flight #	Area	Coordinates	No. of Runs	Data Miles
8 Sept. 74	3	Beaufort Sea	73-14N 155-35 W; 71-00N 152-50 W; 70-20N 143-00W	17	120
9 Sept. 74	5	Arctic Ocean	74-55N 165-40W; 73-40 N 156-50W; 73-10 N 156-40W	9	112
20 Sept. 74	14	Beaufort Sea (Smith Bay)	71-20N 155-50W; 71-05N 152-20W; 70-57N 152-40W	14	54
20 Sept. 74	15	Chukchi Sea	73-40N 177-40W; 73-35N 176-40W	4	38
26 Sept. 74	20	Beaufort Sea	73-16 N 160-40W; 73-04N 159-50W; 73-00N 160-40W	2	8

Note: Coordinates outline <u>included area for sampling</u> and do not imply complete coverage of the area shown.

TABLE I

BESMEX Flight Schedule

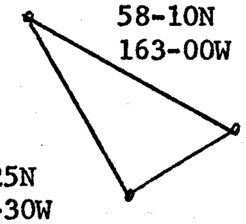
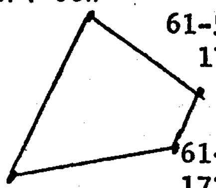
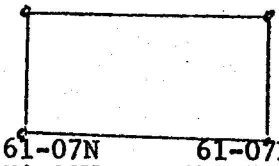
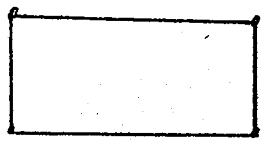
Date	Flight #	Area	Coordinates	No. of Runs	Data miles
5 Apr. 75	4	Western Bering Sea (Ice Edge)	 60-00N 173-30W 58-10N 163-00W 57-25N 168-30W	18	448
6 Apr. 75	5	Bering Sea	 63-00N 174-00W 61-58N 171-18W 61-00N 173-00W 60-36N 178-15W	8	648
7 Apr. 75	6	Bering Sea	 61-33N 174-02W 61-33N 172-55W 61-07N 174-02W 61-07N 172-55W	14	402
8 Apr. 75	7	Bering Sea	 61-33N 174-02W 61-33N 172-55W 61-07N 174-02W 61-07N 172-55W	10	300

TABLE I

BESMEX Flight Schedule

Date	Flight #	Area	Coordinates	No. of Runs	Data Miles
19 Aug. 75	5	Chukchi Sea	71-20N 168-00W; 70-30N 161-00W; 70-00N 169-00W	6	228
23 Aug. 75	7	Chukchi Sea (Barter Isl. → West)	72-14N 166-00W; 71-30N 167-20W; 70-40N 160-00W	19	438
24 Aug. 75	8	Chukchi Sea	71-03N 161-49W; 71-15N 160-25W; 70-33N 161-49W; 70-33N 160-49W	24	592
28 Aug. 75	10	Chukchi Sea (Ice line along North Coast Alas)	71-30N 169-00W; 70-08N 143-40W	3	160

TABLE I

BESMEX Flight Schedule

Date	Flight #	Area	Coordinates	No. of Runs	Data Miles
11 Oct. 75	4	Chukchi Sea (Caribou Run near Cape Seppings)	70-40N 167-50W; 70-40N 160-00W	--	~200
14 Oct. 75	5	Chukchi Sea (Caribou Run)	70-30N 171-30W; 70-40N 168-50W; 69-45N 171-30W; 69-50N 168-50W	(13)	~310
18 Oct. 75	7	St.Lawrence Island & Chukchi Sea	70-00N 171-30W; 69-10N 167-40W; 63-40N 170-40W (St. Lawrence Island)	--	~450
22 Oct. 75	9	Chukchi Sea	70-00N 169-30W; 69-43N 166-05W	--	~16
25 Oct. 75	11	Chukchi Sea & Bristol Bay	69-40N 170-00W; 68-50N 166-50W; ? 58-35N 160-35W; ? 58-35N 159-55W Bristol Bay	--	~210 (Chukchi Sea) ~130 (Bristol Bay) ~340
27 Oct. 75	13	Chukchi Sea	69-40N 170-00W; 69-30N 167-30W; 69-00N 170-00W; 69-00N 167-25W	(19)	~600

Note: Data on these flights are available, but analysis is not yet complete.

TABLE II

Comparison of Survey Times (hours)

	CV-990 (90° Field of View)	Visual Survey at 500 feet (120° Field of View)	
Speed	4.0 nmi/min 240 Kts/hr	2.5 nmi/min 150 Kts/hr	2.0 nmi/min 120 Kts/hr
Times in hours to cover 711 nmi^2	3.0[(a)]	16.6	20.8
Time in hours to cover 1185 nmi^2	3.0[(b)]	27.7	34.6

(a) CV-990 at 3000 ft.

(b) CV-990 at 5000 ft.

<u>Note</u>: 240 Kts/hr = CV-990 survey speed
150-120 " = speed of conventional survey aircraft

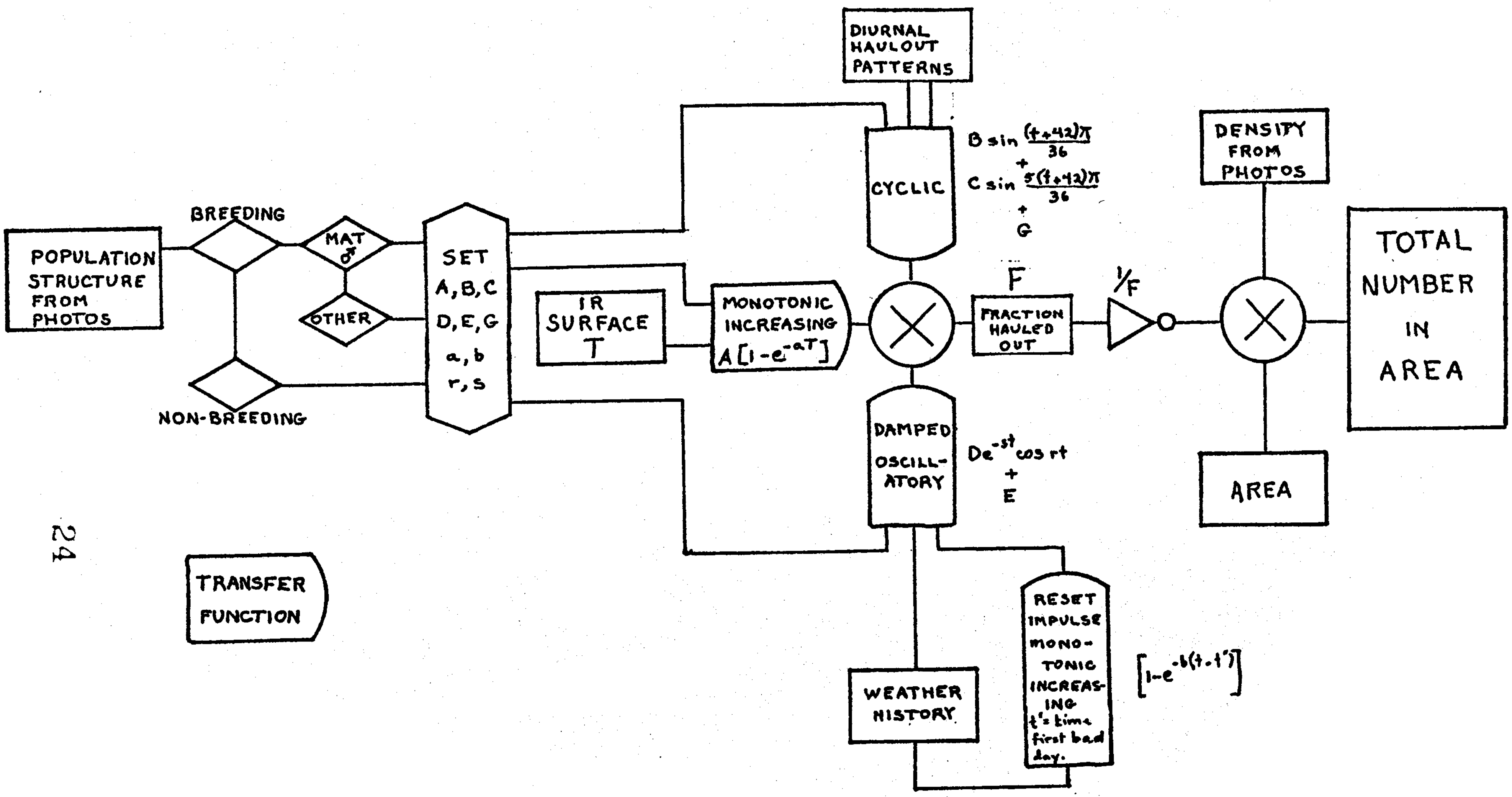
TABLE III

Densities of Marine Mammals Visible
Beaufort-Chukchi Sample Areas
From Aerial Photography

	Walrus 20 Sept. 1974	Bowhead 20 Sept. 1974	Belukha 8 Sept 1974
No. Detected	917	74	73 (58 adult: 15 young)
Survey Area	25 nmi^2	81 nmi^2	205 nmi^2 (1 x 205 nmi)
Density	36.7/nmi^2	0.91 nmi^2	0.36/nmi^2
Total Habitat	?	?	1860 nmi^2 (5 x 372 nmi)
Total Calculated Visible in Habitat	?	?	670 (530 adult: 140 young)

Note: for walrus and bowhead, all data a real, i.e. from film. Clumping prevents a calculation of total habitat area. For belukha, animals appear dispersed, in this case through a band of ice edge 5 nmi wide. The area sampled was 1x205 nmi in extent.

FIG. 1 MODEL FOR PROPORTION OF WALRUS HAULED OUT (WINTER)



APPENDIX I

ATTACHMENT 1

LIST OF CV-990 EXPERIMENTS - 1975 ARCTIC EXPERIMENT PROGRAM - PHASE II

INSTRUMENTATION	EXPERIMENTER	MEASUREMENT
Primary Sensors		
1. 19.35-GHz (1.55-cm) Imaging Microwave Radiometer; Beam Width (BW) = 2.85° x 2.85° (±50° Nadir Scanning)	Dr. Per Gloersen Dr. Thomas T. Wilheit NASA-GSFC	Size and distribution of multiyear ice, first-year ice, and mixtures. Microwave emissivities of various forms of ice and sea state.
2. Two Imaging Radar Systems:		
A. L-Band, 25-cm (1215-MHz); 3 dB BW = 18°; Elevation BW = 90°; Range & Azimuth Resolution = 15 meters (45° Right Side Nadir Viewing)	Mr. Walter E. Brown, Jr. Dr. Charles Elachi JPL	Measures ice cover and sea ice thickness, ice field patterns, ocean wave patterns, and sea surface roughness.
B. VHF, 200-cm (150-MHz); 3 dB BW = 20°; Elevation BW = 180°; Range & Azimuth Resolution = 15 meters (Right Side Nadir Viewing)	Mr. Walter E. Brown, Jr. Dr. Charles Elachi JPL	Measures ice cover and sea ice thickness, ice field patterns, ocean wave patterns, and sea surface roughness.
3. Infrared Radiometers:		
A. TI/RS-310H Infrared Imager; Dual Detectors: 1 x 1 mr and 5 x 5 mr Spatial Resolution (±45° Lateral Nadir Scanning)	Dr. Peter M. Kuhn NOAA-APCL	Temperature maps of sea ice fields and ocean surfaces. Detection of walrus on sea ice cover.
B. IR Surface (IRS) Radiometer (Barnes 14-325); FOV = 2° (Nadir Viewing)	Dr. Peter M. Kuhn NOAA-APCL	Measures the surface IR temperature in the atmospheric window spectral band 9.5 to 11.5 μm.

ATTACHMENT 1

INSTRUMENTATION	EXPERIMENTER	MEASUREMENT
4. Three Camera Systems:		
A. (For BESMEX Flights) RC-8 Camera, 9-in Film, 6-in Lens; FOV = 73° x 73° (Nadir Viewing)	Mr. Bernardo G. Ponseggi NASA-ARC	Photography of sea ice, sea state, and mammals.
B. (For AIDJEX Flights) RC-9 Camera, 9-in Film, 3.5-in Lens; FOV = 104° x 104° (Nadir Viewing)	Dr. William J. Campbell USGS Mr. Bernardo G. Ponseggi NASA-ARC	Photography of sea ice and continental ice field patterns.
C. KS-87B Camera, 5-in Film, 12-in Lens Cone; FOV = 21° x 21° (Nadir Viewing)	Mr. Bernardo G. Ponseggi NASA-ARC	High-resolution photography of sea ice and mammals.
D. Hasselblad Camera, 70-mm Film, 105-mm Sonar Quartz Lens; FOV ∿ 31° x 31° (Nadir Viewing)	Mr. Bernardo G. Ponseggi NASA-ARC	UV photography for the detection of mammals (polar bears and seal pups) located on sea ice and snow fields.
Secondary Sensors		
1. Atmospheric Gas Sensors:		
A. Chemiluminescent NO Detector	Mr. Gregory M. Reck NASA-LeRC	Nitrogen oxide (NO).
B. Ultraviolet Absorption Ozone Detector	Mr. Gregory M. Reck NASA-LeRC	Ozone (O_3).
C. Aluminum Oxide Hygrometer (Al_2O_3)	Mr. Gregory M. Reck	Water Vapor (H_2O).

INSTRUMENTATION	EXPERIMENTER	MEASUREMENT
1. Atmospheric Gas Sensors: (continued)		
D. Light Scattering Particle Counter	Mr. Gregory M. Reck NASA-LeRC	Aerosol number density and size Distribution.
E. Condensation Nuclei Counter	Mr. Gregory M. Reck NASA-LeRC	Concentration of condensation nuclei.
F. Negative Filtering Non-dispersive Infrared Monitor	Mr. Gregory M. Reck NASA-LeRC	Nitrous oxide (N_2O).
G. Sampling Bottles	Mr. Gregory M. Reck NASA-LeRC	Halocarbon (Freon) analysis.
H. Carbon Monoxide Detector	Mr. Gregory M. Reck NASA-LeRC	Concentration of carbon monoxide (CO).

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Supporting Systems

1. Inertial Navigation System (LTN-51)	Aircraft System NASA-ARC	Provides wind speed and direction, position, true heading, attitude, and ground speed.
2. Central Air Data System	Aircraft System NASA-ARC	Provides static air temperature, pressure altitude, and true air speed.
3. Radar Altimeter (APN-159)	Aircraft System NASA-ARC	Provides above-terrain altitude.
4. Time Code Generator and Signal Distribution System	Aircraft System NASA-ARC	Provides UT time correlation, time signals, and pulses.
5. Airborne Digital Data Acquisition System and Closed-Circuit TV Display	Mr. Earl V. Petersen NASA-ARC Mr. Stephen Nelson Informatics	Records and displays aircraft flight, navigation, and experimenters' data.

APPENDIX II

A COMPARISON OF THE ACCURACY AND PRECISION OF VISUAL AND PHOTOGRAPHIC AERIAL CENSUSES OF ICE-INHABITING MARINE MAMMALS: RESULTS OF A SIMULATED FLIGHT

By

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As presented by D. Wartzok at the Workshop on Remote Sensing of Wildlife, organized by the Quebec Department of Tourism, Game and Fish, Quebec, Canada, 17-20 November 1975.

BACKGROUND

One of the important functions of remote sensing in wildlife studies is the hard data it provides of the animals and their habitat. These can be studied in much greater detail and at more leisure than is usually available in the field. These hard data are in sharp contrast to visually acquired data of which the only record is the notes of the observer. The information contained in remote sensing is certainly not the same as the information available to the investigator on a real time basis in the field. In some ways there is additional information content, but in other ways there is less since the data are usually acquired at one instant in time so that dynamic aspects are lost. It is incumbent on those doing assessments of wildlife to be fully aware of the sources of error and variances in the methods employed and to attempt to correct for them when possible.

In this paper, we present an analysis of the use of aerial photography in censusing, considering first some of the biases it removes and then comparing the counts obtained from photographs with those obtained in a simulated censusing flight. A great deal of effort has been devoted by investigators and theoreticians to determine the best survey design, sampling frequency, degree of stratification, and coordinate statistical analyses to minimize the standard error of census estimates. These efforts have resulted in greatly increased precision in estimates for a given effort or amount of aircraft time. Precision, implying repeatability of estimates for the same population, is of course only a part of the problem and is not the same as accuracy, which measures how closely the estimate corresponds to the true number of animals in the population. For example, all of these sampling protocols assume that there is no observational bias--that all the visible animals within the sampled area have been counted. Sufficient attention has not been paid to a variety of mechanical, psychophysical, psychological, and natural history considerations which influence the proportion of animals which are detectable in a sampled area.

Some of the factors which influence what has been called the "countability" of animals (and therefore census accuracy) include physical obstructions such as trees and rocks and, of prime concern for our interests, ice and water. Animals in the water are hard to detect. Depending on the subject/background contrast and water clarity we can see or sense them only a small distance below the surface. Walruses can be counted with confidence only when they are hauled out on the ice. There are a variety of environmental, social, and temporal factors which influence whether the animals are hauled out. Without knowledge about the interplay between environment, behavior and physiology of the animals we will never be able to obtain an accurate census regardless of the sophistication of either the survey technique or the sensors on board the aircraft. Remote sensing, in and of itself, is not going to remove these problems, but it can serve greatly to increase precision which, at present, remains a significant part of the census problem. For example, the walrus population estimate obtained by Kenyon (1972) was 124,000 ± 39,000. The range was derived under the assumption that all animals on the survey strips were counted. When countability variances arising from the natural history and behavior of the animals are included, the need for both more accurate and more precise censusing techniques becomes apparent.

SOME SOURCES OF BIAS

Mechanical

These biases occur in both visual censusing and in remote sensing and include height error, bank error and heading and drift error. Changes in elevation of the aircraft result in changes in the sample strip width, whether measured simply by sighting between marks delimiting a known angle on an aircraft or when making counts from aerial photographs. According to Pennycuick (1969) height errors over uneven terrain can be as much as 50%. We have experienced changes in height of up to 10% by NASA's Convair 990 over open water or ice. Even 10% is an important source of bias and this may be expected to increase with decreased flight altitude. Removal of such bias is relatively easy when using remote sensing and an aircraft such as the CV-990,since photography may be correlated with a computer printout updated every 10 sec. which gives the time, pressure and radar altimeter readings, the location, speed, heading, pitch, and roll of the aircraft. Such data yield quantifiable correction factors.

Pitch and roll contribute analogous biases of varying degrees in estimating the sampled area. With a nadir viewing camera the expected value of these errors will be zero and so they may not introduce any bias. However, for a camera which has an oblique view, such errors will introduce a positive bias in population density estimates as the included area will be greater than that calculated for a given altitude. Lateral drift in response to crosswinds can result in adjacent transects overlapping too much or leaving too large a gap between them. In the process of correcting for drift, heading errors are introduced which are important if the orientation of the animals is being studied. Again all the necessary data for correcting for these errors are contained in the computer printout.

Illumination

An important psychological consideration influencing the countability of animals is the various conditions of illumination. In discriminating an animal from its surroundings we rely on a number of characteristics of light. The important ones are (Graham and Bell, 1969): 1) color contrast both within the outline of the animal and between the animal and its background; 2) the total illumination which affects both contrast and resolution; 3) the relative illumination or the extent to which the animal is illuminated relative to its background; and 4) shadowing. All of these characteristics are also important when considering identifying animals on visual photographs. The need for adequate illumination and exposure requires no elaboration but it is important to emphasize the importance in most instances of color photography. We find it necessary to use color photographs to distinguish walrus from the feces-covered ice constituting their hauling out areas. We have also had much better success counting white belukha whales on color photographs than on black and white ones. Leatherwood and Evans at the Naval Undersea Center in San Diego have also arrived at a similar conclusion relative to the necessity for using color photography for aerial censusing of propoises (personal communication).

Nadir viewing cameras have an advantage under conditions of oblique illumination over either obliquely aimed cameras or human observers who are confined to one side of the aircraft. If the observer of the obliquely viewing camera is on the same side of the animal as the light source, the lateral surface of the animal is receiving the maximum illumination while the background is receiving less. Thus, the animal is highlighted against its background. If the observer is on the opposite side of the animal as the light source, the lateral surface of the animal is illuminated only by diffuse light and the background is reflecting the direct rays of the sun.

Detection and Time

There are many occasions when animals potentially visible to an observer go unrecorded. One of these occasions is when single animals are widely scattered. Under these conditions, detection is enhanced by simultaneous use of an infrared scanner or other such device that gives a non-ambiguous "signature". The reverse situation occurs when there are so many animals visible that there is not enough time to count them. Graham and Bell (1969) have estimated that the average observer can maintain a counting rate of a maximum of 3 animals per second during a flight. Under ideal conditions, counting from photographs, skilled observers were unable to maintain counting rates exceeding 0.8 per second over an eight hour day. Certainly, aerial photographs have a major role to play in counts of species which tend to occur in groups, such as walruses, since the groups can be photographed and then counted at leisure at a later time.

Caughley (1974) discusses several lines of evidence which show that, indeed, time available for counting is the major factor influencing accuracy of counts of observable animals. Using Eberhardt's (1968) simplest sightability model, he shows that when sightability decreases linearly with distance, the regression of apparent density on strip width is also linear. He then shows that this model fits the data from eight years of elephant censuses using different strip widths in different years. If the dominant determinant of sightability were preceived size, we would expect sightability to vary inversely with the square of the distance, or considering the complexities of visual physiology, to at least approximate this relationship. This is not found. However, when the strip width is doubled, the time available for viewing a given area is halved. This would indeed generate a linear regression of sightability on strip width. Additional evidence that time and not distance is the important parameter comes from a study by Pennycuick and Western (1972) in which they demonstrated that approximately the same number of animals was counted on a strip whether its inner boundry was close to the plane or displaced 200m outward.

Psychological Factors

We have seen how aerial photography can remove biases arising from height, bank, drift and heading errors as well as allowing as much time as needed to make accurate counts. However, even on high quality photographs there may still be a problem in determining if a particular image is really an animal or not. The same indecision occurs, probably to an even greater degree, in visual surveys. Thus each individual has his own particular conservative or less restrained psychological viewpoint which can introduce a significant bias, the magnitude of which is difficult to state. Some insight into this was provided by the simulated flight test to be described shortly. In order to conduct this test we first had to determine the number of animals on our test slides. Assisted by T.J. Eley, Jr., we projected each slide onto a screen and examined each slide in detail until we agreed on the number of animals present. These counts were defined as the "correct" counts. Prior to the joint counting session, we had independently made counts of the animals on all the slides. We then used a model developed by Jolly (1969) to determine whether any of us had a significant bias.

Jolly argues that any bias is likely to be roughly proportional to the number of animals counted and therefore a reasonable model for bias is $y=Rx+e$, where y is the individual's count of a sample slide, x is the corresponding correct count, R is the ratio of the expected value of the individual's count to that of the true count and e is the random error in y. The expected value of e is zero. The expected value of a parameter is the average value it would have over a theoretically infinite number of similar counts. The bias in y can be expressed as a proportion of the correct count and is therefore, $\frac{E(y) - x}{x} = \frac{Rx - x}{x} = R-1$ where E(y) signifies the expected value of y. To estimate the bias, R must be estimated. In Jolly's model, a highly efficient estimator of R is the sample ratio (total counts by an individual): (total correct counts) taken over a random sample of the slides, that is, $R = \frac{\Sigma y}{\Sigma x} = \frac{\bar{y}}{\bar{x}}$. Jolly gives formulae for calculating the standard error of the estimate of R. To test whether there is evidence of bias, a "t" test can be used with $t = \frac{R - 1}{S.E.(R)}$. We did such a test and the result was that two of us had no significant bias in the counts from the photographs but one of us did have a bias significant at the .01 level. It turned out that this individual's bias was in favor of overestimating by 24% the number of animals on a given slide. It is important to realize that there can easily be bias factors in censuses, whether conducted by visual means or from aerial photographs. Care should be taken to determine what each counter's bias is and whether it is significant or not. Jolly also gives formulae for correcting counts for this form of bias once it has been recognized.

A SIMULATED CENSUSING FLIGHT

An analysis of inter-observer variability constitutes the remainder of this paper. For a simulated aerial survey we used aerial photographs taken during flights of NASA's NP-3 aircraft over the Chukchi Sea in September 1974. From 12.5x12.5cm and 23 x 23 cm color exposures we made up eighty 8.2 x 10.8 cm lantern slides. Forty of these slides were of walrus habitat; walrus were present on 20 in numbers of 1 to 196. Twenty other slides were of bowhead whale habitat and twenty were of belukha habitat. Half of each included whales in numbers of 1 to 11 for bowheads and 1 to 18 for belukha.

The slides were arranged to mimic an actual flight. First, it "travelled" over the scattered "edge" ice of walrus and belukha habitats, then through the murky inshore waters of bowhead whale habitat, then through more walrus - belukha habitat, etc. The slides were shown to a total of 29 individuals in six different sessions around the country on an opportunity basis.

For the test we wanted to mimic an actual survey flight so we took our parameters from Kenyon's (1972) walrus survey. He surveyed by flying in a Grumman goose at an elevation of 500 feet and at a speed of 140 knots. He felt that all animals within a one mile track width were counted.

In each session, the participants were seated so that the screen occupied 80-90 degrees of their field of view. In Kenyon's survey a 156 degree field of view was shared by two observers. Thus, in both cases the observer had to scan approximately the same angular field although in our test it was directly ahead of the observer while on the survey it was displaced laterally. Each slide was displayed for 10 seconds which is the time an observer would be able to observe a group of animals first seen when they were 78 degrees ahead of the aircraft until they were directly underneath when flying at a speed of 140 knots at 500 feet. The image size was approximately the same as if viewed during an aerial survey at 500 feet. In our test, the animals were displayed the entire 10 seconds as they would appear when directly under the aircraft. All of these conditions are more favorable than during an actual flight. On the other hand, there was no motion of either the animals or the observer relative to the animals. Such motion is often an aid in detection. Also the images were not as sharp as animals viewed through a good aircraft viewing port. Therefore, we have introduced both positive and negative biases, but we have no way of knowing if they come near cancelling each other out, nor can we state how accurately this test measures absolute performance in the field. The value in this test design is to indicate variances of counts between different observer categories and between different sizes of groups of animals. That is, the main emphasis is on intra-test variables and not on extrapolations from the test to the real world.

In order to prevent the participants from becoming keyed for each slide as would have happened if the slides were presented at definite intervals, the intervals between slides were varied on a random basis in 5 second steps between 5 seconds and 70 seconds with a mean of 35 sec. Thus with 10 sec of slide presentation and a mean 35 sec interval, the total session for the 80 slides lasted one hour. This is sufficient time to introduce the oft-stated variable of observer fatigue, as experienced during visual surveys. The same slide presentation sequence and the same interval sequence were used during each session. Variable screen sizes for different sessions around the country were compensated for by varying the viewing distance of the participants. The quality of screens and projectors were comparable in all cases except one in which the screen was of poor quality and there was also light reflection on the screen. Six individuals out of the 29 participants were involved in this one test which had sub-standard viewing conditions.

For analysis, participants were divided into four groups; 1) those experienced in observing walruses; 2) those experienced in observing whales; 3) pilots, and 4) novices. There were 5 in the first category, 4 in the second, 3 in the third, and 17 in the fourth. "Experienced" observers included indiviudals who had seen the species indicated from the air on numerous occasions; "novices" are whose who had seldom, if ever, done so. Pilots were separated out by virtue of their training in aerial observation. Among the novices only 15 attempted to count walrus because of difficulties in differentiating these animals from brown ice or habitat areas, and the counts of two novices of belukha were discarded since they were over an order of magnitude greater than those of all other novices. The latter probably results from difficulties in differentiating belukha from like-sized chunks of white sea ice.

Table I gives the numbers of false positive and false negative responses from the different observer categories for the different species. A false positive is when the animals were reported as being present when none were on the slide and a false negative is when animals were present on the slide but none were reported. For the walrus and bowhead whale there is an indication that the experienced observers are more conservative than the novices in that they reported animals present when they were not present only about half as often. However, the variances between observers were so great that only trends can be indicated. The differences are not statistically significant at the 0.05 level.

Table II shows the mean numbers of bowheads and belukhas for all slides. Again there is no significant difference between the values for the different categories of observers except for novices and pilots viewing bowhead whales. This arises since they represent two extremes in the number of animals seen with the pilots consistently overestimating and the novices consistently underestimating. The fact that there is no significant difference between the estimates of any of the observer categories and the correct count is not an indication of the accuracy of the counts but rather an indication of the imprecision in the counts.

In order to look at the data in a way which would better reflect the accuracy of the counts, we compared the mean value of the counts within each observer category on a given slide with the correct number of animals for that slide. If the difference was significant at the 0.05 level we assigned that slide a value of 1 and if the difference was not significant, we assigned that slide a value of 0. These values we have termed "S" values. We then determined the mean of the S values for the twenty slides of bowhead whale habitat for each observer category. Similar calculations were made for the belukhas and the walrus. (This is an ad hoc test without the support of statistical theory. We are in the process of working up these data under more formal procedures.)

The significances of the differences of the mean S values for the two cetacean species are shown in Table III. The significance of differences matrix shows the pairwise comparisons for all the observer categories with each other and with the correct value. These matrices are symmetric about the diagonal. We see that for both species all observer categories have significant differences from the correct. In general, the experienced whale observers had the least significant difference from the correct. Also for these two species of cetaceans, with the one exception already discussed, there was no significant difference in the ability of the different observer categories to count the animals.

We have the most information on the walrus slides since half of the session was dedicated to walrus. We also had a wide range of walrus group sizes. We were interested to see how the number of animals within a group affected the counting ability of individuals in the different categories. For the purposes of this test, a group was defined as all the animals which were on one slide and the clustering of the animals within the slide were considered to be subgroups.

Table IV shows the results of the means of the walrus counts. We see that in general there was a tendency to overestimate the numbers of animals present except for the pilots who were very conservative. Table V shows the significance of the differences in the means. Again we see that because of the large variances no clear pattern emerges other than that the pilots are significantly different from the other observer categories because of their substantial underestimates. Also the experienced walrus observers appear to do poorer in comparison to the whale observers and the novices when the group sizes are large. Again we have the problem of possible information on accuracy being swamped by large standard deviations. We can gain additional insight by again looking at the S values and the significance of differences in their means as we did in the case of the bowhead and the belukha. Table VI shows the results of these calculations.

Looking first at all group sizes we see a highly significant difference between the observed and the correct values for all observer categories. If we try to determine who is doing better by seeing which group of observers has the least significant difference from the correct, we see that experienced whale observers do better at counting walrus than experienced walrus observers. This holds true for all sizes of walrus groups and, indeed, for the largest size groups, novices appear to be at least as good or better than experienced walrus observers.

Another factor to be considered in addition to accuracy is the precision of the estimates. This can be investigated in two ways. One is to compare counts of the same slide when viewed on two different occasions. The second way is to look at the mean standard deviation of the estimates of different observer categories. Since the standard deviation usually increases with an increasing mean, the standard deviation of each slide for each observer category was calculated as a percentage of the mean. These percentages were then averaged for the different observer categories. The results of these calculations are shown in Table VII. The pilots are the most precise followed by the experienced whale observers. The novices are the least precise. The significances of the differences in the precision between the different observer categories are shown in Table VIII. The smaller the group size, the greater the significance of the difference in precision of the estimates between the experienced observers and pilots on the one hand and the novices on the other.

Let us return now to another way of determining precision of estimates, i.e., by comparing the estimates from two or more presentations of the same slide. Ten of the walrus slides were shown twice, being left-right reversed between showings. None of the participants reported noticing that they had seen the same slide twice. Table IX shows the comparison of the mean estimates for each observer category for the reversals. The second presentation was at a variable time later in the test. This test of precision showed no significant difference between the mean values for the first and second presentation of the slides in any animal group size. You will note that in almost every case the estimate increased the second time. Does this mean that there was a significant shift in the estimates as the session progressed? To investigate this point, the total test was divided into thirds and the means of the walrus estimates for each third determined. These means as a percentage of the total correct for each third of the test are shown in Table X. There was no significant increase in the estimates as the session progressed.

CONCLUSION

The results we obtained from this simulated flight test can be summarized as follows. First, the variance in the counts by all observers for all species and group sizes should be noted. For bowhead whales and belukhas, all observer categories showed siginifcant differences from the correct values with the experienced whale observers appearing to be slightly better but with no significant difference between the observer categories.

The experienced whale observers appeared to do better on the walrus slides also, although no group is very accurate and all groups except the pilots overestimated the numbers of animals present.

When we turn from the accuracy of the counts to the precision we find that the pilots were the most precise followed by the experienced walrus observers. Also the differences in precision are significant for small groups of walrus but not for large groups.

Finally, there was a general trend towards an increase in the numbers estimated during the course of the test, but there was no statistically significant change.

In conclusion, we may compare our results with those obtained in a somewhat similar study on moose censusing. This study was conducted in Alaska by LeResche and Rausch (1974). They flew observers over four one mile square, fenced areas within which were known numbers of moose. We would have preferred to do a test like this also since it is more directly tied to the real world than our test was, but it is impractical to fence in a walrus herd on a chunk of ice floating in the middle of the Bering Sea.

LeResche and Rausch found that observers with current experience were both more accurate and more precise than either novices or observers without current experience. Current experience was defined as a participant having flown a moose survey that year. There was really little difference between the observers without current experience and the novices. We are probably also seeing the effect of current experience in our test. The experienced whale observers appear to be the best with both whales and walrus. All of the experienced whale observers had current experience. Only three of the five experienced walrus observers had current experience. It appears that recent experience, even if it is on a different species, is of more value than experience sometime in the past on the species under study. Experience also seems to pay off most when the group size is small.

ACKNOWLEDGEMENT

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BIBLIOGRAPHY

Caughley, G. 1974. Bias in aerial survey. J. Wildl. Manage. 38:921-933.

Eberhardt, L.L. 1968. A preliminary analysis of line transects. J. Wildl. Manage. 32:82-88.

Graham, A. and R. Bell. 1969. Factors influencing the countablility of animals. E. African Agric. Forestry J. 34 (Special Issue):38-43.

Jolly, G.M. 1969. The treatment of errors in aerial counts of wildlife populations. E. African Agric.Forestry J. 34(Special Issue):50-55.

Kenyon, K.W. 1972. Aerial surveys on marine mammals in the Bering Sea, 6-16 April, 1972. U.S. Bureau of Sport Fisheries and Wildlife, Seattle, Washington ii+79 pp.

LeResche, R.E. and R.A. Rausch. 1974. Accuracy and precision of aerial moose censusing. J. Wildl. Manage. 38:175-182.

Pennycuick, C.J. 1969. Methods of using light aircraft in wildlife biology. E. African Agric. Forestry J. 34(Special Issue):24-29.

Pennycuick, C.J. and D. Western. 1972. An investigation of some sources of bias in aerial transect samplings of large mammal populations. E. African Wildl. J. 10:175-191.

TABLE I

MEAN NUMBER OF FALSE POSITIVE OR NEGATIVE RESPONSES

Observer Category	Walrus False Positive	Walrus False Negative	Bowhead False Positive	Bowhead False Negative	Belukha False Positive	Belukha False Negative
Experienced Walrus	4.4 ± 4.0 (1 - 10)*	4.0 ± 2.0 (1 - 6)	1.3 ± 2.0 (0 - 5)	0.5 ± 0.8 (0 - 2)	3.2 ± 3.1 (0 - 9)	1.5 ± 0.8 (0 - 2)
Experienced Whale	3.3 ± 3.8 (0 - 7)	4.0 ± 2.9 (0 - 7)	1.4 ± 1.5 (0 - 3)	2.8 ± 2.6 (0 - 6)	4.2 ± 4.2 (1 - 10)	1.2 ± 0.8 (0 - 2)
Pilots	5.0 ± 1.0 (4 - 6)	3.0 ± 0 (3 - 3)	4.7 ± 4.2 (0 - 8)	0 ± 0 (0 -0)	3.0 ± 1.7 (2 - 5)	1.3 ± 0.6 (1 - 2)
Novices	8.0 ± 3.1 (3 - 15)	3.9 ± 2.1 (1 - 9)	3.8 ± 3.0 (0 - 11)	2.2 ± 1.8 (0 - 6)	4.4 ± 3.6 (0 - 14)	1.5 ± 1.4 (0 - 4)

*Range

None of the differences are significant at the 0.05 level

TABLE II

MEAN NUMBERS OF ANIMALS OBSERVED

Observer Category	Bowhead Whales	Belukha
Experienced Walrus	2.3 ± 2.4 (0 - 11)*	2.1 ± 4.0 (0 - 22)
Experienced Whale	2.0 ± 2.2 (0 - 8)	2.7 ± 4.0 (0 - 60)
Pilots	3.1 ± 2.8 (0 - 20)	2.0 ± 3.5 (0 - 17)
Novices	1.4 ± 1.9 (0 - 14)	1.8 ± 3.5 (0 - 100)
All observers	2.1 ± 2.3 (0 - 20)	2.1 ± 3.7 (0 - 100)
Correct Count	2.5 ± 2.9 (0- 11)	2.6 ± 4.5 (0 - 18)

* Range

None of the differences are significant at the 0.05 level except for pilots vs novices counting bowhead whales ($p = .015$)

TABLE III

SIGNIFICANCE OF DIFFERENCES IN MEANS OF "S" VALUES

BOWHEADS

	Exp. Walrus	Exp. Whale	Pilots	Novices	Correct
Exp. Walrus	-	NS	NS	NS	.0042
Exp. Whale	NS	-	NS	NS	.0125
Pilots	NS	NS	-	.0376	.0308
Novices	NS	NS	.0376	-	<.0001
Correct	.0042	.0125	.0308	<.0001	-

BELUKHAS

	Exp. Walrus	Exp. Whale	Pilots	Novices	Correct
Exp. Walrus	-	NS	NS	NS	.0020
Exp. Whale	NS	-	NS	NS	.0394
Pilots	NS	NS	-	NS	.0052
Novices	NS	NS	NS	-	<.0001
Correct	.0020	.0394	.0052	<.0001	-

TABLE IV

MEANS OF WALRUS COUNTS

Observer Category	All Group Sizes	Groups of 0-25 Animals	Groups of 26-75 Animals	Groups of 76-200 Animals
Experienced Walrus	54.2 ± 89.0 (0 - 800)*	6.2 ± 9.0 (0 - 150)	77.6 ± 75.5 (0 - 300)	222.7 ± 73.4 (40 - 800)
Experienced Whale	51.8 ± 89.4 (0 - 1000)	17.8 ± 38.7 (0 - 400)	72.5 ± 108.8 (0 - 1000)	188.3 ± 111.3 (0 - 1000)
Pilots	12.4 ± 21.9 (0 - 85)	2.7 ± 3.7 (0 - 30)	15.8 ± 9.7 (4 - 55)	48.0 ± 38.8 (15 - 85)
Novices	37.2 ± 58.4 (0 - 2000)	12.3 ± 25.3 (0 - 2000)	66.5 ± 49.8 (0 - 600)	151.2 ± 67.1 (0 - 1000)
All Observers	38.4 ± 71.2 (0 - 2000)	10.2 ± 24.6 (0 - 2000)	58.1 ± 71.9 (0 - 1000)	152.6 ± 98.2 (0 - 1000)
Correct Count	32.1 ± 52.0 (0 - 196)	3.0 ± 6.3 (0 - 21)	43.0 ± 12.5 (34 - 63)	138.3 ± 45.5 (100- 196)

* Range

TABLE V

SIGNIFICANCE OF DIFFERENCES IN MEANS OF WALRUS COUNTS

ALL GROUP SIZES

	Exp. Walrus	Exp. Whale	Pilots	Novices	Correct
Exp. Walrus	-	NS	.0042	NS	NS
Exp. Whale	NS	-	.0048	NS	NS
Pilots	.0042	.0048	-	.0048	.0272
Novices	NS	NS	.0048	-	NS
Correct	NS	NS	.0272	NS	-

GROUPS OF 0 - 25 ANIMALS

	Exp. Walrus	Exp. Whale	Pilots	Novices	Correct
Exp. Walrus	-	NS	NS	NS	NS
Exp. Whale	NS	-	.0366	NS	.0434
Pilots	NS	.0366	-	NS	.0324
Novices	NS	NS	.0232	-	NS
Correct	NS	.0434	NS	.0324	-

GROUPS OF 26 - 75 ANIMALS

	Exp. Walrus	Exp. Whale	Pilots	Novices	Correct
Exp. Walrus	-	NS	.0214	NS	NS
Exp. Whale	NS	-	NS	NS	NS
Pilots	.0214	NS	-	.0048	<.0001
Novices	NS	NS	.0048	-	NS
Correct	NS	NS	<.0001	NS	-

GROUPS OF 76 - 200 ANIMALS

	Exp. Walrus	Exp. Whale	Pilots	Novices	Correct
Exp. Walrus	-	NS	<.0001	NS	.0164
Exp. Whale	NS	-	.0036	NS	NS
Pilots	<.0001	.0036	-	.0012	<.0001
Novices	NS	NS	.0012	-	NS
Correct	.0164	NS	<.0001	NS	-

TABLE VI

SIGNIFICANCE OF DIFFERENCES IN MEANS OF "S" VALUES

ALL GROUP SIZES

	Exp. Walrus	Exp. Whale	Pilots	Novices	Correct
Exp. Walrus	-	.0050	NS	NS	<.0001
Exp. Whale	.0050	-	.0002	.0384	.0182
Pilots	NS	.0002	-	NS	<.0001
Novices	NS	.0384	NS	-	<.0001
Correct	<.0001	.0182	<.0001	<.0001	-

GROUPS OF 0 - 25 ANIMALS

	Exp. Walrus	Exp. Whale	Pilots	Novices	Correct
Exp. Walrus	-	NS	NS	NS	.0060
Exp. Whale	NS	-	NS	.0488	NS
Pilots	NS	NS	-	NS	.0056
Novices	NS	.0488	NS	-	.0006
Correct	.0060	NS	.0056	.0006	-

GROUPS OF 26-75 ANIMALS

	Exp. Walrus	Exp. Whale	Pilots	Novices	Correct
Exp. Walrus	-	NS	NS	NS	.0006
Exp. Whale	NS	-	.0020	NS	NS
Pilots	NS	.0020	-	NS	<.0001
Novices	NS	NS	NS	-	.0076
Correct	.0006	NS	<.0001	.0076	-

GROUPS OF 76-200 ANIMALS

	Exp. Walrus	Exp. Whale	Pilots	Novices	Correct
Exp. Walrus	-	NS	NS	NS	.0258
Exp. Whale	NS	-	.0052	NS	NS
Pilots	NS	.0052	-	NS	<.0001
Novices	NS	NS	NS	-	NS
Correct	.0258	NS	<.0001	NS	-

TABLE VII

PRECISION OF WALRUS COUNTS
means of
(standard deviation as percentage of mean)

Observer Category	All Group Sizes	Groups of 0-25 Animals	Groups of 26-75 Animals	Groups of 75-200 Animals
Experienced Walrus	113 ± 57	143 ± 52	79 ± 34	68 ± 43
Experienced Whale	145 ± 45	160 ± 42	114 ± 49	132 ± 24
Pilots	101 ± 57	133 ± 60	60 ± 23	77 ± 30
Novices	212 ± 119	263 ± 112	103 ± 23	96 ± 23
All Observers	153 ± 94	192 ± 98	90 ± 39	93 ± 39

TABLE VIII

SIGNIFICANCE OF DIFFERENCES IN PRECISION OF WALRUS COUNTS

ALL GROUP SIZES

	Exp. Walrus	Exp. Whale	Pilots	Novices
Exp. Walrus	-	.0114	NS	<.0001
Exp. Whale	.0114	-	.0008	.0004
Pilots	NS	.0008	-	<.0001
Novices	<.0001	.0004	<.0001	-

GROUPS OF 0 - 25 ANIMALS

	Exp. Walrus	Exp. Whale	Pilots	Novices
Exp. Walrus	-	NS	NS	<.0001
Exp. Whale	NS	-	NS	<.0001
Pilots	NS	NS	-	<.0001
Novices	<.0001	<.0001	<.0001	-

GROUPS OF 26 - 75 ANIMALS

	Exp. Walrus	Exp. Whale	Pilots	Novices
Exp. Walrus	-	.0970	NS	.0990
Exp. Whale	.0970	-	.0048	NS
Pilots	NS	.0048	-	.0002
Novices	.0990	NS	.0002	-

GROUPS OF 76 - 200 ANIMALS

	Exp. Walrus	Exp. Whale	Pilots	Novices
Exp. Walrus	-	.0014	NS	NS
Exp. Whale	.0004	-	.0004	.0080
Pilots	NS	.0004	-	NS
Novices	NS	.0080	NS	-

TABLE IX

WALRUS REVERSALS
Means

Observer Category	All Group Sizes			Groups of 0-25 Animals			Groups of 26-75 Animals			Groups of 76-200 Animals		
	1	2	Sig.	1	2	Sig.	1	2	Sig	1	2	Sig.
Experienced Walrus	80.3±51.1	114.4± 34.7	NS	11.5±6.5	24.8±27.9	NS	53.2±36.7	72.4±27.7	NS	185.3±137.3	206±92.3	NS
Experienced Whale	89.5±71.1	129.0±126.9	NS	23.9±23.2	16.9±13.1	NS	49.6±19.9	72.7±43.2	NS	207.5±228.7	312.9±363.3	N
Pilots	21.8±6.8	23.7±5.1	NS	3.4±1.3	5.2±0.9	.044	18.3±1.3	17.2±5.9	NS	45.0±23.6	50.9±9.4	NS
Novices	67.8±40.7	102.1±87.2	NS	20.0±23.8	17.3±19.1	NS	54.1±25.6	86.5±69.2	NS	134.6±79.6	207.6±197.5	N
All Observers	68.2±47.7	99.4±83.3	NS	16.9±20.0	17.3±19.1	NS	48.9±27.1	73.1±57.0	.055	145.6±123.3	216.1±207.0	N

TABLE X

Trends in Walrus Counts During Test
Mean totals as percentage of correct

Observer Category	First 1/3 (I)	Second 1/3 (II)	Third 1/3 (III)	Significance of Difference I-II	II-III	I-III
Experienced Walrus	156 ± 272	185 ± 280	227 ± 419	NS	NS	NS
Experienced Whale	166 ± 312	140 ± 250	298 ± 527	NS	NS	NS
Pilots	33 ± 46	46 ± 85	44 ± 54	NS	NS	NS
Novices	120 ± 179	142 ± 200	293 ± 303	NS	NS	NS
All Observers	119 ± 226	128 ± 218	216 ± 372	NS	NS	NS

APPENDIX III

SYNERGISTIC REMOTE SENSING OF WALRUS AND WALRUS HABITAT

By

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As presented by G.C. Ray at the Workshop on Remote Sensing of Wildlife, organized by the Quebec Department of Tourism, Game and Fish, Quebec, Canada, 17-20 November 1975.

And

As presented by D. Wartzok at the First Annual Conference on the Biology and Conservation of Marine Mammals, University of California, Santa Cruz, California, 4-7 December 1975.

Visual surveys are currently the most widely used method of censusing marine mammal populations, but are generally recognized as unsatisfactory. Indeed, a recent walrus survey report noted that only "orders of magnitude" population estimates are possible by that method. Another report on walrus stated: "survey data provide a poor basis from which to estimate... the number in the area surveyed."

The variances in visual estimates are very high. In a recent simulated aerial survey we conducted using photographs of walrus, bowhead whales, and belukha whales, the standard deviations of the estimates were 100-150 percent of the means for novices as well as experienced observers. Work by Caughley and others has shown that aerial survey data fit a linear sightability model which suggests that one important factor in detecting animals is the length of time one has to count the animals. Graham and Bell have estimated that the maximum rate at which animals can be counted is 3 per second. Since many species of marine mammals tend to aggregate in large herds, they are routinely encountered at rates far in excess of this figure and so group size becomes a dominant factor. Aerial photography which allows as much time as necessary to make the counts from a permanent record removes these important variances involved in the sightability of animals.

So far we have referred to individuals which are visible, although some are almost invariably overlooked on a visual survey. However, these animals can be detected and counted on high resolution photographs. Nevertheless there are other reasons why animals present in the surveyed area may not be detected. The most important consideration involves the proportion of individuals that are at the surface at any given time where they may be seen versus those underwater and thus not visible by any means. In reference to walrus in particular, the only time one can obtain accurate estimates of their numbers is when they are hauled out on the ice. Their hauling-out behavior is influenced by a variety of factors including circadian rhythms, social behavior, and environmental conditions. Thus, a detailed knowledge of natural history is mandatory in assessment. We are attempting to look at these variables which have been almost totally ignored in previous walrus surveys.

Circadian rhythms can probably best be studied by using radio telemetry. However, much information on the influence of environmental conditions on hauling-out behavior is susceptible to remote-sensing techniques, by employing a multispectral approach. In particular, we have found a combination of visual-spectrum photography and infrared imaging a useful approach. The potential of infrared imagery, in the 10-12 micrometer wavelength band, in the study of wildlife populations has received much attention in the past few years. For many applications the results have been disappointing. The reason for this is that a majority of animals have evolved rather effective methods of minimizing the temperature differential between their surfaces and the environment, resulting in very little thermal contrast with their background. However, the walrus has sparse hair and presents a striking thermal contrast with ice under a variety of environmental conditions, so striking in fact that detection is better by IR than by visual means. Further, repeated careful counts from visual photographs of groups of walruses under a variety of environmental conditions can be correlated with surface temperatures of the animals hauled out; possibly resulting in a model which will aid in predicting the percentage of animals which will be hauled out. Such a model will require intensified long-term research for validation.

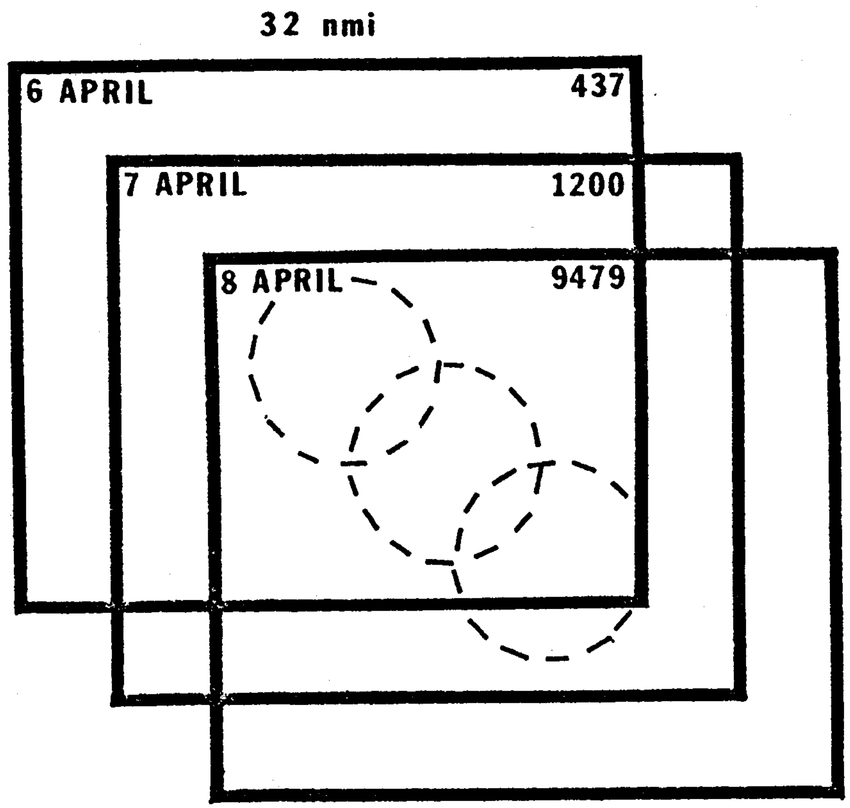
We would also like to point out another important benefit from the simultaneous use of several different types of sensors. Walruses exhibit marked aggregation behavior. This behavior introduces problems for obtaining accurate estimates of the population. We can see intuitively, as more formal statistical approaches verify, that the greater this aggregation behavior is, the greater the proportion of the habitat which must be sampled in order to obtain a population estimate with a given coefficient of variance. The best approach to this problem is better to define the habitat of the walrus so that the total area to be surveyed may be minimized. Accordingly, we are attempting to correlate walrus presence in an area with certain characteristics of a major component of their habitat, namely the sea ice in that area. A variety of sensors is applicable here. First, we usually fly with two visual cameras, one a 9" camera with a 6" lens giving a wide-angle view and the other a 5" camera with a 12" lens giving a telephoto view down the center. The combined use of these cameras gives wide cover and detailed visual spectrum images of walruses and their habitat. The same infrared scanner used to detect walruses and to map their surface temperatures can also provide information on the thickness of the ice in areas of walrus concentration. L-band imaging radar in the sidelooking format can provide information on the surface characteristics of the ice. Imaging microwave, particularly in the 19 GHz band, can be used to distinguish between different types and ages of ice. In addition to the infrared scanner, one or two imaging radars and one or more imaging microwave radiometers, we sometimes have aboard a laser profilometer which can give a detailed profile of the ice surface directly beneath the aircraft. Lastly, the on-board inertial navigation and computer systems provide both a television display and a hard copy printout of pressure and radar altitude, pitch, roll, heading and location among other parameters. This information allows us accurately to determine the footprint area of each photograph, thus removing substantial biases due to height, bank, and heading errors which occur even with good photography if such information is not available. All of these devices, used together, build knowledge of walrus natural history and habitat obtainable in no other way. Eventually, they may introduce a new level of accuracy into assessment.

How are we able to look at the animals and their habitats in so many ways simultaneously? The primary tool we have employed in our program, The Bering Sea Marine Mammal Experiment (BESMEX) is the NASA (Ames) Convair 990, a four engine jet aircraft. Several features of this aircraft make it very suitable for our program. Use of jet engines removes many of the vibration problems that can deteroriate the resolution of visual photographs. The speed and range of the aircraft allows the survey of between

1000 and 2000 nmi^2 in the center of the Bering Sea on each 6 hour mission. The CV-990 is one of the few remote sensing aircraft large enough so that all the sensors mentioned can be accomodated. However, we must emphasize that there are drawbacks and limitations to the use of this type of technology. The major one is, of course, the cost which becomes reflected in tight schedules and limited amounts of flexibility in planning flights when weather conditions are best for obtaining the maximum amount of information from each flight.

Within these constraints let us look at some of the results obtained so far. Figure 1 presents some data obtained in April 1975 which illustrates the extent of the problem in determining how many animals are in a given area from the number hauled out and therefore visible. This figure shows the results of visual estimates on three successive days. The black boxes outline the 32 by 28 nmi area surveyed with complete coverage by the IR scanner (data presently in analysis). The first day, the weather conditions were still rather bad following several days of storms. We estimated about 437 animals in the area, with almost complete visual coverage of the area. The winds remained moderate over the next 24 hours so that the ice with the walrus associated moved only about 6 nmi to the southeast by the next day. We were able to predict the movement of the ice based on calculations made using an ice dynamics model of Reed and Campbell, in which the major driving force is the wind stress field. Centering our grid on the calculated position of the same 32 x 28 nmi ice area for the next day, we were able to identify the same area and on this day the numbers of walrus hauled out were estimated to be about 1200. Similar ice dynamics calculations were made for the next 24 hours, and when we returned to the same ice area on the third day, now shifted another 6 nmi SE in position, we estimated about 9479 animals hauled out. By the third day the temperatures had moderated considerably and there was almost no cloud cover. Because walrus breathing holes in the thin ice betray the animals' presence we are sure all the animals had been there all the time. The counts merely reflected their behavior not their presence.

We will now consider thermal profiles obtained from walrus herds using the infrared scanner. We have already mentioned the fact that IR enhances detection. Typically, we have found late winter ice to be about -10 to -15°C and the hottest portions of walrus herds to be about +10 to 20°C. Although the spatial resolution of the scanner is only 1 milliradian (that is only 3 feet ground resolution from an altitude of 3000 ft) and thus lacks the necessary resolution to distinguish individual animals when they appear in a group, the very large 20 to 35° C temperature differential does aid in detecting the animals over the 90 degree field of view of the scanner. We then refer to the photographs for accurate counts of the animals in a give herd. Small herds which might be missed visually are usually detected by this means and, in addition thermal energetics of the animals may be calculated from the thermal differentials detected.


32 nmi
6 APRIL
437
7 APRIL
1200
8 APRIL
9479

Another value we have found in flying with several sensors is that when the weather unexpectedly turns bad while the aircraft is in the survey area, some useful data can still be obtained from the mission. We have used both SLAR and microwave, in addition to aircraft radar,to plot the ice edge under these conditions. Since several species are usually associated with the ice edge, this information is valuable for optimizing airtime on future flights.

Finally I might mention a few correlations we are just starting to look at and those are between some anomolous SLAR returns and walrus herds and between some thermal spikes and the possible exhalations of cetaceans. It is certain that IR does not pick up every whale exalation and likewise that SLAR cannot be counted on to detect every walrus group. However, there are some tentative correlations that certainly seem worthwhile pursuing.

In summary, we are convinced of the necessity of new technology for investigating marine mammal natural history and abundance. We are still in the R & D stage, but suspect that significant results will soon emerge for walrus and whales, as is already becoming apparent for other species, including harp seals and belukha. Further, it is obvious that these methods are almost _sine qua non_ for ice-inhabiting marine mammals due to the simple paucity of other logistics than aircraft in their habitats and the inadequacy of visual techniques.

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(dg = degrees from here on out)

APPENDIX IV

8 APRIL 1975

stratog lined up over leads.
TIME 21.12.16

old holes r. made in ice by walrus
TIME 21.12.35

also left.
TIME 21.12.39

dispersion N-S, leads oriented aprox N-NKX N-S, wider than yesterday, refrozen grease mostly, some brash

TIME 21.13.37

21 kt 336, 245 grndspd, 5000 ft alt.
TIME 21.13.55

End run *** cameras off.
TIME 21.14.53

end run 1 21 14 43*********

offset of 3 miles to north from west to east for run 2

2 lrg grp w r 35 dg.
TIME 21.16.27

(large as 25 animals)
grease ice underneath.
TIME 21.17.35

.
TIME 21.17.45

begin run 2 21 17 46***
cameras on

clear skies with low stratog over leads

large grp ahead 2 mi on isolated piece ice, will pass to left.
TIME 21.19.56

many w holes, w r.
TIME 21.20.16

at mark C taking UV of large clusters — walrus on ice

many clsters, 100-200, 50, 75 (p), 100, 200, 400 all left
many small groups r.
TIME 21.21.20

more l, and nose with p p p , — IR Pulses
several l.
TIME 21.21.46

most cluster r pppp steady.
TIME 21.21.56

[illegible]	TIME (HMS)	LATITUDE	LONGITUDE	PRESS ALT	HI RAD ALT	LO RAD ALT	PITCH	ROLL	GRND SPEED	TRU AP [illegible]
[illegible]	[illegible]	[illegible] WIND	DRIFT ANGL	[illegible] TEMP	TOTAL TEMP	IR/SF TEM	DP/FP-P	CABIN ALT	CO VOLTS	AUX [illegible]
[illegible]	37 GHZ	THERMATR	RD/HL-JPL	IR SAT	[illegible] HUM-%	N2O-PPM	DP/FP-PM	OZONE-PPM	COND CNT	[illegible]
	211734	6109.6	-17413.5	5055.84	-33946.9	69.2912	3.12603	19.9872	257	[illegible]
	[illegible]	[illegible]	[illegible]	-13.1999	-1.47612	-7.15055	-27.6349	[illegible]	[illegible]	[illegible]
[illegible]	2470.65	.000000	.000000	19.0975	.563152E+16	0.0009	-16.5711	15.2587	1.03200	[illegible]
	211834	6110.3	-17412.5	5046.99	-33946.7	69.2912	1.97753	30.0533	262	[illegible]
	[illegible]	[illegible]	-3.1	-12.1685	-1.42578	-7.66810	-26.5592	[illegible]	[illegible]	[illegible]
[illegible]	2710.62	.000000	.000000	18.6917	.563152E+16	0.0038	-16.2623	-14.0369	-0.4050	[illegible]
	211844	6110.5	-17411.6	5053.48	-33946.5	69.1371	3.40576	29.7945	269	[illegible]
	[illegible]	[illegible]	-3.2	-12.6052	-1.57224	-7.66035	-26.5274	523.021	[illegible]	[illegible]
[illegible]	2637.65	.000000	.000000	18.8216	.563152E+16	0.0039	-16.0756	2.44140	1.07225	[illegible]
	211854	6111.0	-17410.2	5052.18	-33946.2	69.2912	3.62548	18.7207	274	[illegible]
	[illegible]	95.4	-3.2	-15.7990	-1.67940	-6.22241	-26.5303	524.942	[illegible]	[illegible]
[illegible]	2509.90	.000000	.000000	19.0130	.563152E+16	0.0031	-15.9966	.610351	-0.3485	[illegible]
	211704	6111.0	-17408.3	5060.73	-33945.3	69.1371	3.03222	5.09765	276	[illegible]
	[illegible]	99.4	-4.2	-12.3280	-1.71204	-7.32874	-26.5585	537.715	-0.0244	[illegible]
[illegible]	2276.67	.000000	.000000	18.5837	.563152E+16	0.0008	-16.8325	1.93105	1.03400	[illegible]
	211714	6110.9	-17406.9	5842.41	-33946.2	69.2912	3.20800	15.1611	273	[illegible]
	554	96.6	-3.2	-13.7836	-1.54174	-8.67220	-26.8496	529.785	-0.0256	[illegible]
[illegible]	2546.58	.000000	.000000	18.9270	.563152E+16	0.0007	-16.6572	2.44140	-0.3125	[illegible]
	211724	6110.7	-17408.2	5049.13	-33946.2	69.2912	1.82373	-.747070	279	[illegible]
	[illegible]	[illegible]	[illegible]	-14.7803	-1.75347	-3.71368	-27.1336	524.952	[illegible]	[illegible]
[illegible]	[illegible]	.000000	.000000	19.4926	.563152E+16	0.0009	-17.3197	2.44140	1.04747	[illegible]
	211734	6110.4	-17403.6	5445.47	-33945.9	69.2912	1.58203	-3.84521	277	[illegible]
	[illegible]	133.2	-3.2	-13.0843	-1.86964	-2.05644	-27.4992	533.442	[illegible]	[illegible]
[illegible]	1784.16	.000000	.000000	18.9087	.563152E+16	0.0099	-18.4308	2.44140	-0.3216	[illegible]
	211744	6111.2	-17402.1	5045.77	-33946.5	69.1371	3.10603	.855933	273	[illegible]
	547	92.7	-3.4	-12.2849	-2.30892	-8.51231	-27.6859	584.045	-0.0291	[illegible]
[illegible]	2455.46	.000000	.000000	19.1447	.563152E+16	0.0069	-19.2925	2.44140	1.03751	[illegible]
	[illegible]	[illegible]	-17409.7	5438.35	-33946.7	69.4454	1.07666	-19.5419	268	[illegible]
	[illegible]	[illegible]	[illegible]	-14.7633	-2.75240	-9.09133	-27.0347	[illegible]	[illegible]	[illegible]
	[illegible]	.000000	.000000	19.3675	.563152E+16	0.0009	-19.9902	2.44140	[illegible]	[illegible]
	[illegible]	[illegible]	-17399.6	5441.55	-33947.2	69.9630	3.14365	-10.3930	261	[illegible]
	[illegible]	[illegible]	[illegible]	-12.2477	-8.13476	-8.68704	-27.9429	520.064	-0.0226	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0009	[illegible]	2.44140	[illegible]	[illegible]

APPENDIX V

ANNUAL REPORT

Contract No. R7120804
Research Unit 67
Period: 1 April 1975 -
31 March 1976
No. Pages 59

Baseline Characterization: Marine Mammals

Principal Investigators:

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March 15, 1976

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I. Summary of Objectives, Conclusions and Implications with respect to OCS oil and gas development

Proposed oil and gas lease sites as well as major shipping lanes to service the petroleum industry occur in the Bering Sea. Petroleum development must be viewed in terms of its possible effect on the marine mammals that use the Bering Sea either annually or seasonally. The baseline objectives of RU 67 are to identify the kinds of marine mammal species inhabiting the Bering Sea and specifically to increase our knowledge relevant to the distribution and abundance of pinnipeds and cetaceans.

The principal pinneped species inhabiting the Bering Sea are: ringed seal, Phoca hispida; ribbon seal, Phoca fasciata; largha seal, Phoca largha; bearded seal, Erignathus barbatus; walrus, Odobenus rosmarus; northern fur seal, Callorhinus ursinus; northern sea lion, Eumetopias jubata; and spotted or harbor seal, Phoca vitulina. When the sea ice has receded into the Beaufort and Chukchi Seas in the fall, some of these species feed pelagically while others feed near-shore, or haul out on various land forms. Many of these species (e.g. ringed, bearded, largha and ribbon seals, and walrus) also use the sea ice during the spring and summer breeding season. Hence, the geographic distribution and abundance of all species during these critical periods must be determined, especially as they relate to gas-oil lease sites.

Cetaceans frequent the Bering Sea for feeding and migration throughout the year. Some are undoubtedly residents. Those cetaceans known or believed to be present in the Bering Sea, for at least some time during the year, are listed in Table 1. Times of migration, migration routes, and feeding grounds must be identified for each species before management decisions are implemented with regard to petroleum resource development.

II. Introduction

A. General nature and scope of study.
RU 67 proposes to gather general population data on marine mammals in the Bering Sea to develop a baseline of information, by time and place, for evaluating how the activities of man might affect specific marine mammal species. The kinds of baseline information we expect to obtain are estimates of the numbers of animals season by season.

Table 1. Cetaceans occurring seasonally in the Bering Sea.[1]

Suborder ODONTOCETI

Bottle-nosed whale, Berardius bairdii
Belukha, Delphinapterus leucas
Stengers Beaked whale, Mesoplodon stejnegeri
Killer whale, Orcinus Orca
Harbor porpoise, Phocoena phocoena
Dall porpoise, Phocoenoides dalli
Sperm whale, Physeter macrocephalus

Suborder MYSTICETI

Bowhead whale, Balaena mysticetus
Minke whale, Balaenoptera acutorostrata
Sei whale, Balaenoptera borealis
Blue whale, Balaenoptera musculus
Fin whale, Balaenoptera physalus
Gray whale, Eschrichtius robustus
Humpback whale, Megaptera novaengliae

1. From Fay, F.H. 1974. The Role of Ice in the Ecology of Marine Mammals of the Bering Sea. pages 383-399. In, D.W. Hood and E. J. Kelley (Eds.), "Oceanography of the Bering Sea", Institute of Marine Sciences, Univ. of Alaska, Fairbanks.

B. Specific objectives

1. Seasonal distribution and abundance of seals, sea lions and cetaceans in the Bering Sea.
2. Spring and fall migration patterns of gray whales and other cetaceans and pinnipeds in the areas of the Bering Strait and Unimak Pass.
3. Locate rookeries, hauling grounds and feeding areas where oil development may effect marine mammal production.
4. The estimation of animal numbers in critical areas such as oil and gas lease sites.
5. NOAA ship records and whaling and sealing records on marine mammals in the Bering Sea are to be interpreted with aerial survey data.
6. Summarize and evaluate existing literature and unpublished data on the distribution, abundance, behavior and food dependencies of marine mammals in the Bering Sea.

C. Relevance to problems of petroleum development.

Gas and oil lease sites exist in three important areas covered under RU 67. The first potential lease site is in Bristol Bay extending west along the north coast of the Alaska peninsula. This portion of the peninsula is an important site for breeding harbor seals, sea lions and sea otters (Enhydra lutris), as well as for migrating gray whales (Eschrichtius robustus) and walruses. The area also contains a localized population of Belukha whales (Delphinapterus leucas).

The second potential lease site area, called the St. George "Basin", lies directly beneath the path of migrating marine mammals moving into or out of Unimak Pass. This area is of considerable importance to the fur seal management activities of the United States on the Pribilof Islands. The St. George "Basin" area is believed to be one of the most important ecological "habitat" continuums in the Bering Sea.

The third major lease site area in the Bering Sea is north and east of St. Lawrence Island. This area is an important breeding ground for walrus, ringed seals, and perhaps bowhead whales (Balaena mysticetus) and bearded seals.

III. Current state of knowledge

A. Pinnipeds. Sea ice can be divided into three general types as far as providing a habitat for pinnipeds. They are (1) the edge-zone or ice front, (2) heavier pack ice, north of the ice front, and (3) land fast ice. During the breeding season largha and ribbon seals occupy the ice front, while the bearded seal and walrus are usually found farther north in the heavier pack ice. The ringed seal occupies areas of land fast ice. Although there is an overlap in the distribution of all these species, during the breeding season individuals of each species are largely segregated from those of other species. During the breeding season the ice front provides a unique opportunity to determine the abundance and distribution of largha and ribbon seals. The ice front is a defineable area characterized by small ice floes seperated by water or slush. The ribbon seal occupies the inner "edge" of the ice front while the largha seal occupies the outer "edge".

B. Cetaceans. Unfortunately, our knowledge of cetaceans is not as complete as that for pinnipeds. Certain species are known to feed and/or migrate through the Bering Sea. For some species, gray and bowhead whales, the times and routes of migration have been hypothesized. In the late spring and early summer gray whales migrate northward through Unimak Pass, up the eastern Bering Sea over oil and gas lease site areas and into the Chukchi Sea. In the spring, Bowheads migrate northward from west and northwest of St. Lawrence Is. through the Bering Strait. For other cetaceans (Table 1) little information on seasonal movement exists. Hence, many questions remain unanswered about the distribution and abundance of cetaceans in the Bering Sea; especially in relation to oil and gas lease sites.

IV. Study Area

The study area includes open water and islands of the eastern Bering Sea over the continental shelf from approximately 54°N. Latitude to 69°N. Latitude, and 167°W. Longitude to 178°W. Longitude.

V. Sources, Methods and rationale of data collection

Three surveys were conducted during 1975, two along the Bering Sea side of the Alaska Peninsula (surveys number one and two; RU 67-A1 and A-2) and one in the northern Bering and southern Chukchi Seas (survey number three; RU 67-A3).

Aerial survey number one (RU 67-A1) took place from 16-20 June and survey number two (RU 67-A2) from 9-13 August. Both surveys were specifically designed to locate rookeries and hauling grounds for northern sea lions and harbor or spotted seals. The survey aircraft was a Grumman Widgeon, chartered from Peninsula Airways, King Salmon, Alaska.

Flights were made during times of low tide to maximize our efforts of locating animals hauled-out. Visual estimates and photographs of animal concentrations were made at each hauling ground or rookery. One (RU 67-A1) and two (RU 67-A2) Nikon camera(s) with 105mm and 135mm telephoto lenses were used to photograph the animals; identification of species and numbers took place back in the laboratory. Flights were made from King Salmon and Dutch Harbor, with refueling stops at Cold Bay. Transects were systematically flown along the shoreline and around islands and bays. The effective flying altitude was from 300 - 500 feet.

The scientific parties for each survey flight(s) were:

RU 67-A1

Mr. Clifford Fiscus	MMD, NMFS, Seattle, WA
Mr. Marcus Lester	" " " "
Mr. Karl Schneider	ADF&G, Anchorage, AK
Mr. Donald Caulkins	" " "

RU 67-A2

Mr. Clifford Fiscus	MMD, NMFS, Seattle, WA
Mr. Karl Schneider	ADF&G, Anchorage, AK
Mr. Donald Caulkins	" " "

Aerial survey number three (RU 67-A3) took place from 9-14 October. This survey was designed to determine which species of marine mammal(s) occurred in the northern Bering Sea in October, and specifically to try to identify any migration patterns of gray whales. The survey aircraft was a P2V chartered from the Department of Interior's Office of Aircraft Services. Survey flights were made from Nome.

Visual estimates and photographs were taken to determine numbers of animals seen. A Nikon 35mm camera was used with a motorized drive, 105mm and 200mm telephoto lenses. Two observers and one recorder sampled from the bow of the plane while two observers aft took pictures and rotated with the bow observers. The recorder noted animals seen, time, position, weather and other appropriate sighting and environmental data. These data could then be directly transcribed from field format to EDS format.

Flight transects were determined at random before the survey, but some were modified for reasons of poor flying weather. Approximately 2200 miles of ocean and coastline (including islands) were flown from north of the Bering Strait south to approximately St. Mathew and Nunivak Is.

The effective flying altitude was 500 feet unless weather forced the plane to fly lower.

The scientific party for the 9-14 October survey was:

RU 67-A3

Mr. Clifford Fiscus	MMD, NMFS, Seattle, WA
Dr. Howard Braham	" " " "
Mr. Robert Everitt	" " " "
Mr. John Burns	ADF&G, Fairbanks, AK
Mr. Edward Muktoyuk	" Nome, AK

VI. Results

A. General. A sample annotated bibliography which represents selected literature references used in planning for the spring 1976 field season is included in this report as an Addendum. Additional annotations will be provided in the 5th and 6th quarter reports. An integration of past distribution and abundance estimates from the literature with our survey data will be provided in the final report due 1 October 1976.

B. Aerial Survey number one, 16-20 June 1975.
Rookeries, haulout areas, and coastal waters from Hagemeister Island south and west along the Alaska peninsula, Amak Island, Unimak Island, the Krenitzen Islands, Unalaska Island and Umnak Island were surveyed. Fog hampered survey flights in the Krenitzen Islands and prevented our survey of the south sides of Unalaska and Umnak Islands. Survey track lines for the entire area are shown in Figures 1 through 3. The numbers of animals counted are listed according to species in Tables 2 through 9. The locations of sightings are shown in Figures 4 through 18.

C. Aerial survey number two, 9-13 August 1975.
Rookeries, haulout areas and coastal waters from Cape Pierce south and west along the north side of Alaska peninsula and westward into the eastern Aleutian Islands were surveyed. Weather conditions were better than during the June survey and those areas missed in June were examined in August. Northern sea lion distribution varies from June (the height of the breeding season) to August when rookery populations are down and many animals disperse to hauling areas. A survey in June covering the south side of Unalaska and Umak Islands and Bogoslof Island is needed in 1976.

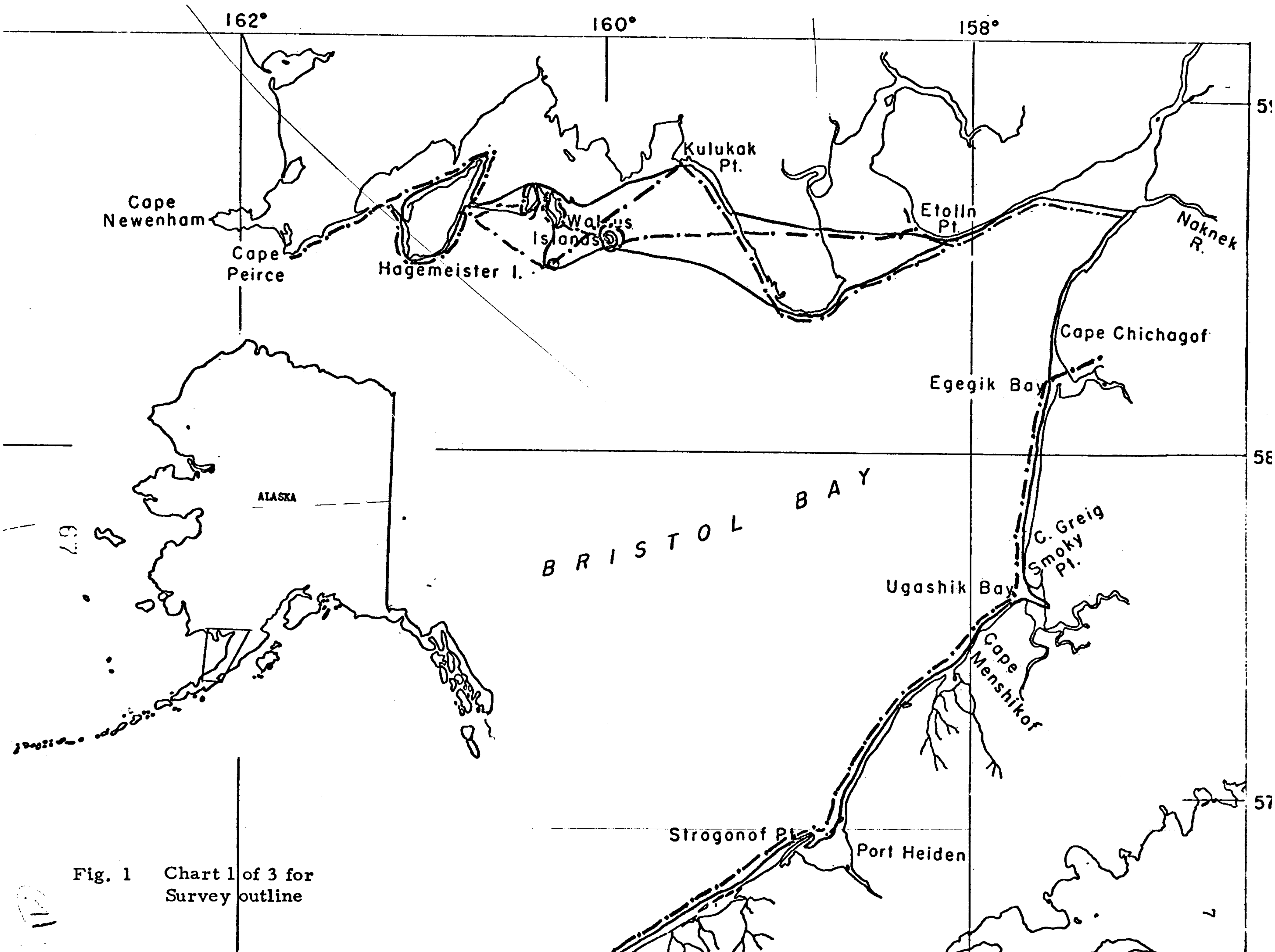


Fig. 1 Chart 1 of 3 for Survey outline

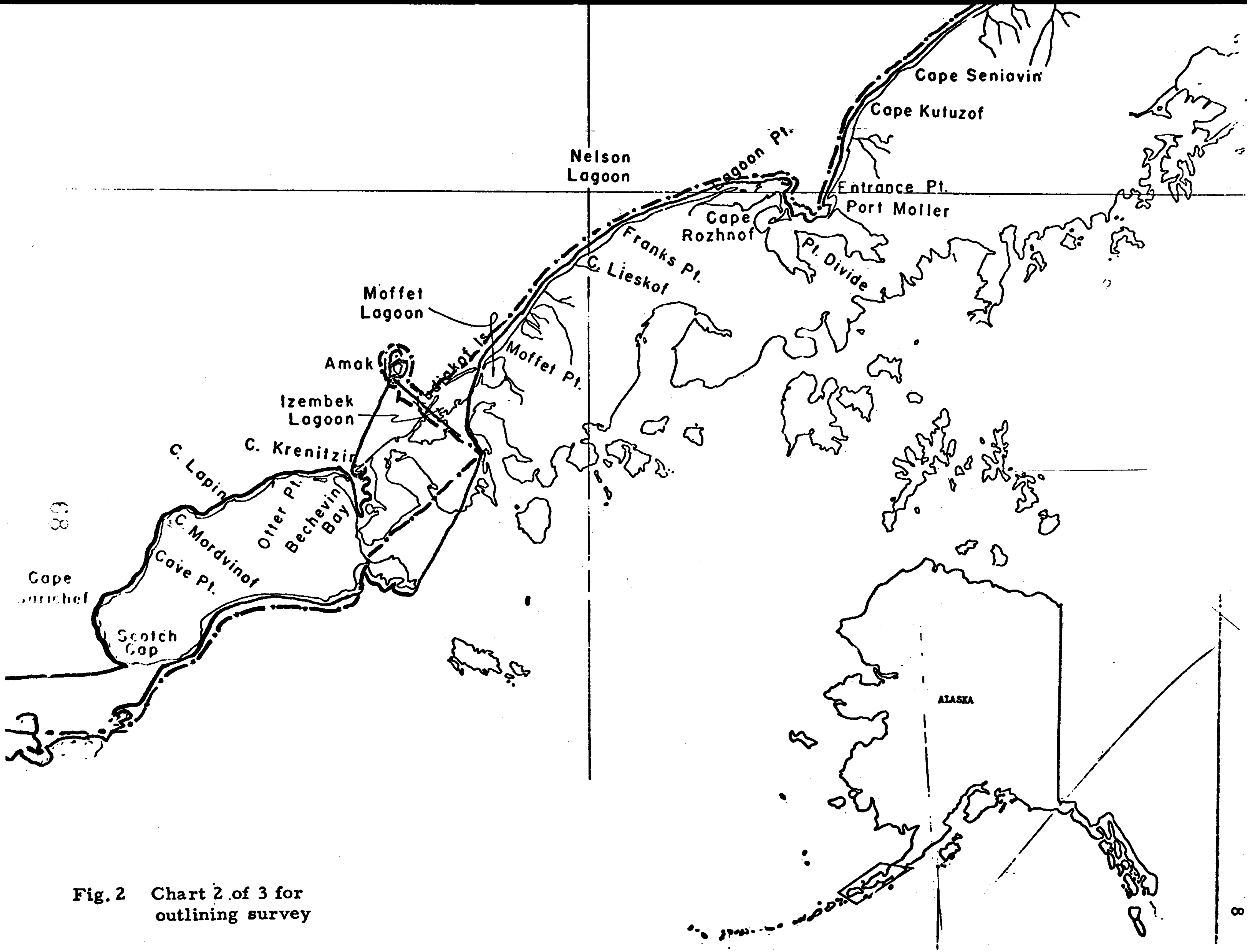


Fig. 2 Chart 2 of 3 for outlining survey

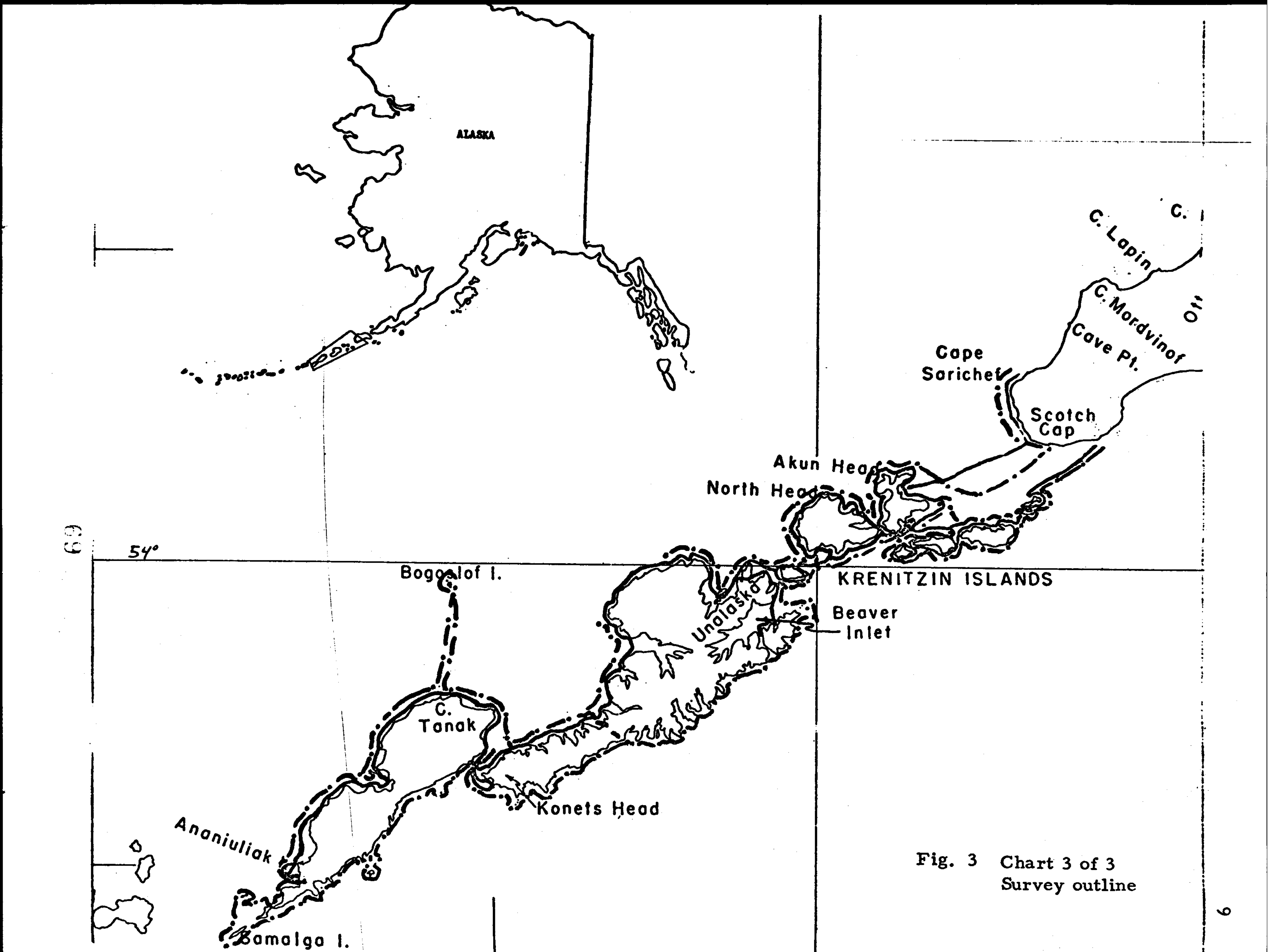


Fig. 3 Chart 3 of 3
Survey outline

Table 2. Observations of Walrus (Odobenus rosmarus) on Round Island, 17 June and 9 August 1975.

Location Lat. (°N) Long. (°W)	Date/Time	Numbers seen	Remarks
Round Island			
58°36' 159°59'	17 June 75 1204-1215	West side total - 2,358	Tide 3.9 ft. falling range 9.5 ft. Counts from Photos: RU67A1 Roll 1 Total walrus = 3,524
	9 Aug 75 1533-1540	West side groups - 12, 5 225, 170, 220, 185, 3, 8, 281, 1041, 87, 79, 121	Counts from Photos: RU67A2 Roll 1 & 1A, Total for west side = 2,437
		East side groups - 102 150, 645, 136, 89, 119, 915 ±, 294, 124, 93, 168, 19, 71	Counts from Photos: RU67A2 Roll 2 & 2A Total for east side = 2,025 Total walrus = 5362
58°38' 159°06'	9 Aug 75 1544	1	in water off Round Island

Table 3. Observations of sea otters (Enhydra lutris) 17-20 June 1975.

Location	Lat. (°N)	Long. (°W)	Date & Time of Observation	Number
Unalaska I.				
McIver Bight	53°30'	167°10.2'	19 Jun - 1003	2
Ship Rock (S)	53°22.3'	167°50'	" - 1518	4p
Ship Rock (N)	53°23'	167°47'	" - 1519	6
Emerald I.	53°17.5'	167°51.5'	" - 1524	29
Tiderip Pt.	53°17'	167°48'	" - 1526	25
Konets Head (E)	53°19'	167°50'	" - 1529	9
Krenitzin I.				
Aiktuk	54°11'	164°51'	18 Jun - 1459	1
Kaligagan I.	54°09'	164°55'	" - 1500	2
	54°09'	164°57'	" - 1500-1510	36
Tigalda I.	54°07.7'	165°06'	" - " "	1
	54°07.5'	165°03'	" - " "	1
	54°07.8'	165°04.6'	" - " "	2
	54°07.8'	165°07.2'	" - " "	1
	54°07.8'	165°08.4'	" - " "	2
	54°07.6'	165°09.9'	" - " "	2
Kelp Bay	54°07'	165°09.6'	" - " "	3
	54°07.5'	165°10'	" - " "	12
	54°07'	165°12'	" - " "	1
Unimak I.	54°58.5' 55°04'	164°07.6' - 163°35'	20 Jun - 1119-1128	3
Alaska Pen.				
Amak I. (west)	55°25'	163°09'	" - 1220	60p
Cape Leontovich	55°40'	162°18'	18 Jun - 1225	1
Cape Pankof	56°02'	160°57'	20 Jun - 1401	1
Kudiakof I.	55°22.5'	162°50'	" - 1321	1
Moffet Lagoon	55°29' 55°37.2'	162°33' - 162°20.5'	" - 1327-1331	25

Table 3. (cont'd)

Location	Lat. (°N)	Long. (°W)	Date & Time of Observation	Number
Alaska Pen.(cont'd)				
Port Moller	55°58'	160°37.5'	20 Jun - 1416	1
Entrance Pt.	56°04'	160°30.5	" - 1419	1
Three Hills	56°33'	159°50'	" - 1443	1
Bechevin Bay				
Isonotski I. (N)	55°00'	162°20'	20 Jun - 1143	51
B. Bay	55°02'	163°22'	" - 1148	132p

p = photo count

Table 4. Observations of Northern Sea Lions (<u>Eumetopias jubatus</u>) 17-20 June 1975. Numbers are based on visual estimates or on counts made from photographs (p).

Location	Lat. (°N)	Long. (°W)	Date & Time of Observation	Numbers
Cape Aslik	53°25'	168°24.5'	19 Jun - 1628	285p
Cape Chagak	53°31.8'	168°14.3'	" - 1633	20p
Cape Starichkof	53°84.5'	167°04'	" - 0955	100
Bishop Pt.	53°58.5'	166°57'	" - 1045:30	172p
Lava Bight	54°08.7'	166°06'	18 Jun - 1610-1675	115
Reef Bight	54°08.8'	166°05.9'	" - " "	100
Cape Morgan	54°03'	166°01'	" - " "	2894p
			20 Jun - 1020	1525
Cascade Bight	54°04'	165°59'	" - "	1675
Battery Pt.	54°02.2'	165°52.2'		30
Talue Pt.	54°04'	165°45.7'		5
Jackass Pt.	54°06.4'	165°33.5'	18 Jun - 1537-1625	20
Billings Head, Akun I. (East to Little Bay)			" - " "	748
Tanginak I.	54°12.2'	165°19.3'	" - 1533	470p
Rock N. of Tigalda I.	54°09.8'	164°59'	" - 1500-1510	80
Ugamak I., N. Pt. to SE Pt.;	54°23'	164°48'	" - 1453-1458	2550;
SE Pt. to Ugamak Bay			" - " "	1390p
Aiktak I.	54°11'	164°51'	" - 1458	1
Rootok I.	54°04'	165°31.6'	" - 1500-1510	118p
Old Man Rock	53°53.3'	166°04.8'	20 Jun - 1215	180p
Cape Lutke	54°29'	164°20'	18 Jun - 1441	22
Rock I.	54°37'	163°38'	" - 1423	25
Sea Lion Rock	55°28'	163°12'	20 Jun - 1207	2006p
Unnamed Rock	55°27'	163°09.3'	" - 1209	108p
Amak I.	55°25'	163°09'	" - 1220	1095p
Round I.	58°36'	159°59'	17 Jun - 1211	325
			9 Aug - 1533	244p
Little Twin	58°36'	169°19'	17 Jun - 1217	50

Table 5. Observations of Harbor Seals (Phoca vitulina richardii) 17-20 June 1975. Numbers are based on visual estimates or on counts made from photographs (p).

Location	Lat. (°N)	Long. (°W)	Date & Time of Observation	Numbers
Umnak Island				
Ananuluk I.	53°00.5'	168°55'	19 June - 1606	5
"	53°08.5'	168°48.2'	" - 1613	
Unalaska Island				
Erskine Pt.	53°59'	166°16.4'	" - 0932	4
Fisherman Pt.	53°56.5'	166°13.7'	" - 0934	15
Brundage Head	53°56'	166°12.3'	" - 0934:30	7
Brundage to Deep Bay	53°54.1'	166°12.6'	" - 0935	10
	53°54.7'	166°12.6'	" - 0935:30	25
Udegak St.	53°48'	166°18'	" - 0940	10
Round I., Beaver Inlet	53°46.3'	166°23'	" - 0944	10
Cathedral Pt.	53°44.4'	166°53.3'	" - 0952:30	20
Cape Starichkof	53°40.5'	167°04.4'	" - 0956	51
Spray Cape	53°37'	167°09.9'	" - 0958	35
Pumiciston Bay (N)	53°33.5'	167°09.7'	" - 1001	6
McIver Bight (S)	53°30'	167°10'	" - 1003	91p
Kasheya Bay	53°29.2'	167°12.5'	" - 1008	27
Sedanka Pt.	53°29.2'	167°19.5'	" - 1011	12
Cape Aspid	53°27'	167°28.3'	" - 1014	25
Cape Kovrizhka	53°50.7'	167°10'	" - 1037-1040	39
Pt. Tebenkof	53°59.4'	166°53'	" - 1046:30	20
Cape Charful	54°01.2'	166°40.4'	" - 1050:30	48
Pustoi Island	53°24'	167°49.4'	" - 1515:30	12
Rock off Konets Head	53°17.5'	167°51.5'	" - 1525	53p
Rocks off Tiderip Pt.	53°17.5'	167°51.5'	" - 1527	100
Konets Head	53°19'	167°51.2'	" - 1529-1531	50
Cape Kalekta	54°00.8'	166°22.5'	20 June - 1003	15
Unalga I.			18 June - 1625-1639	72

Table 5. (cont'd)

Location	Lat. (°N)	Long. (°W)	Date & Time of Observation	Numbers
Baby Islands				
#1	54°00'	166°03.2'	18 June - 1625-1639	10
#2	53°59.6'	166°02.6'	" - "	92
#3	53°59.2'	166°03.2'	" - "	32
#4	53°59.4'	166°04.2'	" - "	35
#5	53°59.8'	166°05'	" - "	9
Krenitzin I.				
Akun Is., Poa I.	54°07.7'	165°29.4'	18 Jun - 1537-1625	20
Rootok I.	54°03.2'	165°30.5'	" - 1500-1525	15
	54°02.7'	165°28.6'	" - " "	35
	54°02.4'	165°29.3'	" - " "	10
	54°01.5'	165-32.3'	" - " "	5
	54°01.6'	165°33.4'	" - " "	3
Avatanak I.	54°03.6'	165°19.6'	" - 1500-1510	10
	54°04.3'	165°23'	" - " "	9
	54°04.3'	165°28.5'	" - " "	25
Rock N. of Kalyaga I.	54°09'	164°55'	" - " "	75
Aiktak I.	54°11'	164°49'	" - 1453-1458	30
	54°11'	164°50.5'	" - " "	20
Alaska Pen.				
Cape Layard	54°36'	163°35'	" - 1422	75
Cape Lapin	54°58.5'	164°07.5'	20 Jun - 1109	125p
North Isonotski I.	55°00'	163°20'	" - 1143:30	258p
Cape Krenitzen	55°04.3'	163°26'	" - 1150:30	110p
Kudiakof Island	55°19'	162°54'	" - 1224	41
Izembeck Lagoon	55°17.5'	162°50.6'	" - 1225:30	75
Bar N. of Kudiakof Is.	55°25'	162°37.8'	" - 1324:30	1923p
Amak I.	55°25'	163°09'	" - 1204-1220	14
Cathedral River	55°37.2'	162°20.5'	" - 1333	29p
Cape Leiskof	55°27'	162°05'	" - 1338:30	96p
Nelson Lagoon (W)	56°00'	161°03'	18 Jun - 1202	565p

Table 5. (cont'd)

Location	Lat. (°N)	Long. (°W)	Date & Time of Observation	Numbers
Alaska Pen. (cont'd)				
Lagoon Pt.	56°01'	161°02.5'	20 Jun - 1359	716p
Port Moller	55°56'	160°40'	18 Jun - 1155-1200	3998p
			20 Jun - 1405-1417	2366+3712= 6078p
Cape Seniavin	56°25'	160°07'	18 Jun - 1133	10
Seal Islands	56°41'	159°24'	" - 1117	1137p
			20 Jun - 1454:20	155
Port Heiden	56°53'	158°47'	18 Jun - 1104-1109	4774p
			20 Jun - 1505-1514	5273p
Cinder River	57°22'	158°06'	18 Jun - 1044	925
			20 Jun - 1532-1537	2867p
Ugashik Bay	57°37'	157°32'	18 Jun - 1035	150
			20 Jun - 1546	196p
Egegik Bay	58°14'	157°32'	" - 1608:30	20p
Egegik Bay	58°16'	157°33'	" - 1610:30	30
N. Bristol Bay, Calin Pt. & vicinity	58°33'	161°05'	17 Jun - 1244-1250	90

Table 6. Observations of Gray Whales (Eschrichtius robustus) 17-20 June 1975 along the northern coast of the Alaska Peninsula and vicinity.

Location Lat. (°N)	Long. (°W)	Date/Time	Numbers	Remarks
58°07'	157°37'	18 Jun - 0956	1	Egegik, Alaska Pen.
58°03'	157°39'	" - 0959	1	
58°01'	157°39'	" - 1000	2	
57°56'	157°39'	" - 1002	1	
57°48'	157°43'	" - 1008	1	Cape Greig
57°40'	157°44'	" - 1012	2	Smokey Pt. (N)
57°38'	157°43'	" - 1013	3	Smokey Pt. (N)
57°37.5'	157°43'	" - 1013	3	Smokey Pt.
57°36'	157°40'	" - 1014	2	Ugushik Bay - sighted from 0956 to 1014; appeared to be headed NE
57°32'	157°53'	" - 1038:30	1	
57°30'	157°58'	" - 1040	2	Cape Menshikof
57°28'	158°00'	" - 1041	1	
57°28'	158°00'	" - 1041:30	1	
57°05'	158°38'	" - 1057	1	Observed from starboard side
57°05'	158°38'	" - 1057:30	2	
56°38'	159°34'	" - 1120	1	Near Seal Islands
56°36'	159°39'	" - 1121:30	2	
56°35'	159°44'	" - 1122	3	Incl. cow & calf - photos RU67A1 Roll 2, frame 21-24
56°34'	159°47'	" - 1123	1	
56°34'	159°47'	" - 1124:30	1	
56°34'	159°47'	" - 1125:30	1	
56°33'	159°51'	" - 1126	4	Three Hills, Alaska Pen.
56°27'	160°03'	" - 1131	2	cow & calf
56°18'	160°22'	" - 1138	1	Cape Kutuzof
55°59'	161°24'	" - 1207	3	Off Nelson Lagoon
55°47'	162°05'	" - 1220	2	Cape Lieskof
		20 Jun - 1338	3	" " incl. cow & calf
55°43'	162°15'	18 Jun - 1224	2	Cape Leontovich
55°40'	162°18'	" - 1225	1	Photos: RU67A1 Roll 3 frame 2

Table 6. (cont'd)

Location Lat. (°N)	Long. (°W)	Date/Time	Numbers	Remarks
55°39'	162°20'	18 Jun - 1226	3+2	
55°37'	162°25'	" - 1227	2	
55°28'	162°36'	" - 1235	2	North end of Moffet Lagoon
54°37.5'	163°43.5'	" - 1425	1	Near Rock Island
54°37'	164°07.5'	" - 1434	1	S. of Cape Rukovitsic
55°48'	162°02'	20 Jun - 1342	1	
55°52'	161°52.5'	" - 1344	1	Photos: RU67A1 Roll 10 frame 27
55°56.5'	161°37.2'	" - 1350	1	Plane circled for positive ID
55°58'	161°29'	" - 1352	1	South of Lagoon Pt.
56°01.6'	160°48'	" - 1404	1	Cape Rozkauf
56°28'	160°00'	" - 1436	2	Circled. Photos: RU67A1 Roll 13, frames 12-15
56°33.5'	159°47'	" - 1446	2	Photos: RU67A1 Roll 13 frames 16-18
56°35'	159°42'	" - 1447	1	
56°37'	159°37'	" - 1448	1	
56°43'	159°20'	" - 1456	1	Seal Island
56°50'	159°02'	" - 1502	1	
57°01.5'	158°42'	" - 1520:30	1	Photos: RU67A1 Roll 16 frames 1-9
57°33'	157°52'	" - 1543	1	
57°50'	157°42'	" - 1553:30	1	
58°00°	157°40'	" - 1557:30	1	Plane circling for positive
		" - 1558	1	IDs
58°04'	157°39'	" - 1600	1	Photos: RU67A1 Roll 18 frames 9-21
58°10'	157°35'	" - 1604	1	
58°11'	157°35'	" - 1605	1	
58°12.5'	157°33'	" - 1607	1	South side Egegik Bay
		total	84	

Table 7. Observations of Belukha (Delphinapterus leucas), Minke Whale (Balaenoptera acutorostrata), Harbor Porpoise (Phocoena phocoena) and unidentified cetaceans from 17-20 June 1975.

	Location Lat. (°N)	Long. (°W)	Date/Time	Numbers	Remarks
Belukha					
	58°42.5'	157°24'	17 Jun - 1125	1+1	portside between Naknik R. & Etolin Pt.
Minke Whale					
	54°26'	164°24'	18 Jun - 1443:30	1	near Cape Latke
	53°25.5'	167°33.4'	19 Jun - 1023	1	Chernofski Pt. Unalaska I.
	53°27.4'	167°28.3'	19 Jun - 1025	1	Cape Aspid, Unalaska I.
	53°24'	167°38.3'	19 Jun - 1535	1	Station Bay, Unalaska I.
Harbor Porpoise					
	57°56.5'	157°39'	18 Jun - 1001	1	
	55°51'	161°55'	18 Jun - 1218	3	(tan in color)
	53°52.7'	166°32'	18 Jun - 1900	1	Unalaska, Village Channel
	57°05'	158°39'	20 Jun - 1522	1	
	57°15'	158°28'	20 Jun - 1527	3+1+1+1	
	58°00'	157°40'	20 Jun - 1557	1+1	circling for positive identification
	58°04'	157°39'	20 Jun - 1559	1	
	58°04'	157°39'	20 Jun - 1600	1+2	Photos RU67A1 Roll 18, frames 9-21
	58°11'	157°35'	20 Jun - 1606	1	

Table 7. (cont'd)

	Location Lat. (°N)	Long. (°W)	Date/Time	Numbers	Remarks
Unidentified Cetaceans					
	58°48'	160°16'	17 Jun - 1312	1	whale, north of High I., Bristol Bay - w
	56°04'	160°31'	18 Jun - 1145	1	whale between Cape Kutugof & Port Moller
	53°25'	167°33.4'	19 Jun - 1016	1	whale, Chernofski Pt.
	53°25'	167°33.4'	19 Jun - 1017	1	whale, Chernofski Pt.
	53°25'	167°35'	19 Jun - 1022	3+1	whale, (probably minke)
	53°27'	167°24'	19 Jun - 1022	1	whale, Wedge Pt.
	53°38'	167°10'	19 Jun - 1032	1	whale, Spray Cape
	53°38.5'	167°09	19 Jun - 1032	1	whale
	53°40'	167°03'	19 Jun - 1033	1	whale
	53°23'	167°47'	19 Jun - 1518	1	whale - near Ship Rock
	53°24.5'	167°37'	19 Jun - 1536	1	whale, Peacock Bay, Unalaska I.
	53°59'	166°28.6'	20 Jun - 1001	1	porpoise (harbor?)

Table 8. Marine Mammal Carcasses Observed during RU67-A1 Aerial Survey Flights, 17-20 June 1975

Location Lat. (°N)	Long. (°W)	Date/Time	Species	Remarks
58°38'	160°16'	17 Jun - 1225	1 Walrus	Crooked Island (south end)
54°37'	164°07.5'	18 Jun - 1434	1 Gray Whale	Unimak Bight, Unimak Island, Photos: Roll 3 frames 13-16. (brown bear standing near carcass)
53°28'	167°12'	19 Jun - 1007	1 Unid. Whale	Buck Bight, Unalaska Is.
56°14.8'	169°23'	20 Jun - 1425	1 Gray Whale	Sandy River - Photos: Roll 12, frames 29-31.
56°17'	160°22'	" - 1426	1 Gray Whale	Cape Kutuzof - Photos: Roll 13, frames 1-5.
56°20'	160°07'	" - 1431	1 Gray Whale	West of Muddy River Photos: Roll 13, frames 6-11.

Table 9. Marine Mammal Carcasses Observed during RU67-A2 Aerial Survey Flight, 9-13 August 1975

Location Lat. (°N)	Long. (°W)	Date/Time	Species	Remarks
58°26'	159°05'	9 Aug - 1517	1+1 walrus	S/W end of Nushagak Pen.
58°28'	159°06'	" - 1518	1 walrus	"
58°31'	159°10'	" - 1520	1 walrus	W tip of Nushagak Pen.
58°42'	160°16'30"	" - 1550	1 walrus	NE side of Crooked Island
58°42.5'	160°27.5'	" - 1556	1 walrus	Floating in water NE of High I.
58°48'	160°43'	" - 1607	1+1 walrus	NE side of Hagemeister I.
58°49'	159°33'	" - 1709	1 walrus	Tvativak Bay
58°49'	159°29.5'	" - 1710	1+3 walrus	Coast S/E Trativak Bay
58°46'	159°23'	" - 1712	1 walrus	W coast of Nushagak Pen.
58°40'	159°16'	" - 1713	1 walrus	On coast NW of Kikertalik Lake
58°39'	159°16'	" - 1713	1 walrus	On coast W of Kikertalik Lake
58°32'	159°11'	" - 1716	1 walrus	W coast Nushagak Pen.
57°08'	158°31'	11 Aug - 1343	1 gray whale	Coast Ne Port Heiden Photos: Roll 4, frame 1
56°42'	159°20'	" - 1404	1 gray whale	Seal Islands - Photos: Roll 3A frames 16-17 Roll 4 frames 13-14
56°41'	159°24'	" - 1406	1 gray whale	Seal Island - Photos: Roll 4, frames 15-16
56°39'	159°29'	" - 1409	1 gray whale	S end Seal Islands - Photos: Roll 3A, frame 18; Roll 4 frame 17
56°31'	159°50'	" - 1415	1 gray whale	10 miles NE of Cape Seniavin - Photos: Roll 3A frame 19; Roll 4 frame 18
56°20'	160°14.5'	" - 1424	1 gray whale	Cape Seniavin, Brown bear nearby. Photos: Roll 3A frame 20; Roll 4, frame 19
56°18'30"	160°19'	" - 1427	1 gray whale	On coast between Cape Seniavin and Cape Kutuzof. Photos: Roll 3A, frame 21 Roll 4 frame 20
56°01.5'	161°00'	". 1447	1 walrus	Nelson Lagoon

Table 9. (cont'd)

Location Lat. (°N)	Long. (°W)	Date/Time	Species	Remarks
56°01'	161°04'	11 Aug - 1449	1 harbor seal	Nelson Lagoon
55°51'	161°53'	" - 1500	1 harbor seal	N. of Cape Lieskof
55°41°16	162°08°	" - 1507	1 gray whale	S. of Cape Lieskof Photos: Roll 5, frame 1; Roll 4A, frame 3
55°29'	162°31'	" - 1520	1 sea lion(?)	Moffet Point, brown bear nearby. Photos: Roll 5, frames 3-4; Roll 4A, frame 4
54°09'	165°29'	13 Aug - 1154	1 sea lion	Tankivak I.
		" - 1607	1 gray whale	Same one observed 11 Aug 1975 at 1427
		" - 1609	1 gray whale	Same one observed 11 Aug 1975 at 1424
		" - 1617	1 gray whale	Same one observed 11 Aug 1975 at 1415
		" - 1624	1 gray whale	Same one observed 11 Aug 1975 at 1409
56°41'	159°26'	" - 1626	1 gray whale	Same one observed 11 Aug 1975 at 1404, but moved. Seal I.
		" - 1626:30	1 gray whale	Same one observed 11 Aug 1975 at 1406
57°54.5'	157°39'	" - 1742	1 gray whale	N. of Cape Greig
57°54.5'	157°39'	" - 1745	1 gray whale	N. of Cape Greig - Photos: Roll 18, frame 10

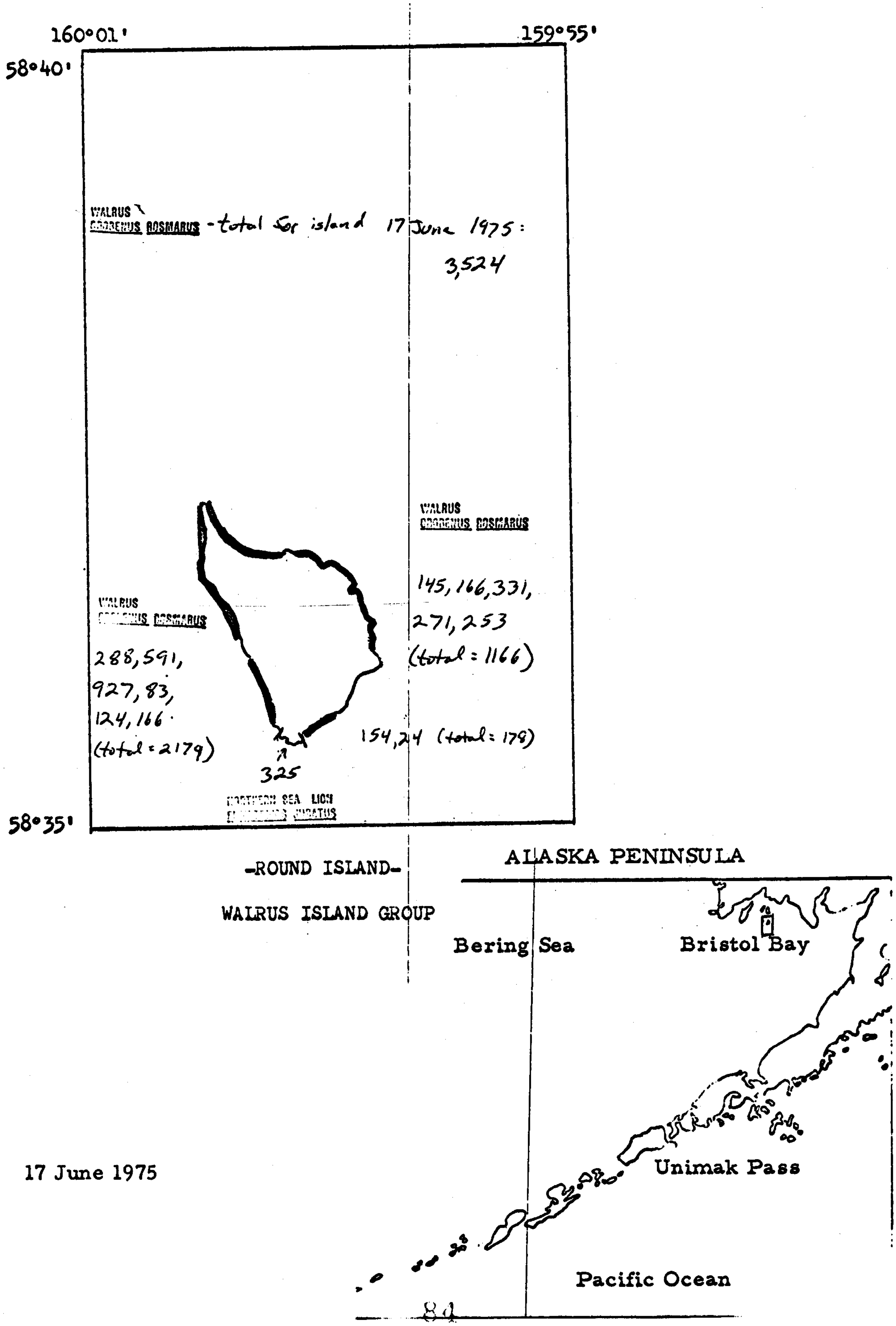


Fig. 4 17 June 1975

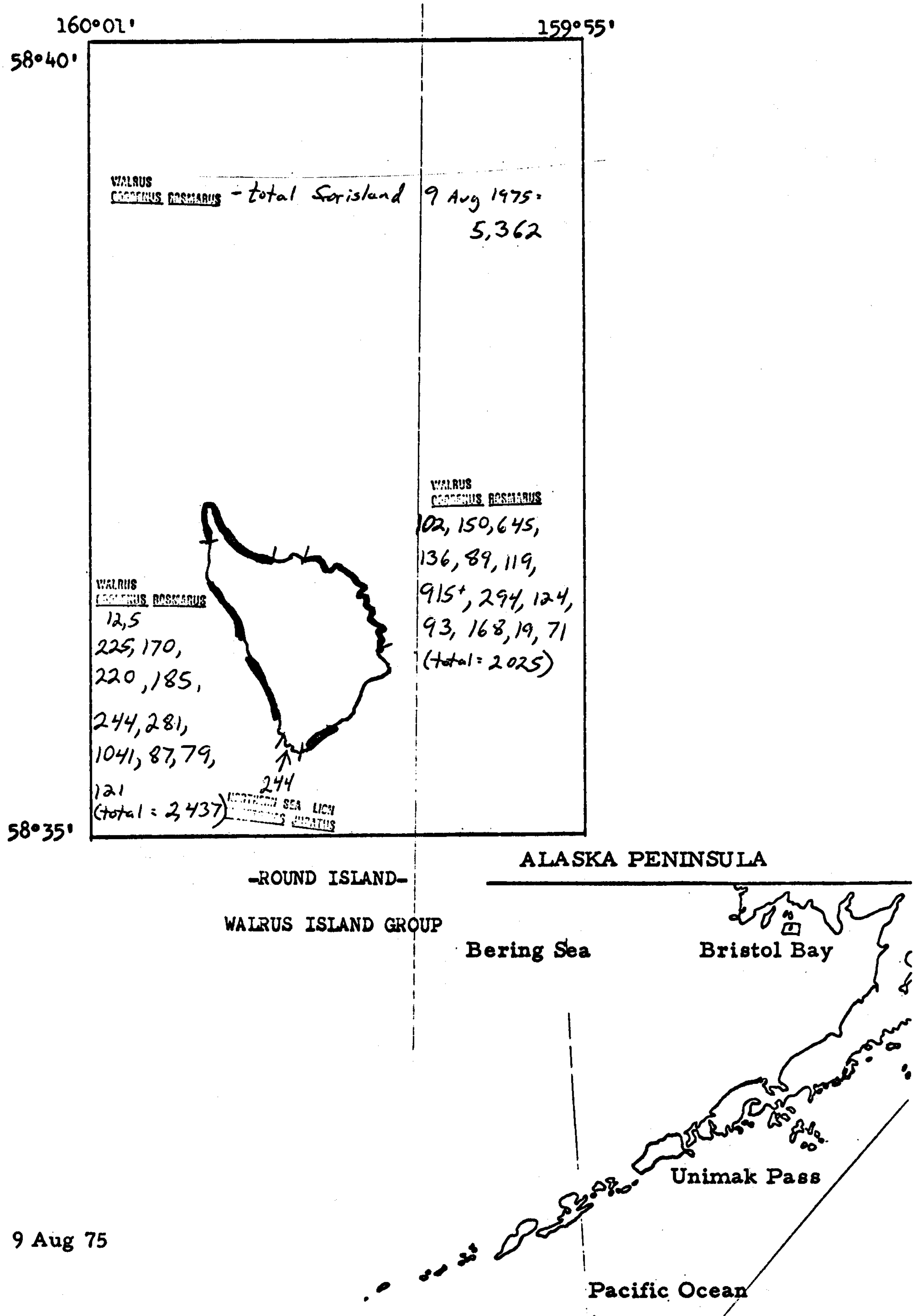

160°01'
159°55'
58°40'
58°35'
WALRUS
- total for island 9 Aug 1975:
5,362
WALRUS
102, 150, 645,
136, 89, 119,
915+, 294, 124,
93, 168, 19, 71
(total = 2025)
WALRUS
12, 5
225, 170,
220, 185,
244, 281,
1041, 87, 79,
121
(total = 2,437)
244
-ROUND ISLAND-
WALRUS ISLAND GROUP
ALASKA PENINSULA
Bering Sea
Bristol Bay
Unimak Pass
Pacific Ocean

Fig. 5 9 Aug 75

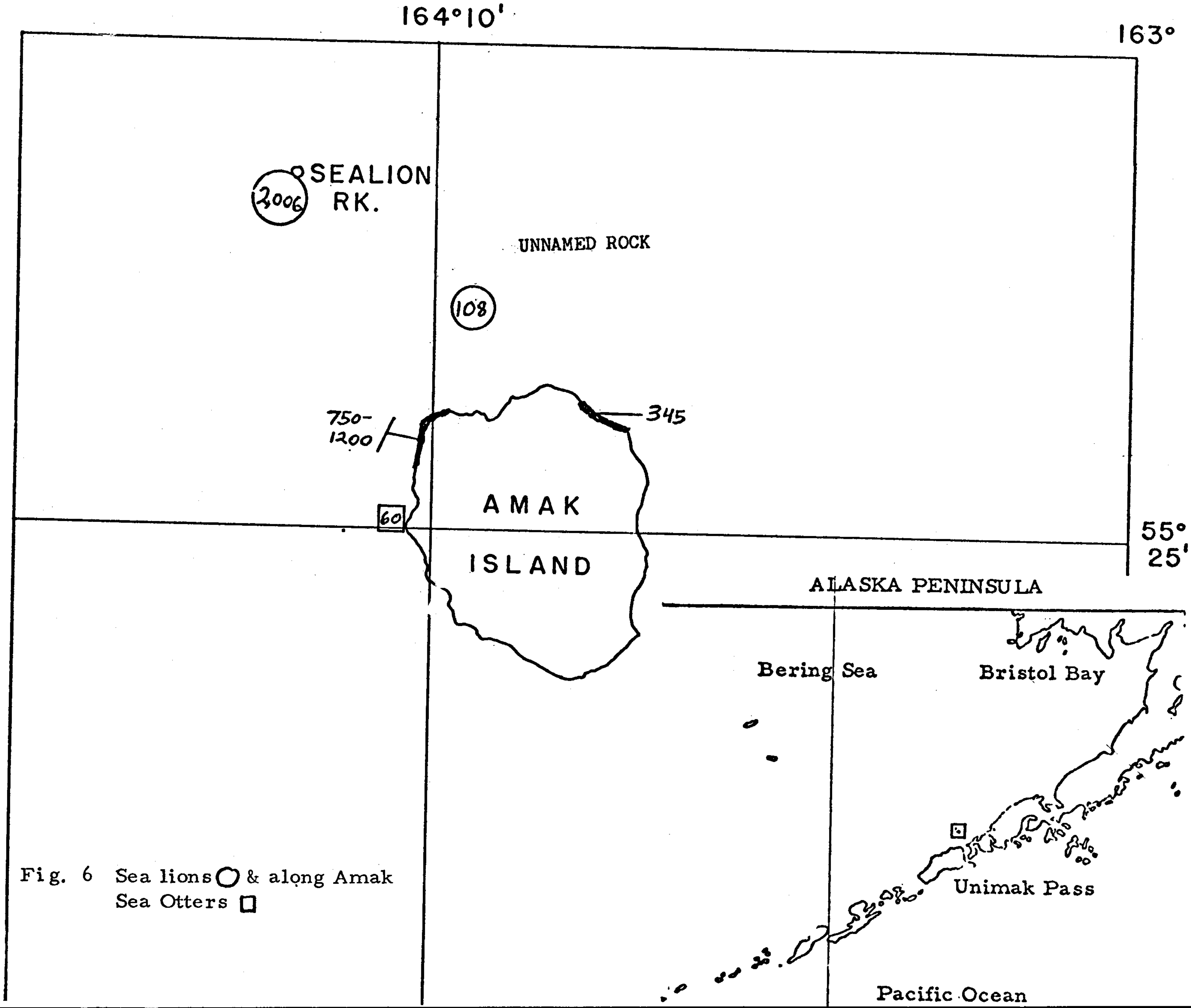


Fig. 6 Sea lions ○ & along Amak
Sea Otters □

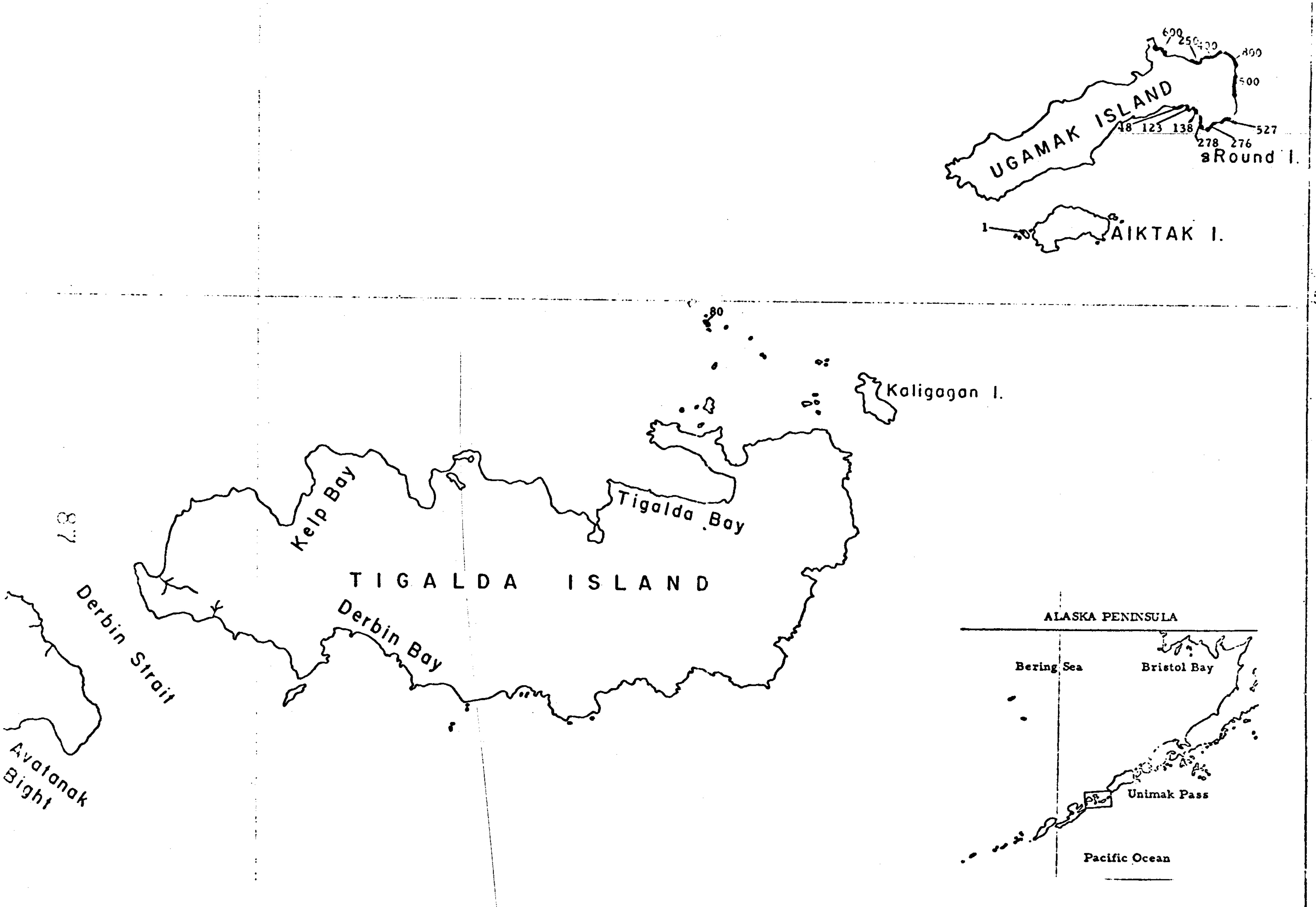


Fig. 7 Sea lions - June 75 - Krenitzin Islands

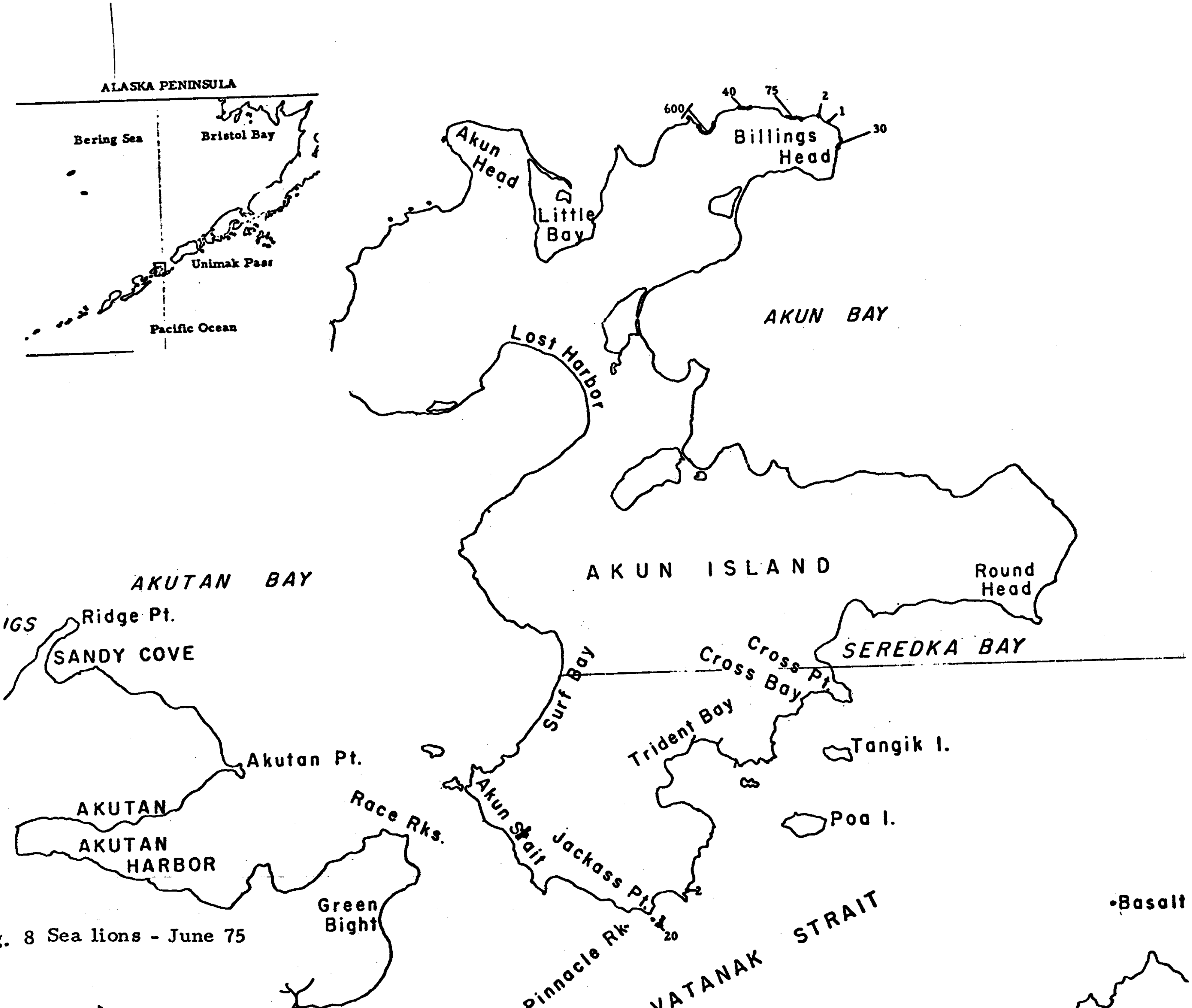


Fig. 8 Sea lions - June 75

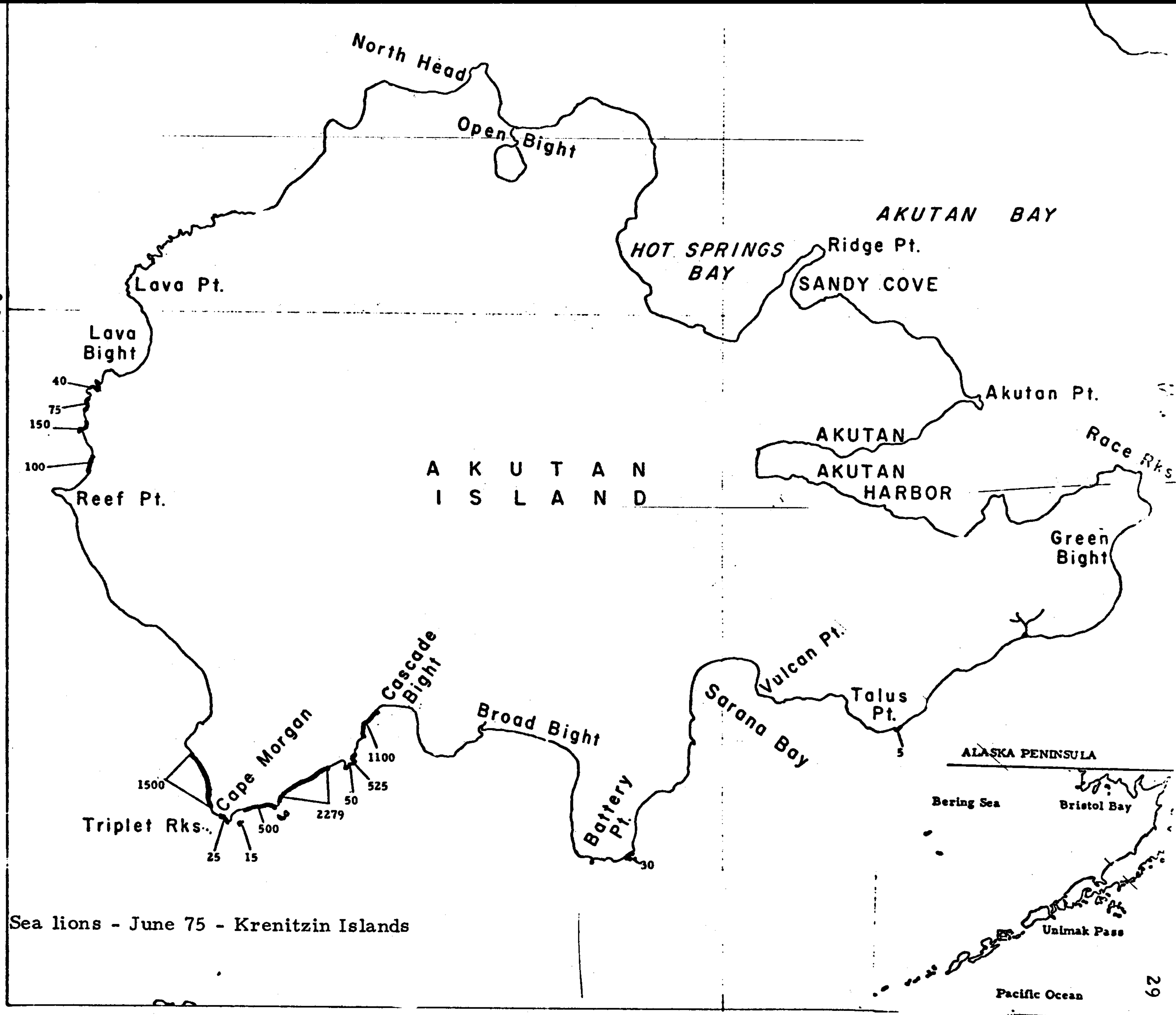
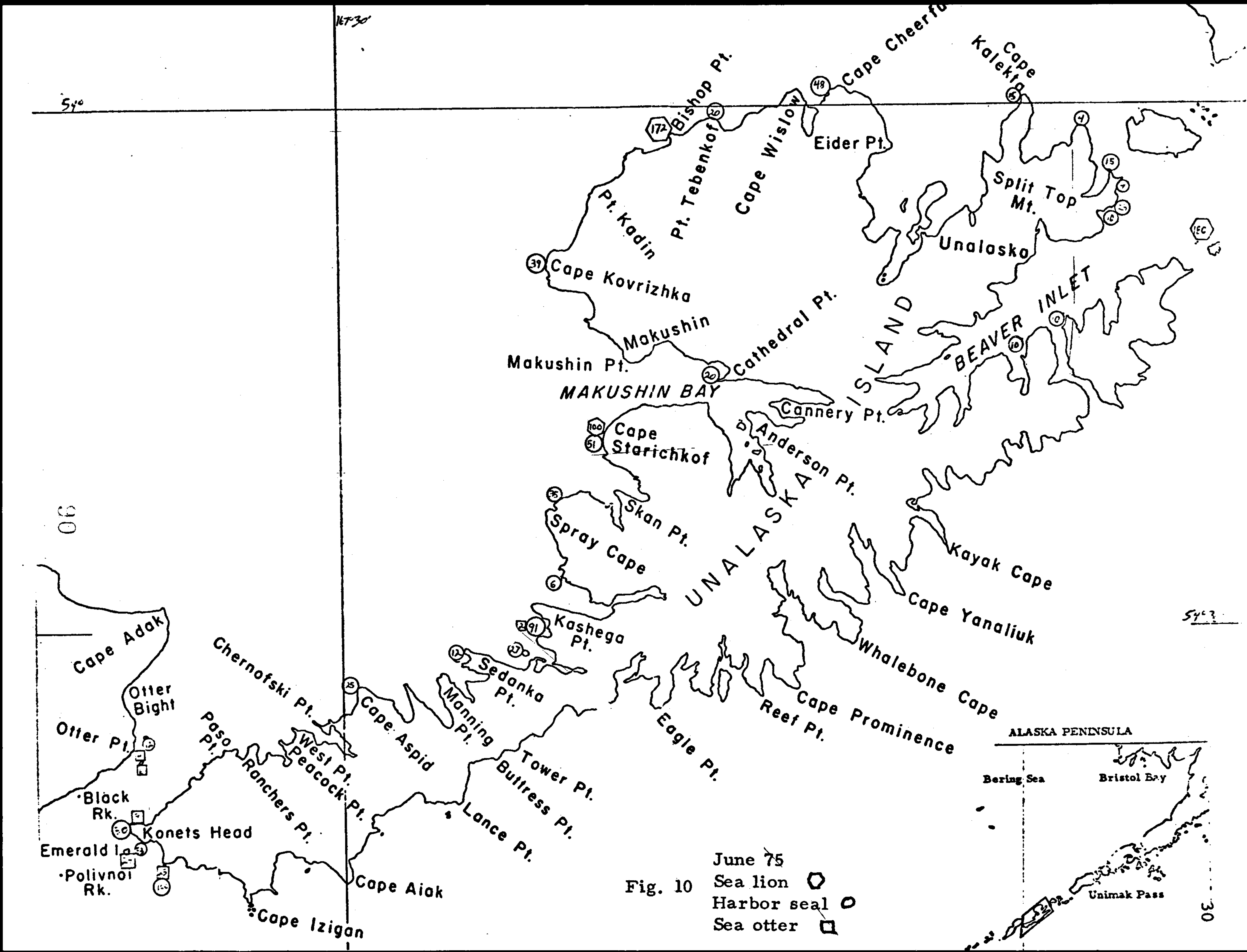


Fig. 9 Sea lions - June 75 - Krenitzin Islands



54°
Bishop Pt.
Cape Cheerful
Cape Kalekta
Eider Pt.
Cape Wislow
Pt. Tebenkof
Pt. Kadin
Split Top Mt.
Unalaska
Cape Kovrizhka
Makushin
Cathedral Pt.
Makushin Pt.
MAKUSHIN BAY
BEAVER INLET
ISLAND
UNALASKA
Cannery Pt.
Cape Starichkof
Anderson Pt.
Skan Pt.
Spray Cape
Kayak Cape
Cape Yanaliuk
Kashega Pt.
Sedanka Pt.
Whalebone Cape
Cape Adak
Chernofski Pt.
Otter Bight
Otter Pt.
Cape Aspid
Manning Pt.
Cape Prominence
Reef Pt.
Eagle Pt.
Tower Pt.
Buttress Pt.
West Pt.
Peacock Pt.
Paso Pt.
Ranchers Pt.
Black Rk.
Konets Head
Emerald Is.
Polivnoi Rk.
Lance Pt.
Cape Aiak
Cape Izigan
ALASKA PENINSULA
Bering Sea
Bristol Bay
Unimak Pass
June 75
Sea lion
Harbor seal
Sea otter

Fig. 10

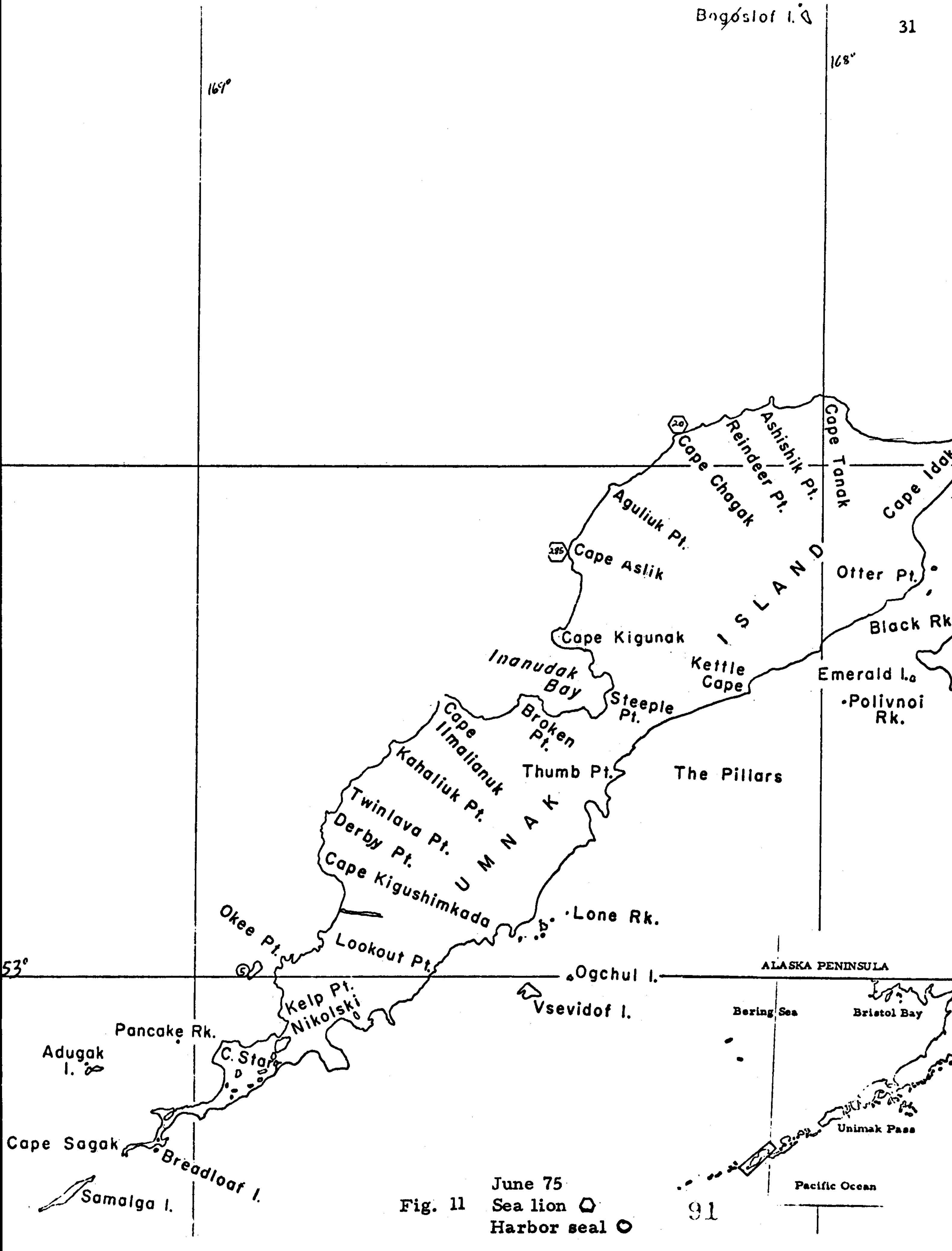


Fig. 11 June 75
Sea lion
Harbor seal

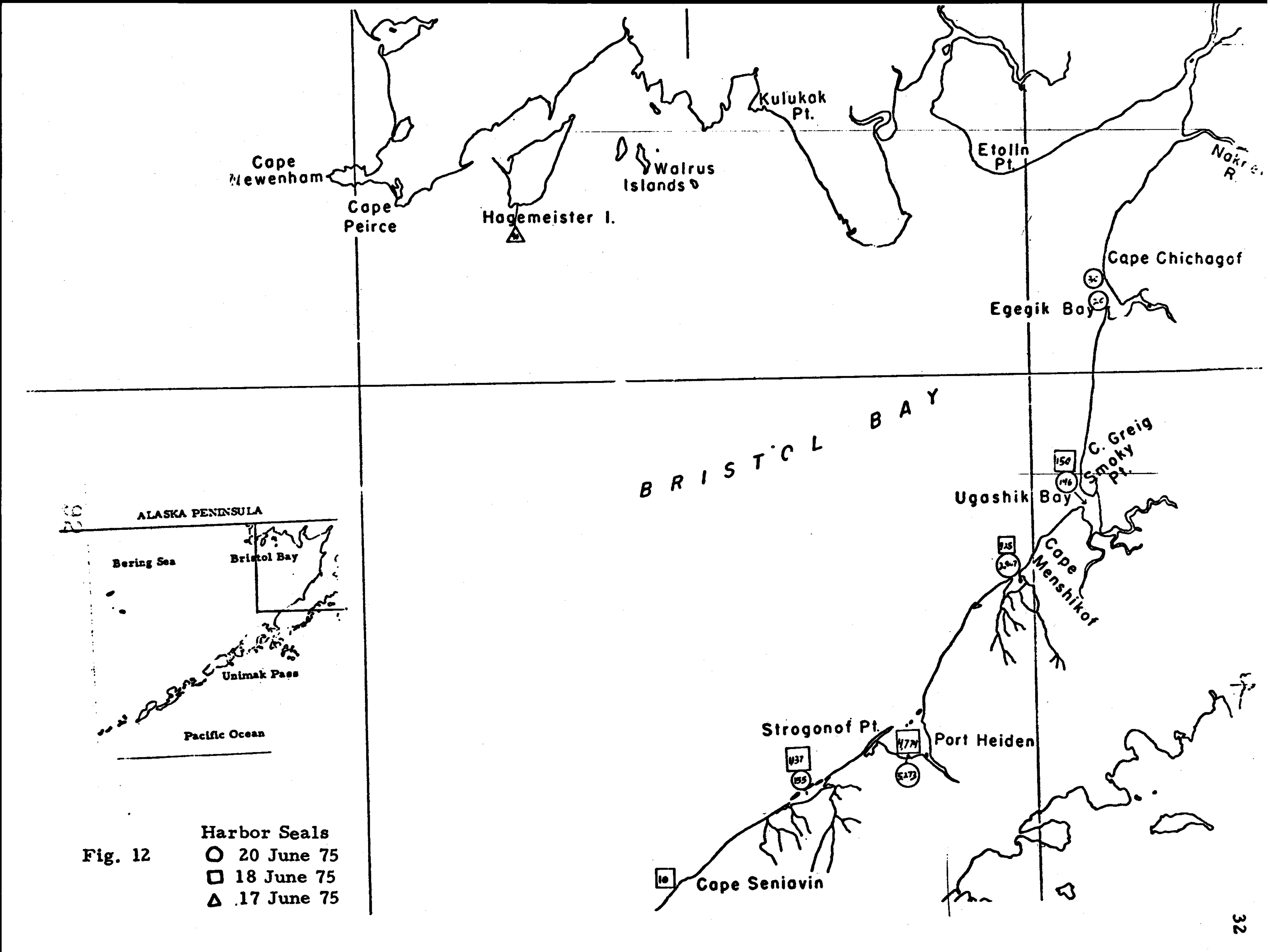

Cape Newenham
Cape Peirce
Hagemeister I.
Walrus Islands
Kulukak Pt.
Etolin Pt.
Cape Chichagof
Egegik Bay
BRISTOL BAY
C. Greig
Smoky Pt.
Ugashik Bay
Cape Menshikof
Strogonof Pt.
Port Heiden
Cape Seniavin
ALASKA PENINSULA
Bering Sea
Bristol Bay
Unimak Pass
Pacific Ocean
Harbor Seals
O 20 June 75
□ 18 June 75
△ 17 June 75

Fig. 12

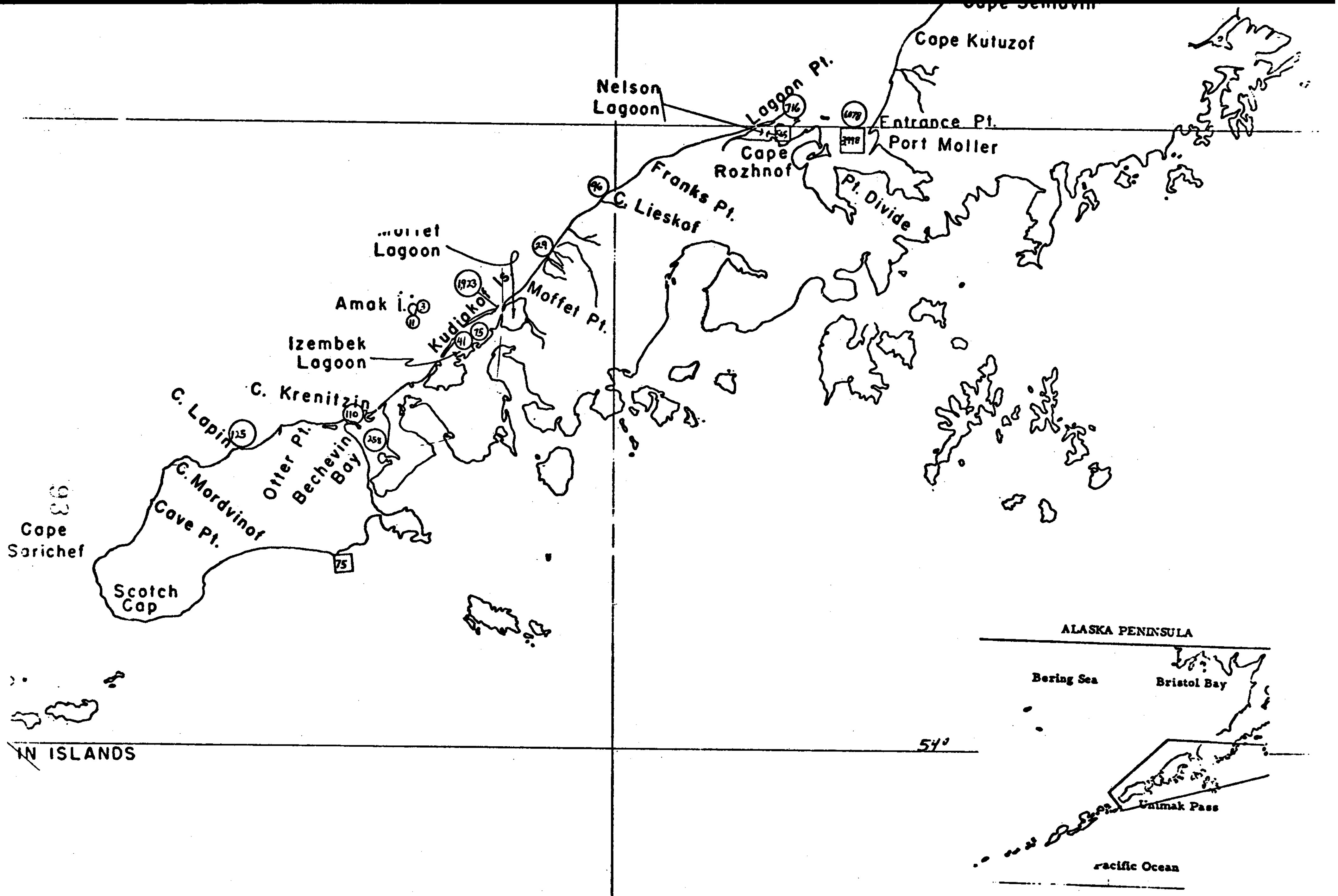


Fig. 13

Harbor Seals
○ 20 June 75
□ 18 June 75

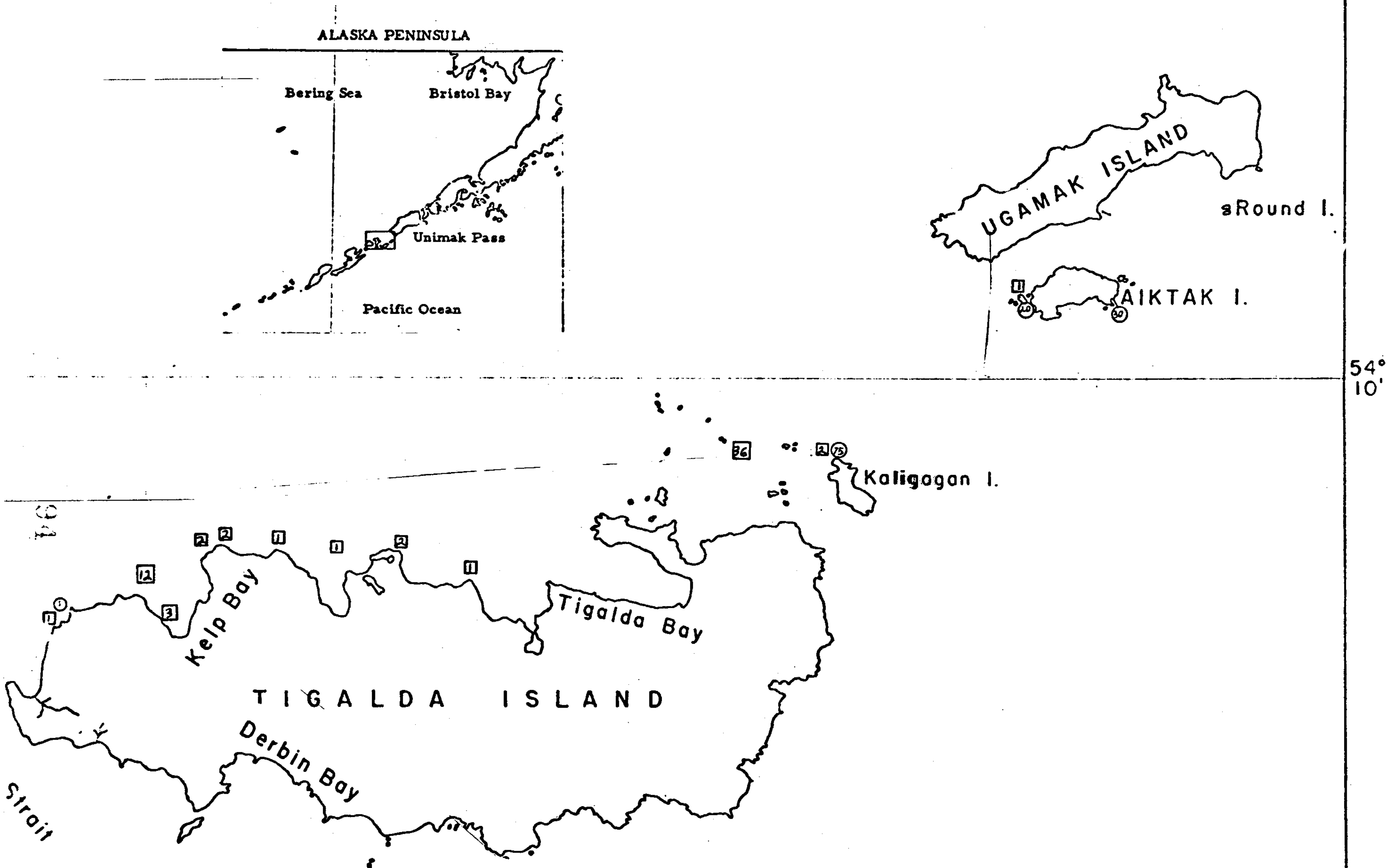


Fig. 14 June 75
○ Harbor Seals
□ Sea Otter

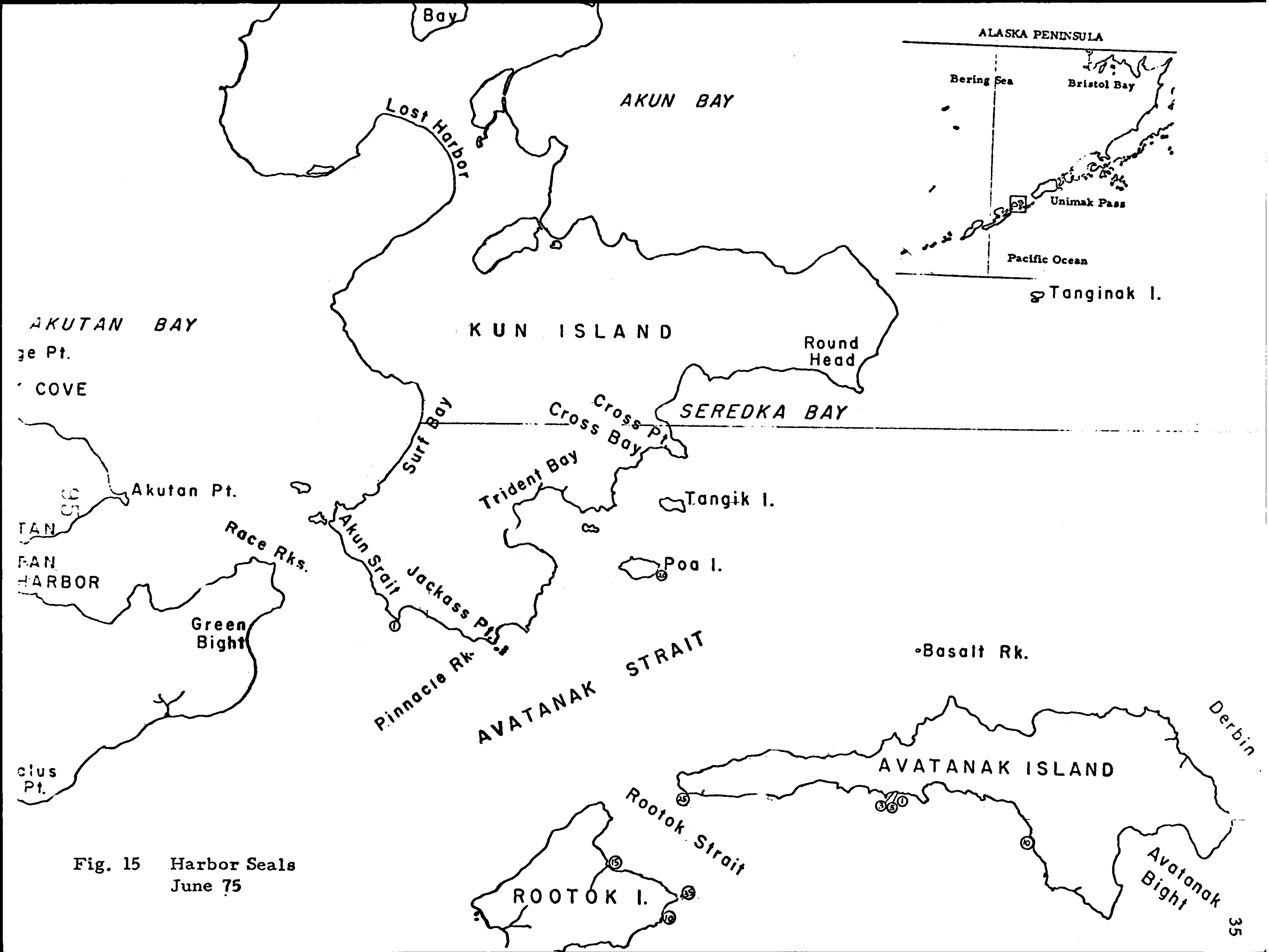


Fig. 15 Harbor Seals
June 75

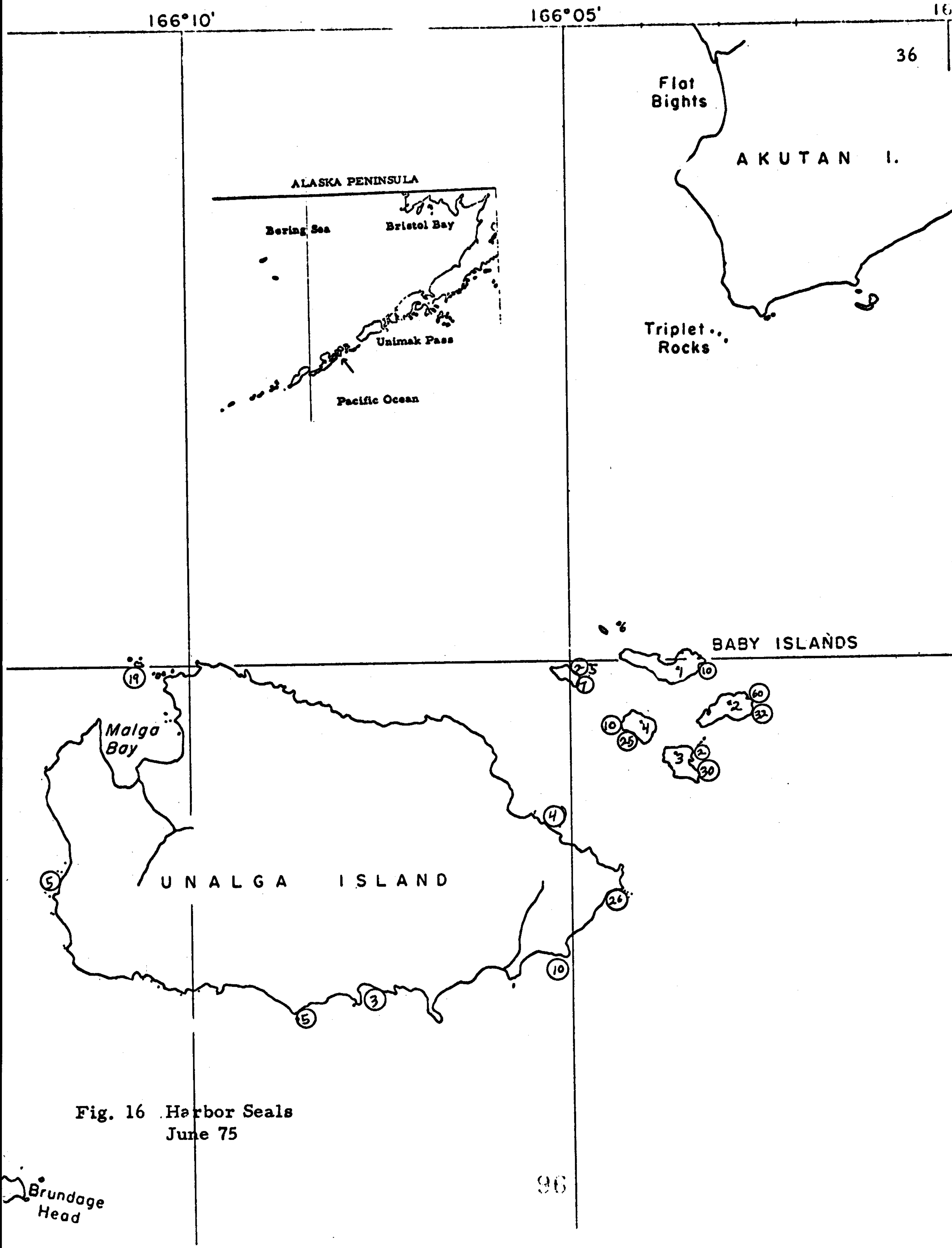


Fig. 16 Harbor Seals
June 75

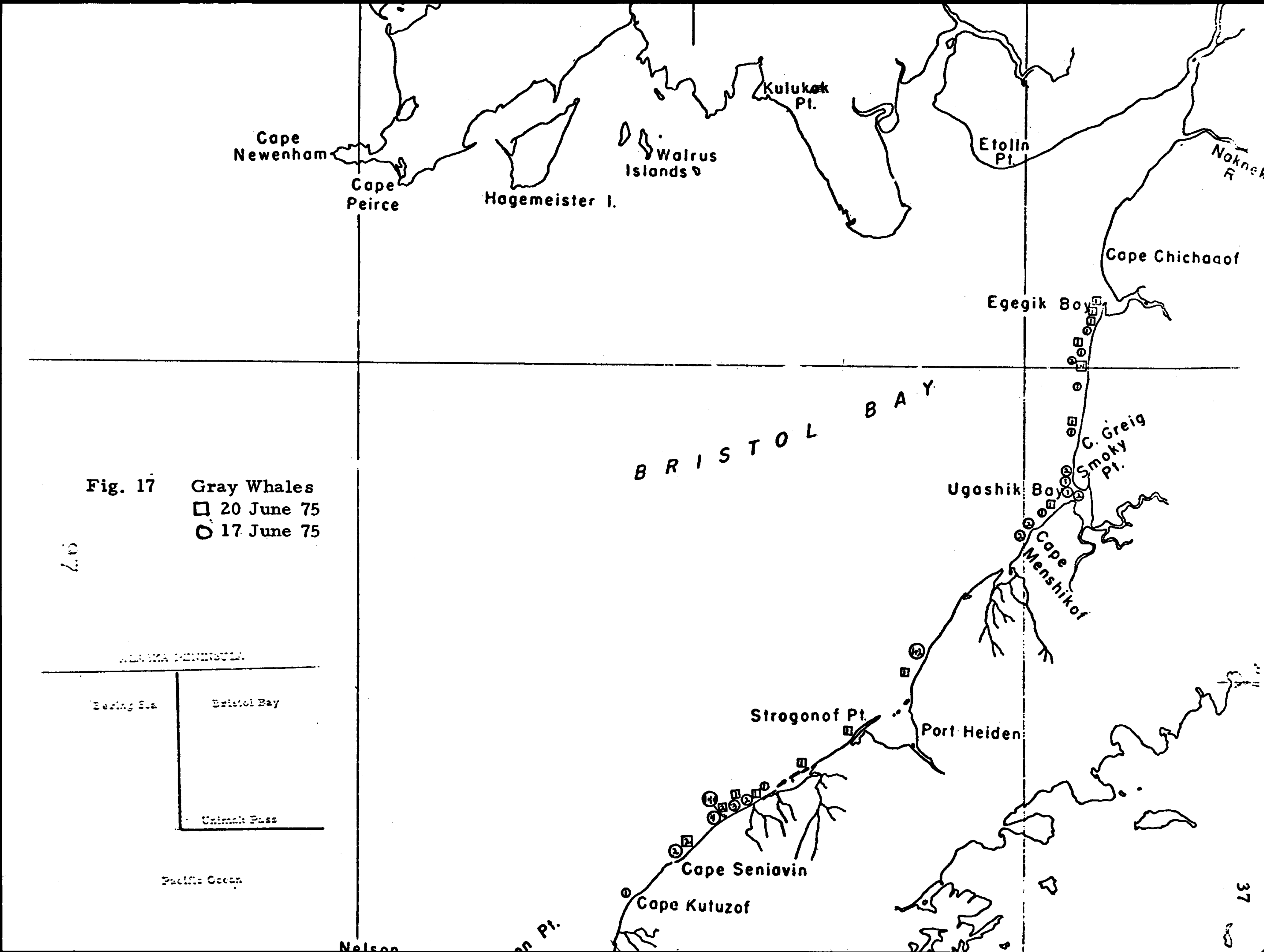
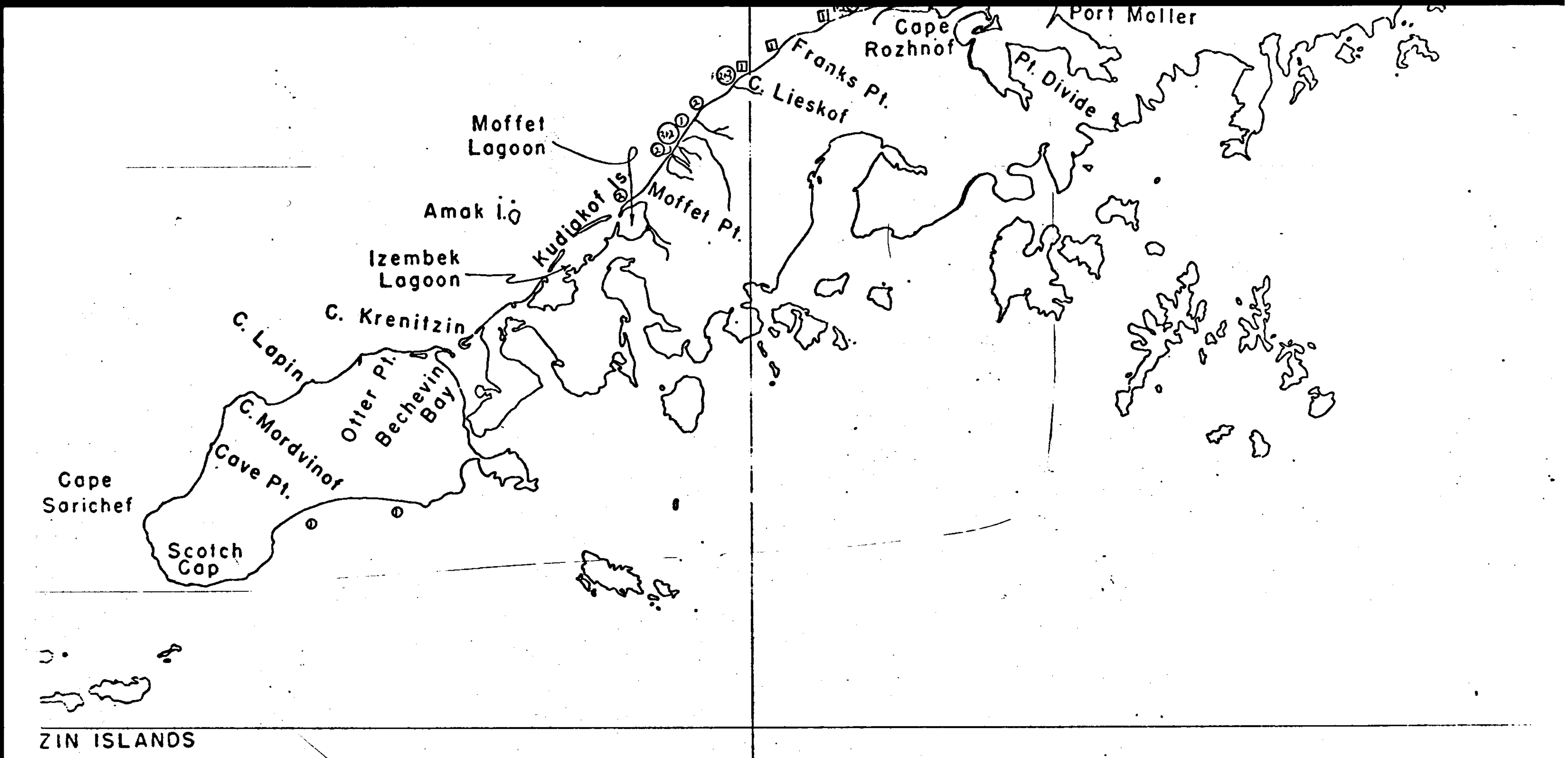


Fig. 17 Gray Whales
□ 20 June 75
○ 17 June 75



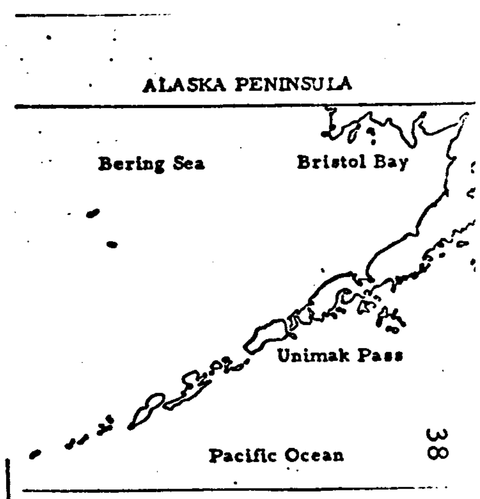


Fig. 18 Gray Whales
□ 20 June 75
○ 17 June 75

The August survey trackline is shown in Figures 1 through 3. Approximately 2600 miles of coastline were flown in August and 950 photographs of marine mammals were taken. Counts of animals are being made from the slides and the results of the counts will be presented in the final report.

The species observed during the August survey were:

Sea Otter	Enhydra lutris
Northern Sea Lion	Eumetopias jubatus
Walrus	Odobenus rosmarus
Harbor Seal	Phoca vitulina
Gray Whale	Eschrichtius robustus
Minke Whale	Balaenoptera acutorostrata
Harbor Porpoise	Phocoena phocoena

D. Aerial survey number three, 9-14 October 1975.
All pelagic marine mammals observed in the southern Chukchi and northern Bering Sea during the October survey are summa rized in Table 10. Four unidentified whales were seen, three in the southern Chukchi Sea northwest of Kivalina, AK and one in the Bering Sea west of Nome, AK. Of the 13 walruses observed, six were seen in the southern Chukchi Sea, one north of St. Lawrence Is. and six south of Hagemeister Is. in north Bristol Bay. Four bearded seals were observed in the southern Chukchi Sea west of Kotzebue Sound.

Twelve largha and/or spotted (Harbor)seals were seen; one in the Bering Strait and 10 just west of Nunivak Is. Approximately 333 northern sea lions were photographed hauled out along the east shore of Hall Island just northwest of St. Mathew Island. A chronological geographic listing of each marine mammal species sighted is recorded in Table 11.

Many dead or beached marine mammal carcasses were observed during the survey (Table 12). These data were forwarded to Dr. Francis Fay, Univ. of Alaska, for use in his OCS research project on mortality and morbidity in marine mammals (RU 194).

VII. Discussion

A. Aerial surveys one and two, 16-20 June and 9-14 August.
Life histories, distribution and abundance of each species surveyed along the Alaska peninsula will be described in detail in the final report (1 October 1976). The numbers observed and locations of animal concentrations will be compared to the summer 1976 surveys, with other OCS

Table 10. A summation of the numbers of marine mammals observed by species or group during aerial survey number three, 9-14 October 1975.

Species or group	Number of animals seen			
	9 Oct.	12 Oct.	14 Oct.	Total
Walrus (Odobenus rosmarus)	6	1	6	13
Bearded seal (Erignathus barbatus)	4	0	0	4
Largha and/or harbor seal (Phoca spp.)	1	1	10	12
Northern sea lion (Eumatopias jubatus)	0	0	333* 3	336
Unidentified whales	3	1	0	4
Unidentified seals	1	0	0	1

* Hall Is.

Table 11. A summary of marine mammal sightings by time and location during aerial survey number three, 9-14 October 1975.

Date-Time	Lat. (N) Long. (W)	Species (#)	Distance from track (miles)	Remarks
9 Oct.				
1317	67°41' 167°11'	1 UW	< 1/8 s	
1322	" 41.9' " 58.5'	1 BS	< 1/8 s	
1339	" 41.5' 169°26.5'	1 UW	> 1/2 s	Single blow
1350	" 41' 170°30'	1 UW	on track	Sounding
1356	" 27' " 29'	2 W	< 1/8 s	
1426	" 11.9' 168°12.3'	1+1 W	< 1/8	
1432	" 13.2' 167°34'	1 US	-	
1545	" 02.5' " 57'	1+1 BS	R/aft*	
1548	" 02.6' 168°08.7'	1 BS	R/aft	
1559	" 03.4' 169°32.6'	2 W	R/aft	Bulls
1640	66°54.1' 167°21.3'	1 LS	R/aft	
12 Oct.				
1013	63°09.1' 168°20'	1 LS	-	Surfaced
1147	64°21' 170°13.9'	1 W	-	
1237	" 21.2' 166°04'	1 UW	> 1/2	
14 Oct.				
1328	60°40' 173°03.3'	333 SL	-	Hall Is.
1517	" 03.4' 167°18.8'	10 LS	-	Cape Mon-igan, Nunivak Is.
1621	58°42.4' 162°46.6'	3 SL	< 1/8 p	
1645	" 20.8' 160°57.1'	1 W	< 1/8 s	
1649	" 20.3' " 39.8'	1+1 W	< 1/8 s	
1650	" 20.1' " 35.1'	2 W	< 1/8 s	
1651	" 19.9' " 31.5'	1 W	< 1/8 s	

Key: W walrus BS bearded seal LS largha seal SL northern sea lion UW unidentified whale US unidentified seal p-port s-starboard
* observed from aft compartment of the P2V, not recorded in the general flight log.

Table 12. Beached carcasses or dead marine mammals observed during aerial survey number three, 9-14 October 1975.

Time	Lat. (N)	Long(W)	Species (#)	Remarks
9 Oct.				
1130	64°59'	166°41'	1 unident. whale 6 walruses	Walruses spread along the beach at Cape Douglas
12 Oct.				
1005	63°05'	168°50'	39 walrus	Punuk Is.
1010	" 08.1'	" 55.3'	1 walrus	s/e St. Lawrence Is.
1014	" 09.4'	169°14.2'	1+1+1 unident. whales	s/e St. Lawrence Is.
1016	" 06.2'	" 24.8'	1 unident. whale	n/e Southwest Cape, St. Lawrence Is.
1019	62°58.8'	169°39.6'	1 unident. whale	East Pt., Southeast Cape, St. Lawrence Is.
14 Oct.				
1622	58°39'	162°38'	1 walrus	Floating in water west of Cape Newenham.

surveys and with published accounts. These data will be discussed at some length in the final report in terms of habitat and critical times when the effects of oil-gas development might be of greatest concern.

B. Aerial survey number three, 9-14 October.
Most animals seen during the October survey occurred within 1/8 mile on either side of the trackline. Those animals seen beyond 1/8 mile were all whales. Pinnipeds were apparently not identifiable outside of the 1/4 mile strip, although the data could not be quantified because of the small sample size. This preliminary finding suggests that future pelagic surveys concentrate on strip census techniques rather than using the transect method.

Whether the ~~low numbers~~ of marine mammals seen at sea during October represented a real population condition or as a result of poor visibility, cannot be concluded upon at this time. Fog, high winds, rain, snow and other environmehtal factors all affect the success of survey flights. During the October pelagic survey most transects were flown over rough seas or in and out of snow squalls; both conditions making it very difficult to sight marine mammals. Better weather and thus better observation conditions occur earlier in the fall, hence future fall surveys will be flown in September rather than October.

Because of rapidly changing weather conditions, a considerable amount of time was spent recording. This seemed to unnecessarily burden the recorder and directed his attention away from the observation effort. This will be eliminated by use of a tape recorder to record weather and sea state - visibility while keeping a written account of sightings; serving as a back-up in case of tape recorder malfunction. This will enable the recorder to spend more time as an observer and thus increase the sighting effort.

Our field format sheet has been updated to include a check list method of recording data. This will also reduce recording time. Data reduction and synthesis will be made more efficient now that the field format and the data management format are systematically compatable.

VIII. Conclusion

Although statistical analyses of the data are not complete, it would appear that a major portion of northern sea lion and harbor seal populations in the southern Bering Sea haul-out and breed along the northern Alaska Peninsula. Their distribution and use of specific, and perhaps traditional, breeding grounds has not been completely delineated, but appear to be definable in terms of determining their juxtaposition to oil-gas lease sites in Bristol Bay. The importance of these breeding sites may never be fully known until a comprehensive distribution map is made of these animals from the Aleutian Is. chain and along the southern boundaries of the Alaska Peninsula. We espect to have a good understanding of site-specific uses by sea lions and harbor seals after the spring-summer 1976 surlvey in which confirmation of data collected in 1975 should be forthcoming. At that time our judgement as to the critical nature of habitat use, and animal abundance should be clearer.

Fall aerial surveys in the northern Bering Sea and southern Chukchi Sea will be critically analysed for their feasibility -- on a cost benfefit ratio. Our view is that site selected sampling near St. Lawrence Is. through the Bering Strait and into the southern portions of the Chukchi Sea is possible but must be refined before reducing any aerial survey effort in the fall. Revisions in the fall survey effort will be offered for FY 1977 allowing us time to make an adequate evaluation of the survey effort in general, yet providing enough sampling time (i.e. data) to make a quantitative determination of its feasibility. Time permitting, an evaluation of the fall 1976 survey will be included in the final report (1 October 1976) with a judgement as to its usefulness.

X. Summary of 4th. quarter operations.

A. Ship or laboratory activities.
1. Ship or field trip schedule.
a. None - spring field season for RU 67 begins in April, 1976.
2. Scientific party.
a. None.
3. Methods.
a. Field sampling operations for the upcoming spring season (April-June) were developed and summarized. It was determined, a priori, that a combination of systematic and randomized aerial transect flights would maximize our sampling effort (i.e. population abundance estimates) yet minimize our time spent surveying.
4. Sample localities.
a. None during the 4th. quarter.
5. Data collected or analyzed.
a. Laboratory analysis - data collected during the October, 1975 aerial survey in the northern Bering Sea were summarized and evaluated (see annual report). These data are being processed into data management format, and should be ready for EDS during the 5th. quarter period.

ADDENDUM

Sample Annotated Bibliography

Research Unit 67

Bibliographic citations listed may apply to one or more research units. In the final report (1 October 1970) each RU will have listed a comprehensive annotated bibliography covering the appropriate geographic region(s) for which each RU is responsible.

Bailey, Alfred M. and Russell W. Hendee. 1926. Notes on the mammals of northwestern Alaska. J. Mammal. 7(1): 9-28.

Recounts an expedition of 15 months in 1921-22, visiting King and St. Lawrence Islands, Wainwright, Point Hope, Demarcation Point, and points on the Siberian coast. Includes observations on: polar bear, largha seal, bearded seal, ringed seal, walrus, bowhead whale, gray whale, killer whale and harbor porpoise.

Barabash-Nikiforov, I. 1938. Mammals of the Commander Islands and the surrounding sea. J. Mammal. 19(4): 423-429.

Briefly describes geography, climate, flora and fauna of the islands, and describes 18 species of marine mammals: otter, 7 pinnipeds, 5 great whales, 3 beaked whales, killer whale and 3 other dolphins. Notes seasonality of most species.

Burns, John J. 1965. Marine Mammal Report. Vol. VI, Annual Project Segment Report, Federal Aid in Wildlife Restoration Project, Alaska Department of Fish and Game. 45 pages.

Covers calendar year 1964. Major spring migration of walrus through Bering Strait occurred during the last week in May and the first week of June. This was at the same time as during previous years, in spite of an unusually slow retreat of the pack ice. Forty-one adult females examined were 64% parturient, 24% pregnant, and 12% barren. Parturition rate was found to be one calf every 2.02 years, among twenty-nine animals. Also contains short sections on migration (including notes on correlates of ice movement), segregation of sexes, and foetal development. in addition to reproductive investigations.

Notes that 10 or 12 whales, mostly grays, were taken at Barrow during the summer. Bearded seal biology is given in detail. Nursing period is short, 12-18 days, and by weaning time the pup has reached 69% of adult length. Migration is generally concurrent with the seasonal advance and retreat of the pack ice, although young seals are sometimes found where there is no ice.

Burns, John J. 1965. Marine Mammal Investigations in northwestern Alaska. Paper presented at the 45th Annual Conference of the Western Assoc. of State Game and Fish Commissioners, Anchorage, AK, July 8, 1965. 10 pages.

Discusses biology and management of walrus and bearded seal, with concise presentation of natural history.

Burns, John J. 1965. The Walrus in Alaska. Vol. V, Fed. Aid in Wildlife Restoration Project Report covering investigations completed by Dec. 31, 1963. Alaska Dept. of Fish and Game. 48 pages.

The history of walrus exploitation, economic role in Alaska, and recent and current research are discussed. Some of the early chronicles, and nearly all scientific investigators are listed and referenced in the bibliography. Original research reported was collected for walrus observations to determine migration and distribution patterns. Most females start to breed around age 6, males about the same. Most mature females bear one calf every 2 years. Major food species are Mya truncata and Clinocardium nuttalli (clams). Walrus predation on seals is discussed. Minimum population is estimated at 90,000. Migration and known distribution is given, by season, combining published and unpublished observations. Collected observations of hauling out areas are given, including the Walrus Islands in Bristol Bay and the Punuk Islands. Collected behavioral observations are given.

Burns, John J. 1966. Marine Mammal Report. Vol. VII Annual Project Segment Report, Fed. Aid in Wildlife Restoration. Alaska Dept. of Fish and Game. 47 pages.

Walrus teeth were examined from known age walruses, and the tooth interpretation method previously used was found valid. Reproductive tracts of 160 mature females from nursery herds were examined; 71 percent were newly parturient, 21% were pregnant, 8% were barren. Females first breed at age five or six, and calve from then on an average of once every 2.2 years. Adult female Pacific walrus reach a weight of about 2,100 pounds. The main migration moved through Bering Strait from 20 May - 18 June. Some positions and dates of of walrus concentrations are noted. 21,015 seals were harvested and bountied from just south of Nunivak Island to Barrow, by 512 hunters: 13,~~590 ringed~~, 3,430 bearded, and 3,995 harbor seals.

Burns, John J. 1967. Marine Mammal Report. Vol. VIII, Annual Project Segment Report, Federal Aid in Wildlife Restoration Project. Alaska Dept. of Fish and Game. 44 pages.

Analysis of the age composition of 353 male walrus taken at Savoonga indicated an annual mortality rate of about 12 percent (maximum) for year classes 14 through 28, and about 14 percent (maximum) for year classes 14 through 33. Size of population is apparently continuing to increase. Walrus observations are reported from Nushagak Bay (May), Round Island in Bristol Bay (May-June), Big Diomede Island and the Punuk Islands (early December). Eighty percent of the walruses harvested were taken by the villages of Gambell, Savoonga, Diomede and King Island. It is noted that some male walrus winter, singly or in small herds, much further north than the main groups (occassionally as far north at Lat. 70° in late February). Concentrations of animals were moving through the Bering Strait from May 28 to July 4. Five species of pinnipeds in the northern Bering Sea are discussed: ringed, ribbon, bearded and harbor seals, and walrus. A map gives the distribution of these species in April-early May and the distribution is discussed as it corresponds to their different adaptations.

Burns, John J. 1970. Remarks on the distribution and natural history pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51(3): 445-454.

Author's abstract: "Five species of pagophilic (Ice-loving) pinnipeds live in the Bering and Chukchi seas: *Odobenus rosmarus*, *Phoca* (Pusa) *hispida*, *Phoca* (Histriophoca) *fasciata*, an ice-breeding population of *Phoca* (Phoca) *vitulina*, and *Erignathus barbatus*. Breeding adults of these species are mostly separated from each other during late winter and early spring, when throughout the pupping and subsequent mating periods, *P. vitulina* and *P. fasciata* occupy the edge-zone of of the seasonal pack ice, *E. barbatus* and *O. rosmarus* are mainly farther north within the heavier pack ice, and *P. hispida* occupies areas of extensive land-fast ice. This paper discusses differences in body structure, ecological adaptation, and behavior in relation to distribution of the five species."

Burns, John J. 1973. Marine Mammal Report. Vol. XIII, Project Progress Report, Federal Aid in Wildlife Restoration. Alaska Dept. ~~of Fish and~~ Game. 29 pages.

Research activities included three cruises; the first in the eastern Bering Sea from Nome to west of Unimak Pass, 27 March-21 April 1971; the second, in March and April of 1972, restricted to the southern Bering Sea; the third in the waters near Juneau, November 1972. Fifty-three harbor seals and two ribbon seals were tagged on the first cruise, 23 harbor seals and 1 ribbon seal on the second. On the third cruise, 21 specimens of *Phoca vitulina richardii* were taken. Fish and invertebrates were also collected as part of the second topic, preparatory to studying pinniped feeding. Information on biological and commercial status, including seasonal distribution of *P. largha*, *P. fasciata*, *E. barbatus* and *P. hispida* are described. 1 fig., 4 tables.

Burns, John J. and Loren W. Croxton. 1963. Marine Mammal Investigations. Vol. III, Annual Project Segment Report, Fed. Aid in Wildlife Restoration, Alaska Dept. of Fish and Game. 38 pages.

Walrus biology and population status covering the period April 1 - June 30, 1962. Northward migration passed Gambell May 8-24, Savoonga May 3-23, Bering Strait June 1-7. Harvest records of walrus and sea otters are included.

Burns, John J. and Samuel J. Harbo, Jr. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25(4): 279-290.

Flights were made to survey the landfast ice from Point Lay to Barter Island from 8-15 June 1970, to establish baseline distribution and density of ringed seals. The density of seals in sectors east of Point Barrow was low and relatively uniform (2.28, 1.06, 1.38 and 2.43 seals/mi^2). Within sectors southwest of this point, density was substantially higher (5.36 and 3.70 seals/mi^2). The minimum population was estimated at 11,612 animals. Areas of previous seismic oil exploration within the survey area were compared to undisturbed portions and no appreciable difference in ringed seal occurrence was found. 4 figs., 3 tables.

Burns, John J., G. Carleton Ray, Francis H. Fay, and Peter C. Shaughnessy. 1972. Adoption of a strange pup by the ice-inhabiting harbor seal, Phoca vitulina largha. J. Mammal. 53(3): 594-598.

On 20 April 1971 at Lat. 57°51'N, Long. 165°54'W, the authors replaced the 4-week-old pup of a pair of seals with a previously captured 2-week-old pup. They subsequently observed the new pup nursing from the female. During their cruise from 11-20 April they sighted 103 pairs of adult harbor seals in the 20-mile wide ice front zone to the north and east of the Pribilof Islands. 2 photos.

Burns, John J. and James E. Morrow. 1973. "The Alaskan arctic marine mammals and fisheries". Paper given at the Fifth International Congress of the Fondation Francaise D'Etudes Nordiques, called "Arctic Oil and Gas: Problems and Possibilities", at Le Havre, May 2-5, 1973. 22 pages.

Author discusses fishes and marine mammals of the Chukchi Sea, the arctic coast of Alaska and the northern Bering Sea with respect to offshore oil development. Toxicity of crude or refined oil to fishes is known and extreme toxicity to eggs and larvae is noted. Oil spilled in arctic waters will persist, due to the low temperature and slower decomposition. Seismic exploration by several different concerns often involves a succession of explosions in the same areas which destroy fish. Epontic algae grows on the under surface of the ice. Accidental or chronic gradual discharge of oil would spread under the ice, be trapped there for long periods of time, and either kill the algae there or be incorporated into the food chain from there on up. The same results can occur among benthic organisms when oil is deposited on the bottom. The occurrance of all arctic marine mammals is discussed.

Clarke, Robert. 1957. Migration of marine mammals. Norsk Hvalfangsttidende 46(1): 609-630.

A general review of migrations of the large whales and of small numbers of small cetaceans, fur seals, phocid seals, and walruses. Notes lack of understanding of mechanisms of migration. 11 figs., 76 refs.

Fay, Francis H. 1960. Carnivorous walrus and some arctic zoonoses. Arctic 13(2): 111-122.

Information on carnivorous walruses are reviewed. Eskimos report that eating walrus liver produces the same illness as does eating polar bear liver. This illness is probably hypervitaminosis-A. Trichinosis has been identified with some walrus meat, but the incidence of infected walruses seems very low. Both species eat largely ringed and bearded seals.

Fay, Francis H. 1963. Unusual behavior of gray whales in summer. Physhologische Forschung 27: 175-176.

On July 26, 1960, near Kangee, on the southern coast of St. Lawrence Island, the author observed three whales involved in what appeared to be courtship behavior, and possible copulation.

Fay, Francis H. 1974. The role of ice in the ecology of marine mammals of the Bering Sea. In D. W. Wood and E. J. Kelley (Eds.), "Oceanography of the Bering Sea." Inst. of Marine Sci., U. of Alaska, Fairbanks. Pages 383-399.

Describes different kinds of ice; describes seasonal changes of ice and corresponding movements of marine mammals. Lists 25 species of marine mammals in 3 categories according to contact with ice. Good detail. Good understanding of habitats. Insights into evolution are discussed.

Fay, Francis H. 1975. Quarterly Report for Quarter Ending September 30, 1975. Project Title (BLM): "Morbidity and Mortality of Marine Mammals". 5 pages. (unpublished)

Several areas of Alaska coastline were surveyed for marine mammal carcasses: the north coast of the Alaska Peninsula from Bechevin Bay to the mouth of the Naknek River; the eastern shore of Kuskokwim Bay from Chagvan Bay to Jacksmith Bay; the coast of St. Lawrence Island; the Punuk Islands; and Kotzebue Sound from Sheshalik to Point Hope. Nearly four hundred carcasses were found. Well over half of these were walrus. Thirteen species in all are discussed. Causes of death included gunshot, trauma, predation, hemorrage, and probable bacterial infection. 3 maps.

Fiscus, Clifford H., Dale W. Rice, and Ancel M. Johnson. 1969. New records of *Mesoplodon stejnegeri* and *Ziphius cavirostris* from Alaska. J. Mammal. 50(1): 127.

Floating carcass of *Mesoplodon stejnegeri* found 43 km west of Cape Edgecombe, Gulf of Alaska, at Lat. 57°04'N, Long. 146°32'W. Skull of *Z. cavirostris* found at Trident Bay, Akun Island, at Lat. 54° 09'N., Long. 165°33'W.

Ichihara, Tadayoshi. 1958. Gray whale observed in the Bering Sea. Sci Rpts. Whales Res. Inst. 13: 201-206.

Gray whales were seen near St. Lawrence Island and in Unimak Pass in 1957, and 3 groups were found west of St. Lawrence Island in 1955. This suggests a migration route through the eastern Aleutian passes as Kellogg proposed in 1929, rather than around to the west of the Commander Islands as Gilmore proposed in 1955. 2 figs.

Johnson, Murray L. and Gordon D. Alcorn. 1962. The return of the sea otter. Outdoor Calif. 23(2): 4-5.

Recounts history of exploitation since 1741. Present population is estimated as high as 40,000. Distribution includes Amchitka Island, Delarof, Andreanof and Fox Islands, Alaska Peninsula, Kodiak archipelago, and Kenai Peninsula to Cape St. Elias in Alaska, and the California coast.

Kenyon, Karl W. 1961. Cuvier beaked whales stranded in the Aleutian Islands. J. Mammal. 42(1): 71-76.

Two carcasses of *Ziphius cavirostris* found on Amchitka Island apparently shot by rifle. Complete measurements given. 3 plates.

Klinkhart, Edward G. 1967. Birth of a harbor seal pup. J. Mammal. 48(4): 677.

On June 15, 1967, a female harbor seal gave birth at Tugidak Island, Alaska (Lat. 56°33'N., Long. 155°20'W.). One half-hour of observation, from 12 minutes before the birth until 18 minutes afterward, is reported.

Klinkhart, Edward. 1969. The harbor seal in Alaska. Alaska Dept. of Fish and Game, Wildlife Notebook Series. 2 pages.

Both ice- and non-ice-inhabiting harbor seals are described. Natural history is given. Annual harvest in northern Alaska is given as 4,000, and 30,000 in southern Alaska. A bounty was in effect from 1927 to 1967.

Lensink, Calvin J. 1960. Status and distribution of sea otters in Alaska. J. Mammal. 41(2): 172-182.

A detailed report and review of census efforts from Cook Inlet to Amchitka Island from 1936 to 1957. "The present status of the otter is such that we can expect a rapid expansion in numbers from the Andreanof Islands eastward. West of the Andreanof Islands the habitat is limited and the population may already be near the carrying capacity. Here, sea otters are perhaps as abundant as they were before exploitation by the Russians. On Amchitka Island the evidence indicates that a high population has resulted in increased mortality and a lowered reproductive rate." - from author's summary. Estimates present Alaska population at 40,000. Includes distribution map.

Marine Mammal Biological Lab., Bureau of Commercial Fisheries U.S. Fish & Wildlife Service, Seattle, Wash., "Birds and Mammals Observed at Sea; 1958-present." (unpublished)

An on-going compilation of marine mammal sightings from pelagic fur seal cruises, comprising 25 species. Each species is broken down by geographical area (e.g. Gulf of Alaska, Bering Sea). Lat./Long. for each sighting are given.

Nasu, Keiji. 1963. Oceanography and whaling ground in the subarctic region of the Pacific Ocean. Sci. Rpts. Whales Res. Inst. 17: 105-155.

Data was obtained by whaling factory and whale marking boats in the North Pacific Ocean and Bering and Chukchi Seas. Extensive oceanographic data collected. Usual whaling grounds for blue, fin, humpback, sei, and sperm whales are discussed. Areas north and south of Unalaska are particularly productive for all species except perhaps blue. 51 figs.

Nikolaev, A.M. 1961. [The distribution, quantity and biology of the sea otter]. Trudy Soveshchaniy Ikhtiologicheskoy Komissii, Vol. 12, pages 214-217. Translated by Division of Foreign Fisheries-National Marine Fisheries, NOAA. Trans. 520, 1970.

Tabulates population estimates for years 1912 to 1939 from Kuriles, Kamchatka, Aleutians and Alaska, and California. Otter habitat analyzed. Suggests possibility that sea otters give birth only once every two years.

Nishiwaki, Masahuru. 1966. Distribution and migration of marine mammals in the North Pacific area. Eleventh Pacific Science Congress, August 24, 1966.

Maps and short discussions on present knowledge of distribution of each species of marine mammal (excluding polar bear) found in the North Pacific, Bering Sea and waters north of Bering Strait. Thirteen pinnipeds, fifty-three cetaceans.

Nishiwaki, Masahuru. 1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. In K.S. Norris (Ed.), "Whales, Dolphins and Porpoises." Univ. of California Press, Berkeley and Los Angeles, 1966. Pages 171-191.

Whaling catches reported for 1945-1962 for blue, fin, humpback, sei, Bryde's and sperm whales. Table and map for each species. Area includes North Pacific, Gulf of Alaska and Bering Sea. Catches are analyzed by 10° squares of area. Months of whaling activity are noted. Population estimates offered.

Ohsumi, Seiji. 1975. Incidental catch of cetaceans with salmon gillnet. J. Fish. Res. Bd. Can 32(7): 1229-1235.

Reports data from salmon research vessels, 1962-1971. Species caught were Dall porpoise, True's porpoise, harbor porpoise, pilot whale and Baird's beaked whale. Many animals were not identified to species. The area fished included northern north Pacific, Bering Sea, Sea of Okhotsk and Sea of Japan. 6 figs.

Okutani, Takashi and Takahisa Nemoto. 1964. Squids as the food of sperm whales in the Bering Sea and Alaskan Gulf. Sci. Rpts. Whales Res. Inst. 18: 111-122.

Seven genera of squid were found in stomachs of sperm whales from Aleutian Island waters, Bering Sea and Alaskan Gulf. Distribution of whales caught is mapped, according to (1) whether they contained fish or squid, and (2) what kind of squid they contained. Squids predominated over fish in the western part of the Aleutian chain, while fish predominated in the Gulf of Alaska. 5 plates, 5 figs.

Omura, Hideo. 1955. Whales in the northern part of the North Pacific. Norsk Hvalfangsttidende 44(6): 323-345

Describes history of whaling in the North Pacific and compiles catch statistics since beginning of commercial whaling. Recent Japanese catches on each of 3 whaling grounds, (A) south of Commander Islands, (B) north of Akutan, and (C) south of Akutan, are analyzed for each species by sex, length, and sexual maturity. Peculiarities of results are discussed. Also reports on 2 marking cruises. 17 tables, 18 figs.

Omura, Hideo. 1955. Whales in the northern part of the North Pacific. Norsk Hvalfangsttidende 44(7): 395-405.

See Omura, Hideo. 1955. Whales in the northern part of the North Pacific. Norsk Hvalfangsttidende 44(6): 323-345.

Omura, Hideo. 1958. North Pacific Right Whale. Sci Rpts. Whales Res. Inst. 13: 1-52.

Reports data of two kinds: (1) the physical descriptions of 2 right whales taken near Japan in 1956, and (2) collected right whale sightings from the years 1925-34, 41, 48-57, in the coastal waters of Japan and the North Pacific. Black right whales appear in the Bering Sea in June and stay all summer. Of all sightings, 68% were of single individuals. Largest group seen was four. 8 plates, 27 figs. including 25 photos.

Omura, Hideo and Seiji Ohsumi. 1964. A review of Japanese whale marking and in the North Pacific to the end of 1962, with some information on marking in the Antarctic. Norsk Hvalfangsttidende 53(4): 90-112.

Reports on marking of blue, fin, humpback, sei (and Bryde's), and sperm whales from 1949 to 1962. Of 3,343 whales marked, 282 were recaptured, 80% of which were fin and sperm. Area included waters east of Japan to Long. 160°E., waters south of the Aleutian chain, and the Bering Sea. Possibly independent populations are discussed. Appendix 2 gives sex, length, date and locations of marking and recapture of each whale (including those recaptured by the USSR), plus USSR marks recovered by the Japanese 1956-1962. 12 Tables, 5 maps.

Omura, Hideo, Seiji Ohsumi, Takahisa Nemoto, Keiji Nasu, and Toshio Kasuya. 1969. Black Right Whales in the North Pacific. Sci Rpts. Whales Res. Inst. 21: 1-78.

Gives detailed anatomical descriptions of 13 black right whales, including 2 previously reported by Omura, in 1958. Distribution is shown in maps, by month from April to September, based on Japanese whaling ship's records and Sleptsov's 1962 article. Extensive comments made on movements in the Aleutian area, and Gulf of Alaska, and the Bering Sea. 27 figs., 18 plates.

Pike, Gordon C. 1962. Migration and feeding of the gray whale (Eschrichtius gibbosus). J. Fish. Res. Bd. Can. 19(5): 815-838.

Observations of gray whales from the coasts of British Columbia, Washington and Alaska are combined with published accounts in an effort to define the timing and route of the migration, and feeding areas in the Bering and Chukchi Seas. Uncertainty remains as to the route between British Columbia and the Bering Sea. Feeding observations, particularly around St. Lawrence Island, are given. 4 figs., 2 are maps.

Scammon, C.M. 1870. The sea otters. Am. Nat. 4(2): 65-74.

Describes appearance and behavior of sea otters. Notes distribution from Lower California to Washington in some detail. Alaskan distribu- noted as abundant in the Aleutian Islands and Fox Islands. Describes methods of hunting sea otters used by Indians and whites, including detailed descriptions of hunting in Washington state both from boats and from land.

Scammon, C.M. 1874. The Marine Mammals of the Northwestern Coast of North America, John H. Carmany and Co., San Francisco and G.P. Putnam's Sons, New York. 319 pages.

The first major account of marine mammals in Alaska coupled with detailed descriptions of each species encountered. The book is written in three sections: I. Cetacea, II. Pinnipedia, and III. The American Whale-fishery.

Scheffer, Victor B. 1949. The Dall porpoise, Phocoenoides dalli, in Alaska. J. Mammal. 30(2): 116-121.

Reports on observations during two cruises in 1947 and 1948. Describes

range in southern Bering Sea, Aleutian Island waters, Gulf of Alaska and southeast Alaska. No seasonality was observed. Anatomical measurements given for 5 speciments. Liver analysis done. 2 plates.

Skaptason, Patricia Ann. 1971. The sea otter (Enhydra lutris). U.S. Dept. of Int., Office of Library Services, Washington, D.C.

Bibliography of 194 references. Includes English language materials and translations from the Russian from 1950-1970, plus one 1897 publication. Index by subject and geographic area.

Vania, John and Edward Klinkhart. 1967. Marine Mammal Report. Vol. VIII, Annual Project Segment Report, Federal Aid in Wildlife Restoration. Alaska Dept. of Fish and Game. 24 pages.

Reproductive tracts of 11 adult female Steller sea lions collected in October, 1966, were examined to learn about reproductive biology. Delay of implantation appears to last about 3 months. Molt at Lat. 58°-59°N lasts from the last week in July until beyond Oct. 25.

Thirty otters were transplanted from Prince William Sound to Klag Bay (Southeast Alaska) and Yakutat Bay. This transplant followed a similar effort in 1965. Breeding success of the transplanted animals has not been confirmed.

Reports on studies of harbor seals at Tugidak Island and the Port Heiden - Port Moller area, primarily oriented towards commercial harvesting for pelts. Three hundred pups were tagged on Tugidak Island; 45 were recovered. Aerial surveys were carried out of Tugidak Island, Port Heiden-Port Moller, and Sitkinak Island, Seal Island, and Cinder River. Four belugas were collected in the Kvichak River and measurements and stomach contents are given.

Vania, John, Edward Klinkhart and Karl Schneider. 1968. Marine Mammal Report. Vol. IX, Annual Project Segment Report, Federal Aid in Wildlife Restoration. Alaska Dept. of Fish and Game. 46 pages.

Harvesting activities on sea lions were monitored on Sugarloaf Island and Marmot Island where hunters took 4, 855 sea lion pup pelts. Hunting activity cause a shift of several thousand sea lions from one area of the rookery to another.

Sightings of transplanted otters near Klag Bay are reported.

Examination of pelage harbor seals collected at 2-week intervals during 1966-67 indicated that molt begins in late August and is completed by late October. Eleven hundred and six pups were tagged at Tugidak Island (June 2-21), and 180 at Port Heiden (June 14-28). Pupping areas on Tugidak Island, Port Heiden and Port Moller were surveyed by air during June, July and August. Results are tabulated for 1965-1967.

Wilke, Ford, and Clifford H. Fiscus. 1961. Gray whale observations. J. Mammal. 42(1): 108-109.

Reports observations off Washington, off Kodiak and in the Chukchi Sea, Bering Sea and Gulf of Alaska. Includes thoughts on route of migration and observations of feeding.

ANNUAL REPORT

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Research Unit 68
Period: 1 April 1975 -
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No. Pages 18

Abundance and Seasonal Distribution of Marine Mammals in the Gulf of Alaska

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I. Summary of Objectives, Conclusions and Implications to OCS.

The baseline objectives of this project are to provide a better understanding of the relative seasonal distribution and abundance of marine mammal species. These objectives will be accomplished by integrating (1) sighting records taken aboard NOAA ships and chartered vessels working in and crossing through the Gulf of Alaska; (2) data from aircraft surveys collected by supporting OCSEAP projects (e.g. Alaska Department of Fish and Game); and (3) from historical whaling and sealing records.

The northern and coastal regions of the Gulf of Alaska are expected to be important areas where oil-gas research and tanker traffic will occur. These areas also represent localized habitats for many marine mammals (e.g. northern sea lion, *Eumetopias jubatus*) as well as an area for seasonal migrations (e.g. California gray whale, *Eschrichtius robustus*). The Gulf of Alaska, therefore, represents an important area of study for understanding the interaction of marine mammal resources and oil-gas resource development.

II. Introduction.

A. General Nature and Scope of Study

Research under RU 68 will consist of a review of the existing literature concerning marine mammals in the Gulf of Alaska; and from data collected on a vessels of opportunity marine mammal reporting program now in existence. The emphasis will be on collecting sighting data from aboard ocean going ships and correlating these to past seasonality and abundance information.

B. Specific Objectives

1. An annotated bibliography of marine mammal literature for work already accomplished in the Gulf.
2. Computer card summarization of two seasons worth of "Platforms of Opportunity" (an on-going NOAA program) data presently in our files, and data which will be collected during the remainder of the project period.
3. Whale and seal catch statistics, and a comprehensive literature survey of the historical data on abundance estimates and seasonal distribution of marine mammals in the Gulf of Alaska.

C. Relevance to problems of oil development

Species abundance and distribution, behavior, population production, specific food web relationships and susceptibility to direct contact with petroleum and/or developmental operations are factors which must be known before any estimate can be made of the impact of petroleum development on marine mammals. RU 68 will provide some of this information particularly data pertaining to seasonal abundance and distribution.

III. Current State of Knowledge.

There are approximately 21 species of marine mammals that are known, or believed to occur in the Gulf of Alaska, either as residents, migrants, or seasonal visitors. They are: (pelagic - offshore; coastal - near shore)

Sea Otter (Enhydra lutris)	Coastal resident.
Northern Sea Lion (Eumetopias jubatus)	Coastal resident; pelagic migrant (?).
Northern Fur Seal (Callorhinus ursinus)	Pelagic migrant.
Harbor Seal (Phoca vitulina)	Coastal resident.
Harbor Porpoise (Phocoena phocoena)	Coastal and pelagic resident.
Dall Porpoise (Phocoenoides dalli)	Coastal and pelagic resident.
Northern Pacific Whitesided Dolphin (Lagenorhynchus obliquidens)	Pelagic visitor (?).
Killer Whale (Orcinus orca)	Coastal and pelagic resident and migrant (?).
Giant Bottle-nose Whale (Berardius bairdi)	Pelagic migrant or visitor (?).
Goose-Beaked Whale (Ziphius cavirostris)	Pelagic or coastal visitor (?).
Other Beaked Whales (Mesoplodon spp.)	Pelagic or coastal visitors (?).
Sperm Whale (Physeter macrocephalus)	Pelagic; seasonal visitor (?).
Gray Whale (Eschrichtius robustus)	Coastal and pelagic seasonal migrant.
Right Whale (Balaena glacialis)	Pelagic visitor (?)
Humpback Whale (Megaptera novaeangliae)	Coastal; seasonal.
Blue Whale (Balaenoptera musculus)	Pelagic; seasonal visitor (?).
Fin Whale (Balaenoptera physalus)	Pelagis; seasonal visitor (?)
Sei Whale (Balaenoptera borealis)	Pelagic; seasonal visitor (?)
Minke Whale (Balaenoptera acutorostrata)	Coastal and pelagic; seasonal.
Belukha Whale (Delphinapterus leucas)	Coastal resident
Risso's Dolphin (Grampus griseus)	Pelagic visitor.

Other species may occasionally be found in the Gulf of Alaska. We know little about the frequency of occurrance of most marine mammals in the Gulf (especially cetaceans), thus the information provided by RU68 should give us a valuable baseline for oil-gas development decisions.

IV Study Area.

The study area consists of the northern Pacific Ocean including the Gulf gyre and western Gulf from Unimak Pass on the west, to southeastern Alaska on the east. The approximate southern boundary of the survey area is considered to be 52° North latitude.

V Methods.

A. A comprehensive bibliography is being prepared of all known literature on marine mammals in the Gulf of Alaska.

B. Marine mammal observers aboard NOAA ships (the "Platforms of Opportunity Program") will have little input into trackline selection. Hence, there is no systematic sampling method behind data collection efforts using NOAA vessel personnel. A pilot sutdy using systematic sampling procedures is being tested by Marine Mammal Division employees.

C. Sightings are coded and carded for species, number seen, location, behavior, direction of travel, weather and related information. Computer printout of the data and charts indicating location of sightings by month will be compiled.

D. Distributional data are examined through computer programs by month, where sufficient sightings are available, or by season (3 month periods). Sightings per unit effort are compared and displayed in a manner similar to that used in studies on pelagic fur seal distribution. Since most pelagic and coastal research in the study area is conducted from spring through the late fall (March - November), data on winter distribution and abundance will be minimal.

VI Results.

The annotated bibliography is progressing on schedule. A sample of the bibliography is included in this report as an Addendum.

Due to delays in finalization of a data management format, the field data have not been logged and smoothed sufficiently for computer plot reproduction.

VII. Discussion.

We plan to provide a report by 30 September 1976 reviewing historic records of whaling and sealing in the area, modern whaling catch statistics, seasonal distribution of marine mammal species found in the Gulf, and an annotated bibliography listing all known published accounts of marine mammals in the survey area.

Catch statistics of commercially taken species and sighting records from NOAA ships may provide preliminary data on local and seasonal abundance of some species and possibly an indication of critical habitat. These data, however, must be considered preliminary until sufficient records have accumulated over the next 3 to 5 years. We hope to obtain marine mammal sighting records from marine bird studies done onboard NOAA ships. Reports from NOAA ships will increase as more ship's personnel are trained and become experienced at identifiying marine mammals at sea. To date, we are pleased with the acceptance of our program by the NOAA Corps.

RU 68 relates directly to other OCS projects as it expects marine mammal sighting reports from all vessels involved in the OCS program. The marine bird aerial survey program is also capable of providing marine mammal sighting reports in the Gulf of Alaska augmenting the vessel reports.

VIII. Conclusions.

None at this time.

IX. Needs for Further Study.

Some aerial support, both helicopter and fixed wing aircraft, would be desirable in order to obtain ground truth data (i. e. shipboard sighting reliability).

Attention should be given to seamounts as areas of productivity with regard to marine mammals and upwellings. This might require a sampling of seamount areas during all seasons of the year. The series of seamounts that are of initial interest range from Bowie to Welker, and Pratt and Giacomini. These seamounts may be located along the migration route of the gray whale, and perhaps, be of some significance with respect to their migratory path.

Information about prey species for all marine mammals that feed along the continental shelf will be essential for determining potential distribution and the impact of petroleum development in the Gulf.

X. <u>Summary of 4th Quarter Operations</u>.

A. Ship or laboratory activities.
Designated ships officers, on NOAA vessels engaged in OCSEAP programs, have been trained to identify marine mammals and record sightings in logbooks provided by the Marine Mammal Division, Northwest Fisheries Center.

1. Assigned Ship's Marine Mammal Officers trained to 1 April 1976:

<u>NOAA Ships:</u>

OCEANOGRAPHER	Ens. Rodney Swope
	Ens. Larry Parsons
DISCOVERER	Ens. Christine Wencker
SURVEYOR	Ens. Todd Baxter
FAIRWEATHER	Ens. Gregory Kosinski
	Ens. Mark Sullivan
RAINIER	Ltjg. Richard Ellis
	Ens. John Osborn
MILLER FREEMAN	Ltjg. Terry Jackson
	Ens. Patrick Rutten
MCARTHUR	Lt. Greg Segur
	End. Lars Pardo
DAVIDSON	Ens. Mary Huestis
	Ens. Edward Wheaton
JOHN COBB	Thomas Dunaton, 1st Mate
OREGON	Riley Wilson

2. Scientific Party - to 1 April 1976:

Dr. Howard Braham	SURVEYOR 8-13 March
Keith Parker	
Robert Everitt	
Patrick McGuire	

Carl Brooks

Robert Everitt — Surveyor - 13 March - 2 April

3. Methods.
a. Laboratory analysis. Some marine mammal sightings from NOAA ships were keypunched onto computer cards and will be transferred to data management format for EDS, NOAA, Rockville, MY. These sample data are presently being verified.
b. Field sampling. Distance measurements to observed animals by using triangulation from horizontal was attempted during the March 1976 cruise. The data have not been finalized to date. A new systematic sampling technique was also attempted. An updated field format and marine mammal identification manual was tested. All of these activities will be reported on during the 5th and 6th quarter reports.

4. Sample localities/tracklines.
Surveyor, 8 March - 2 April -- The Surveyor first tracked from Seattle to Kodiak (8-13 March) and then from Kodiak to the ice front in the southern Bering Sea. Enroute, marine mammal data were collected in the southern Gulf, and along the southern edge of the Alaska Peninsula in the Gulf of Alaska in an area seldom sampled in late winter. The trackline information in the southern Bering Sea is not available at this time.

5. Data synthesis on NOAA ship sightings was begun between 1 Jan and 1 April 1976, on information collected from the following voyages:

Operations in Gulf	NOAA Ship	Dates
GOA	Oceanographer	28 Jan - 5 March 1975
Transits *	McArthur	5 March - 17 Aug 1975
GOA	Discoverer	9 March - 23 June 1975
GOA	Oregon	3 April - 12 July 1975
GOA - Transits	Rainier	21 April - 26 Aug 1975
GOA	Townsend Cromwell	28 April - 10 June 1975
NWGOA - Transits	Fairweather	5 May - 21 Aug 1975
Transits	Davidson	6 May - 7 Oct 1975
Transits	Surveyor	10 July - 18 Nov 1975
Transits	Miller Freeman	11 Aug - 11 Dec 1975
GOA	Discoverer	15 Oct - 17 Dec 1975

*Transits - tracklines from or to Seattle

The above information indicates whether the vessel(s) simply transited the Gulf of Alaska or whether it (they) actually operated in the Gulf at some time during the period listed. Data were collected by many of the same vessels during 1974 but they will have to be more thoroughly evaluated before an itemized list can be prepared.

ADDENDUM

Sample Annotated Bibliography

Research Unit 68

Bibliographic citations listed may apply to one or more research units. In the final report (1 October 1970) each RU will have listed a comprehensive annotated bibliography covering the appropriate geographic region(s) for which each RU is responsible.

ADDENDUM

Sample Annotated Bibliography: RU68

Annual Report, FY 1976

Burns, John J. 1965. The W[illegible] in Alaska. Vol. V, Fed. Aid in Wildlife Restoration Project Report covering investigations completed by Dec. 31, 1963. Alaska Dept. of Fish and Game. 48 pages.

The history of walrus exploitation, economic role in Alaska, and recent and current research are discussed. Some of the early chronicles, and nearly all scientific investigators are listed and referenced in the bibliography. Original research reported was collected for walrus observations to determine migration and distribution patterns. Most females start to breed around age 6, males about the same. Most mature females bear one calf every 2 years. Major food species are <u>Mya truncata</u> and <u>Clinocardium nuttalli</u> (clams). Walrus predation on seals is discussed. Minimum population is estimated at 90,000. Migration and known distribution is given, by season, combining published and unpublished observations. Collected observations of hauling out areas are given, including the Walrus Islands in Bristol Bay and the Punuk Islands. Collected behavioral observations are given.

Burns, John J. 1966. Marine Mammal Report. Vol. VII Annual Project Segment Report, Fed. Aid in Wildlife Restoration. Alaska Dept. of Fish and Game. 47 pages.

Teeth were examined from known age walruses, and the tooth interpretation method previously used was found valid. Reproductive tracts of 160 mature females from nursery herds were examined; 71 percent were newly parturient, 21% were pregnant, 8% were barren. Females first breed at age five or six, and calve from then on an average of once every 2.2 years. Adult female Pacific walrus reach a weight of about 2,100 pounds. The main migration move through Bering Strait from 20 May - 18 June. Some positions and dates of walrus concentrations are noted. 21,015 seals were harvested and bountied from just south of Nunivak Island to Barrow, by 512 hunters: 13,590 ringed, 3,430 bearded, and 3,995 harbor seals.

Burns, John J. 1967. Marine Mammal Report. Vol. VIII, Annual Project Segment Report, Federal Aid in Wildlife Restoration Project. Alaska Dept. of Fish and Game. 44 pages

Analysis of the age composition of 353 male walrus taken at Savoonga indicated an annual mortality rate of about 12 percent (maximum) for year classes 14 through 28, and about 14 percent (maximum) for year classes 14 through 33. Size of population is apparently continuing to increase. Walrus observations are reported from Nushagak Bay (May), Round Island in Bristol Bay (May-June), Big Diomede island and the Punuk Islands (early December). Eighty percent of the walruses harvested were taken by the villages of Gambell, Savoonga, Diomede and King Island. It is noted that some male walrus winter, singly or in small herds, much further north than the main groups (occasionally as far north at Lat. 70° in late February). Concentrations of animals were moving through the Bering Strait from May 28 to July 4. Five species of pinnipeds in the northern Bering Sea are discussed: ringed, ribbon, bearded and harbor seals, and walrus. A map gives the distribution of these species in April-early May, and the distribution is discussed as it corresponds to their different adaptations.

Burns, John J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51(3): 445-454.

Author's abstract: "Five species of pagophilic (ice-loving) pinnipeds live in the Bering and Chukchi seas: Odobenus rosmarus, Phoca (Pusa) hispida, Phoca (Histriophoca) fasciata, and ice-breeding populations of Phoca (Phoca) vitulina, and Erignathus barbatus. Breeding adults of these species are mostly separated from each other during late winter and early spring, when throughout the pupping and subsequent mating periods, P. vitulina and P. fasciata occupy the edge-zone of the seasonal pack ice, E. barbatus and O. rosmarus are mainly farther north within the heavier pack ice, and P. hispida occupies areas of extensive land-fast ice. This paper discusses differences in body structure, ecological adaptation, and behavior in relation to distribution of the five species."

Burns, John J. 1973. Marine Mammal Report. Vol. XIII, Project Progress Report, Federal Aid in Wildlife Restoration. Alaska Dept. of Fish and Game. 29 pages.

Research activities included three cruises; the first in the eastern Bering Sea from Nome to west of Unimak Pass, 27 March-21 April 1971; the second, in March and April of 1972, restricted to the southern Bering Sea; the third, in the waters near Juneau, November 1972. Fifty-three harbor seals and two ribbon seals were tagged on the first cruise, 23 harbor seals and 1 ribbon seal on the second. On the third cruise, 21 specimens of *Phoca vitulina richardii* were taken. Fish and invertebrates were also collected as part of the second topic, preparatory to studying pinniped feeding. Information on biological and commercial status, including seasonal distribution of *P. largha*, *P. fasciata*, *E. barbatus* and *P. hispida* are described.

Burns, John J. and Loren W. Croxton. 1963. Marine Mammal Investigations. Vol. III, Annual Project Segment Report, Fed. Aid in Wildlife Restoration. Alaska Dept. of Fish and Game. 38 pages.

Walrus biology and population status covering the period April 1 - June 30, 1962. Northward migration passed Gambell May 8-24, Savoonga May 3-23, Bering Strait June 1-7.

Burns, John J., G. Carleton Ray, Francis H. Fay, and Peter C. Shaughnessy. 1972. Adoption of a strange pup by the ice-inhabiting harbor seal, *Phoca vitulina largha*. J. Mammal. 53(3): 594-598.

On 20 April 1971 at Lat. 57°51'N., Long. 165°54'W., the authors replaced the 4-week-old pup of a pair of seals with a previously captured 2-week-old pup. They subsequently observed the new pup nursing from the female. During their cruise from 11-20 April they sighted 103 pairs of adult harbor seals in the 20-mile wide ice front zone to the north and east of the Pribilof Islands. 2 photos.

Burns, John J. and James E. Morrow. 1973. "The Alaskan arctic marine mammals and fisheries". Paper given at the Fifth International Congress of the Fondation Francaise D'Etudes Nordiques, called "Arctic Oil and Gas: Problems and Possibilities", at Le Havre, May 2-5, 1973. 22 pages.

Author discusses fishes and marine mammals of the Chukchi Sea, the arctic coast of Alaska, and the northern Bering Sea with respect to offshore oil development. Toxicity of crude or refined oil to fishes is known and extreme toxicity to eggs and larvae is noted. Oil spilled in arctic waters will persist, due to the low temperature and slower decomposition. Seismic exploration by several different concerns often involves a succession of explosions in the same areas which destroy fish. Epontic algae grows on the under surface of the ice. Accidental or chronic gradual discharge of oil would spread under the ice, be trapped there for long periods of time, and either kill the algae there or be incorporated into the food chain from there on up. The same results can occur among benthic organisms when oil is deposited on the bottom. The occurrance of all arctic marine mammals is discussed.

Clarke, Robert. 1957. Migration of marine mammals. Norsk Hvalfangsttidende 46(1): 609-630.

A general review of migrations of the large whales and of a small number of small cetaceans, fur seals, phocid seals, and walruses. Notes lack of understanding of mechanisms of migration. 11 figs., 76 refs.

Fiscus, Clifford H., Dale W. Rice, and Ancel M. Johnson. 1969. New records of Mesoplodon stejnegeri and Ziphius cavirostris from Alaska. J. Mammal. 50(1): 127.

Floating carcass of Mesoplodon stejnegeri found 43 km west of Cape Edgecombe, Gulf of Alaska, at Lat. 57#04'N., Long. 146°32'W. Skull of Z. cavirostris found at Trident Bay, Akun Island, at Lat. 54°09'N., Long. 165°33'W.

Johnson, Murray L. and Gordon D. Alcorn. 1962. The return of the sea otter. Outdoor Calif. 23(2): 4-5.

Recounts history of exploitation since 1741. Present population is estimated as high as 40,000. Distribution includes Amchitka Island, Delarof, Andreanof and Fox Islands, Alaska Peninsula, Kodiak archipelago, and Kenai Peninsula to Cape St. Elias in Alaska, and the California coast.

Kasuya, Toshio. 1971. Consideration of distribution and migration of toothed whales off the Pacific coast of Japan based upon aerial sighting record. Sci. Repts. Whales Res. Inst. 23: 37-60.

Reports odontocete sightings recorded during oceanographic aerial surveys 1959-1970, comprising 171,809 nautical miles flown. Describes conditions of observation.

Kenyon, Karl W. 1961. Cuvier beaked whales stranded in the Aleutian Islands. J. Mammal. 42(1): 71-76.

Two carcasses of *Ziphius cavirostris* found on Amchitka Island, apparently shot by rifle. Complete measurements given. 3 plates.

Klinkhart, Edward G. 1967. Birth of a harbor seal pup. J. Mammal. 48(4): 677.

On June 15, 1967, a female harbor seal gave birth at Tugidak Island, Alaska (Lat. 56°33'N., Long. 155°20'W.). One half-hour of observation, from 12 minutes before the birth until 18 minutes afterward, is reported.

Klinkhart, Edward. 1969. The harbor seal in Alaska. Alaska Dept. of Fish and Game, Wildlife Notebook Series. 2 pages.

Both ice- and non-ice-inhabiting harbor seals are described. Natural history is given. Annual harvest in northern Alaska is given as 4,000, and 30,000 in southern Alaska. A bounty was in effect from 1927 to 1967.

Lensink, Calvin J. 1960. Status and distribution of sea otters in Alaska. J. Mammal. 41(2): 172-182.

A detailed report and review of census efforts from Cook Inlet to Amchitka Island from 1936 to 1957. "The present status of the otter is such that we can expect a rapid expansion in numbers from the Andreanof Islands eastward. West of the Andreanof Islands the habitat is limited and the population may already be near the carrying capacity. Here, sea otters are perhaps as abundant as they were before exploitation by the Russians. On Amchitka Island the evidence indicates that a high population has resulted in increased mortality and a lowered reproductive rate." -from author's summary. Estimates present Alaska population at 40,000. Includes distribution map.

Marine Mammal Biological Lab., Bureau of Commercial Fisheries U.S. Fish & Wildlife Service, Seattle, Wash. "Birds and Mammals Observed at Sea; 1958-present". (unpublished).

An on-going compilation of marine mammal sightings from pelagic fur seal cruises, comprising 25 species. Each species is broken down by geographical area (e.g. Gulf of Alaska, Bering Sea). Lat./Long. for each sighting is given.

Nasu, Keiji. 1963. Oceanography and whaling ground in the subarctic region of the Pacific Ocean. Sci. Repts. Whales Res. Inst. 17: 105-155.

Data was obtained by whaling factory and whale marking boats in the North Pacific Ocean and Bering and Chukchi Seas. Extensive oceanographic data collected. Usual whaling grounds for blue, fin, humpback, sei, and sperm whales are discussed. Areas north and south of Unalaska are particularly productive for all species except perhaps blue. 51 figs.

Nikolaev, A.M. 1961. [The distribution, quantity and biology of the sea otter]. Trudy Soveshchaniy Ikhtiologicheskoy Komissii, Vol. 12, pages 214-217. Translated by Division of Foreign Fisheries, National Marine Fisheries, NOAA. Trans. 520, 1970.

Nikolaev, A.M. 1961 (cont'd)

Tabulates population estimates for years 1912 to 1939 from Kuriles, Kamchatka, Aleutians and Alaska, and California. Otter habitat analyzed. Suggests possibility that sea otters give birth only once every two years.

Nishiwaki, Masahuru. 1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. In K. S. Norris (Ed.), "Whales Dolphins and Porpoises." Univ. of California Press, Berkeley and Los Angeles. Pages 171-191.

Whaling catches reported for 1945-62 for blue, fin, humpback, sei, Bryde's and sperm whales. Table and map for each species. Area includes North Pacific, Gulf of Alaska and Bering Sea. Catches are analyzed by 10° squares of area. Months of whaling activity are noted. Population estimates offered.

Nishiwaki, Masahuru. 1966. Distribution and migration of marine mammals in the North Pacific area. Eleventh Pacific Science Congress, August 24, 1966.

Maps and short discussions on present knowledge of distribution of each species of marine mammal (excluding polar bear) found in the North Pacific, Bering Sea and waters north of Bering Strait. Thirteen pinnipeds, fifty-three cetaceans.

Ohsumi, Seiji. 1975. Incidental catch of cetaceans with salmon gillnet. J. Fish. Res. Bd. Can. 32(7): 1229-1235.

Reports data from salmon research vessels, 1962-71. Species caught were Dall porpoise, True's porpoise, harbor porpoise, pilot whale and Baird's beaked whale. Many animals were not identified to species. The area fished included northern north Pacific, Bering Sea, Sea of Okhotsk and Sea of Japan. 6 figs.

Okutani, Takashi and Takahisa Nemoto. 1964. Squid as the food of sperm whales in the Bering Sea and Alaskan Gulf. Sci. Reps. Whales Res. Inst. 18: 111-122.

Seven genera of squid were found in stomachs of sperm whales from Aleutian Island waters, Bering Sea and Alaskan Gulf. Distribution of whales caught is mapped, according to (1) whether they contained fish or squid, and (2) what kind of squid they contained. Squids predominated over fish in the western part of the Aleutian chain, while fish predominated in the Gulf of Alaska. 5 plates, 5 figs.

Omura, Hideo. 1955. Whales in the northern part of the North Pacific. Norsk Hvalfangsttidende 44(6): 323-345.

Describes history of whaling in the North Pacific and compiles catch statistics since beginning of commercial whaling. Recent Japanese catches on each of 3 whaling grounds, (A) south of Commander Islands, (B) north of Akutan, and (C) south of Akutan, are analyzed for each species by sex, length, and sexual maturity. Peculiarities of results are discussed. Also reports on 2 marking cruises. 17 tables, 18 figs.

Omura, Hideo. 1955. Whales in the northern part of the North Pacific. Norsk Hvalfangsttidende 44(7): 395-405.

See Omura, Hideo. 1955. 44(6): 323-45.

Omura, Hideo. 1958. North Pacific Right Whale. Sci. Reps. Whales Res. Inst. 13: 1-52.

Reports data of two kinds: (1) the physical description of 2 right whales taken near Japan in 1956, and (2) collected right whale sightings from the years 1925-34, 41, 48-57, in the coastal waters of Japan and the North Pacific. Black right whales appear in the Bering Sea in June and stay all summer. Of all sightings, 68% were of single individuals. Largest group seen was four. 8 pls., 27 figs. including 25 photos.

Omura, Hideo and Seiji Ohsumi. 1964. A review of Japanese whale marking and in the North Pacific to the end of 1962, with some information on marking in the Antarctic. Norsk Hvalfangst-tidende 53(4): 90-112.

Reports on marking of blue, fin, humpback, sei (and Bryde's), and sperm whales from 1949 to 1962. Of 3,343 whales marked, 282 were recaptured, 80% of which were fin and sperm. Area included waters east of Japan to Long. 160°E., waters south of the Aleutian chain, and the Bering Sea. Possibly independent populations are discussed. Appendix 2 gives sex, length, date and locations of marking and recapture of each whale (including those recaptured by the USSR), plus USSR marks recovered by the Japanese 1956-1962. 12 tables, 5 maps.

Omura, Hideo, Seiji Ohsumi, Takahisa Nemoto, Keiji Nasu, and Toshio Kasuya. 1969. Black Right Whales in the North Pacific. Sci. Reps. Whales Res. Inst. 21: 1-78.

Gives detailed anatomical descriptions of 13 black right whales, including 2 previously reported by Omura, in 1958. Distribution is shown on maps, by month from April to September, based on Japanese whaling ships' records and Sleptsov's 1962 article. Extensive comments made on movements in the Aleutian area, and Gulf of Alaska, and the Bering Sea. 27 figs., 18 plates.

Pike, Gordon C. 1962. Migration and feeding of the gray whale (*Eschrichtius gibbosus*). J. Fish. Res. Bd. Can. 19(5): 815-838.

Observations of gray whales from the coasts of British Columbia, Washington and Alaska are combined with published accounts in an effort to define the timing and route of the migration, and feeding areas in the Bering and Chukchi Seas. Uncertainty remains as to the route between British Columbia and the Bering Sea. Feeding observations, particularly around St. Lawrence Island, are given. 4 figs., 2 are maps.

Scammon, C. M. 1874. The Marine Mammals of the Northwestern coast of North America. John H. Carmany and Co., San Francisco and G. P. Putnam's Sons, New York. 319 pages.

The first major account of marine mammals in Alaska coupled with detailed descriptions of each species encountered. The book is written in three sections: I. Cetacea, II. Pinnipedia, and III. The American Whale-Fishery.

Scheffer, Victor B. 1949. The Dall porpoise, Phocoenoides dalli, in Alaska. J. Mammal. 30(2): 116-121.

Reports on observations during two cruises in 1947 and 1948. Describes range in southern Bering Sea, Aleutian Island waters, Gulf of Alaska and southeast Alaska. No seasonality was observed. Anatomical measurements given for 5 specimens. 2 plates.

Schiller, Everett L. and Robert Rausch. 1956. Mammals of the Katmai National Monument, Alaska. Arctic 9(3): 191-201.

Occurrence and distribution of mammals obtained in the summer of 1953 at Katmai National Monument. Harbor seals were found to be common along the Shelikof Strait, especially in Kukak, Katmai, and Portage bays. Includes map of Katmai area with collection localities marked.

Skaptason, Patricia Ann. 1971. The sea otter (Enhydra lutris). U. S. Dept. Int., Office of Library Services, Washington, D. C.

Bibliography of 194 references. Includes English language materials and translations from the Russian from 1950-1970, plus one 1897 publication. Index by subject and geographic area.

Vania, John and Edward Klinkhart. 1967. Marine Mammal Report. Vol VIII, Annual Project Segment Report, Federal Aid in Wildlife Restoration. Alaska Dept. of Fish and Game. 24 pages.

Reproductive tracts of 11 adult females Steller sea lions collected in October, 1966, were examined to learn about reproductive biology. Delay of implantation appears to last about 3 months. Molt at Lat. 58° 59°N lasts from the last week in July until beyond Oct. 25.

Thirty otters were transplanted from Prince William Sound to Klag Bay (Southeast Alaska) and Yakutat Bay. This transplant followed a similar effort in 1965. Breeding success of the transplanted animals has not been confirmed.

Reports on studies of harbor seals at Tugidak Island and the Port Heiden-Port Moller area, primarily oriented towards commercial harvesting for pelts. Three hundred pups were tagged on Tugidak Island; 45 were recovered. Aerial surveys were carried out of Tugidak Island, Port Heiden-Port Moller, and Sitkinak Island., Seal Island and Cinder River.

Four belugas were collected in the Kvichak River and measurements and stomach contents are given.

Vania, John, Edward Klinkhart and Karl Schneider. 1968. Marine Mammal Report. Vol IX, Annual Project Segment Report, Federal Aid in Wildlife Restoration. Alaska Dept. of Fish and Game. 46 pages.

Harvesting activities on sea lions were monitored on Sugarloaf Island and Marmot Island where hunters took 4,855 sea lion pup pelts. Hunting activity cause a shift of several thousand sea lions from one area of the rookery to another. Sightings of transplanted otters near Klag Bay are reported. Examination of pelage: harbor seals collected at 2-week intervals during 1966-67 indicated that molt begins in late August and is completed by late October. Eleven hundred and six pups were tagged at Tugidak Island (June 2-21), and 180 at Port Heiden (June 14-28). Pupping area on Tugidak Island, Port Heiden and Port Moller were surveyed by air during June, July and August. Results are tabulated for 1965-1967.

Wilke, Ford, and Clifford H. Fiscus. 1961. Gray whale observations. J. Mammal. 42(1): 108-109.

Reports observations off Washington, off Kodiak and in the Chukchi Sea, Bering Sea and Gulf of Alaska. Includes thoughts on route of migration and observations of feeding.

ANNUAL REPORT

Contract No. R7120807
Research Unit 69
Period: 1 April 1975 -
31 March 1976
No. Pages 15

Resource Assessment: Abundance and Seasonal Distribution of Bowhead and Belukha Whales - Bering Sea

Principal Investigators:

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March 15, 1976

I. Summary of Objectives, conclusions and implications with respect to OCS oil and gas development.

Proposed oil and gas lease sites occur in the northern Bering Sea west from Norton Sound, and the southern Chukchi Sea west from Kotzebue Sound. Bowhead (Balaena mysticetus) and belukha (Delphinapterus leucas) whales pass through these areas from about March through July and again in the fall. These animals apparently winter in the Bering Sea, although those portions of the population that do are unknown. Calving of bowhead is believed to occur in the northern Bering Sea in May, but again, no reliable data are known to exist. Since adverse affects to these animals could result from oil or gas related perturbations, identification of population centers, seasonal movements and potential areas of production are major considerations in developing energy resource management decisions.

II. Introduction.

A. General nature and scope of study.
The intent of RU69 is to extend our knowledge of the general ecology and population parameters of the bowhead and belukha whales. To accomplish these objectives, an analysis of early spring movements and the identification of important geographic requirements for migration and calf production are essential. Because of potential interrelationships between all marine mammals in the Bering Sea, population density and distribution estimates will also be made on other species, such as walrus (Odobenus rosmarus) and bearded seal (Erignathus barbatus).

B. Specific Objectives:

1. To ascertain if bowheads and/or belukhas use open water polynyas as a place to winter over, or for spring staging prior to the northern migration.
2. Identify time and location of movements of bowhead and belukha as spring leads develop in the northern Bering Sea and the southern Chukchi Sea.
3. Determine if bowheads may be breeding and/or calving within oil-gas lease sites in the northern Bering Sea and/or the southern Chukchi Sea.
4. Survey for belukha and bowhead to determine distribution and relative abundance.
5. Develop aerial survey sampling techniques; and, provide maps describing spring distribution.

C. Relevance to problems of petroleum development.
Oil-gas leases in the northern Bering and southern Chukchi Seas, if granted, are contiguous to the spring and fall migration paths of both species. Bowheads are believed to give birth in the northern Bering Sea while in migration north. Since the bowhead is a harvested resource and thus of economic value to the Arctic Eskimo economy, and an endangered species, protected by the Rare and Endangered Species Act of 1973 and international agreement, research on abundance and distribution in these areas is of considerable value.

III. Current state of knowledge.

It would appear from the literature that very little information exists concerning the distribution and abundance of bowhead and belukha in the Bering Sea during the late winter and early spring. Whaling records indicate that bowhead and belukha were taken over the continental shelf in northwestern Bering Sea from May through August, however, reliability of population estimates from these "data" are difficult. Those early records suggest that these animals may not migrate to open water south of the ice edge, and thus seek open water (polynyas) west and southwest of St. Lawrence Island to winter over.

Two hypotheses exist: 1) Animals migrate north from the southern Bering Sea in March and April as leads develop in the northern Bering Sea; and/or 2) remain in the northwestern Bering Sea in polynyas prior to migrating into the Chukchi and Beaufort Seas in April and May.

Previous sightings of bowhead movements past Pt. Hope and Pt. Barrow, Alaska, have revealed that three or four "waves" or groups pass at different intervals during the spring. Immature and young bowheads apparently migrate first (late April - early May) while females with calves and bulls migrate later (late May - late June).

IV. Study Area.

The study area generally includes the region southwest and west of St. Lawrence Island east to the Yukon Delta, north throughout the northern Bering Sea into the southern Chukchi Sea to approximately Cape Lisburne. The geographic boundaries of the survey area are within Lat. 58°N. to the south and Lat. 69°N. to the north, and Long. 178°W. to the west and Long. 165°W. to the east.

V. Sources, methods and rationale of data collection.

Sighting data are collected exclusively from aerial surveys flown over open water and pack ice. Aerial surveys are the best method available to cover an area as extensive or as variable, with reagrds to ice conditions. Pack ice, polynyas and ice leads are sampled using random and systematic transects.

The study area is surveyed using the Department of the Interior, Office of Aricraft Services' P2V and Gruman Super Goose. Scheduled transects, sampling methodology and rationale are summarized in the 4th quarter operations report (No. X, page 6).

VI. Results.

Survey flights under RU69 began for the first time in March 1976, hence no analysis of the data sampled are available at this time. Preliminary data summarization will be made during the 5th quarter report (1 April - 30 June 1976).

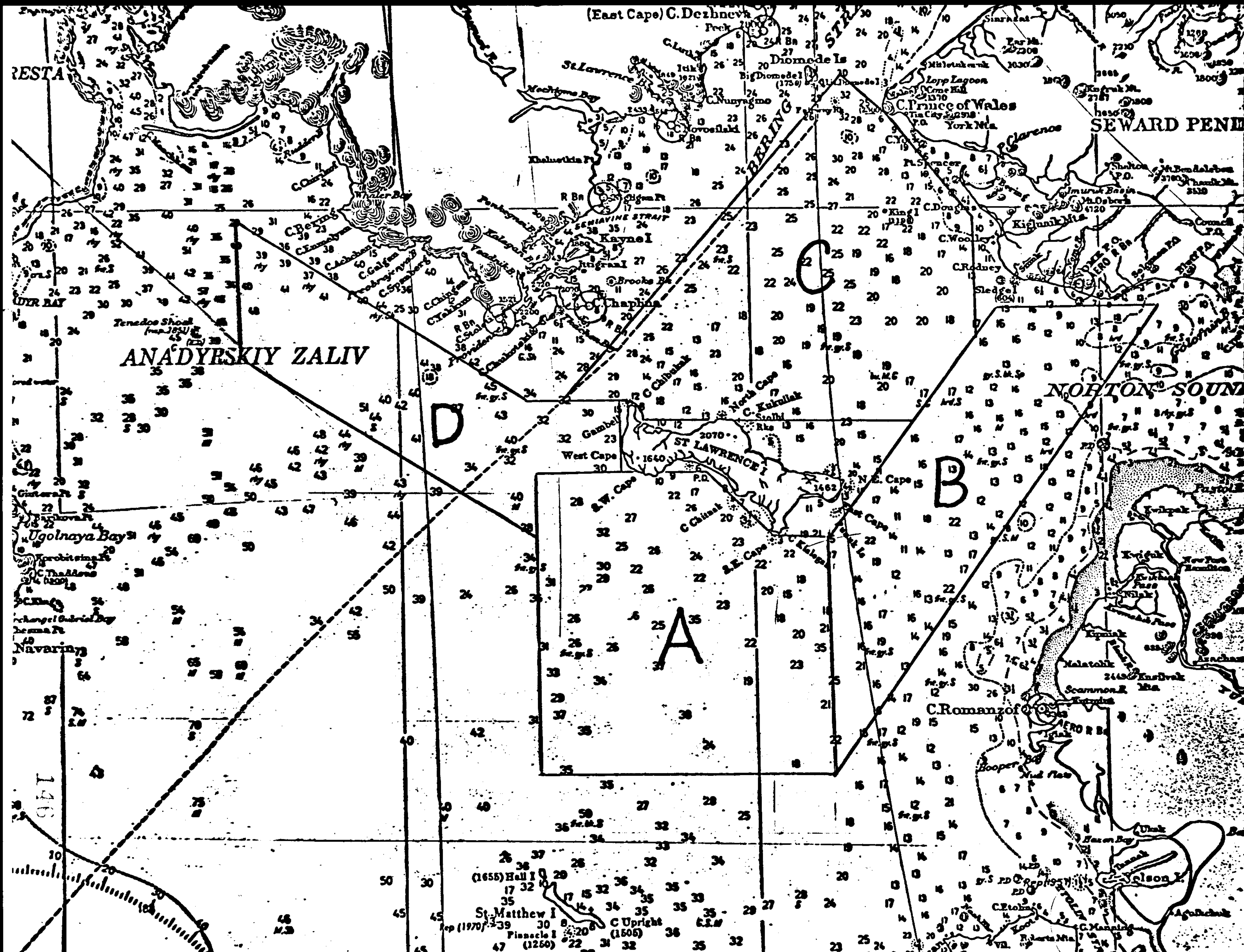
A sample annotated bibliography covering bowhead and belukha whales and other marine mammals in the northern Bering Sea and southern Chukchi Sea is included as an Addendum to this report.

VII. Discussion.

Surveys are flown in four geographic areas of the northern Bering Sea (developed during the 4th quarter planning stage), which represent four oceanographic-environmental conditions (Figure 1).

Section A generally consists of pack ice during the early spring with some open water south of St. Lawrence Island. Sector B is somewhat under the influence of fast ice to the east with some open water towards St. Lawrence Is. Sector C is characterized by large areas of broken ice and developing leads to the north and southewst, while emergent fast ice in the southern part of Sector C is forced up against the northern edge of St. Lawrence Island. Sector D may be an important area where bowhead and perhaps belukha remain during the winter or congregate during the early spring prior to their northern movements into the Chukchi and Beaufort Seas. Areas of open water in Sector D, called polynyas, could therefore represent significant distributional constraints on the movements of bowheads. Ice conditions in all

Figure 1. Survey area of the northern Bering Sea sampled for bowhead and belukha whales during 15-25 March 1976.



(East Cape) C. Dezhneva
Diomede Is
Big Diomede I
C. Prince of Wales
York Mts.
SEWARD PENI
St. Lawrence B.
C. Nunyagmo
C. Novosilski
BERING
STR
Lopp Lagoon
Mechigme Bay
Whaler Bay
C. Bering
C. Chaplino
C. Chukotskiy
SENIAVINE STRAIT
Kayne I
Brooks Bk
C. Spencer
C. Douglas
C. Woolley
C. Rodney
Sledge I
Kigluaik Mts.
NOME
AERO R Bn
ANADYRSKIY ZALIV
Tenedos Shoal
Ugolnaya Bay
Navarin
Gambell
West Cape
North Cape
ST LAWRENCE I
S.W. Cape
N.E. Cape
S.E. Cape
C. Chibukak
NORTON SOUND
C. Romanzof
Scammon B.
Hooper Bay
Nelson I.
Hazen Bay
Kwikluak
Kwiguk
St. Matthew I
Hall I
Pinnacle I
C Upright
C. Etolin
A
B
C
D

sectors are strongly influenced by wind, especially from the north and south.

VIII. Conclusions.

None.

IX. Needs for further study.

A priori it would appear from the limited literature sources that surveys using ships with ice breaker capabilities would be extremely helpful. Oil-gas lease areas in the northern Bering Sea are believed to be in the direct path of bowhead and belukha migration, and perhaps within their calving areas. Localized studies on certain population characteristics cannot be completely carried out by aircraft nor from shore, principally because of land fast ice conditions, but may from aboard ships.

X. Summary of 4th quarter operations.

A. Ship or laboratory activities.

1. Ship or field trip schedule.
   a. 15-25 March, Super Goose aircraft.
2. Scientific Party
   a. Dr. Howard Braham (Principal Investigator)
   b. Mr. Keith Parker (RU 67/69 coordinator)
   c. Mr. Bruce Krogman (RU70 coordinator)
   d. Mr. Patrick McGuire (observer)
3. Methods - See V (page 3)
4. Sample localities.

The survey area covered Lat. 62°N. to the south and 66°N. to the north; and Long. 177°W. to the west and 165°W. to the east. Pre-determined survey tracklines are summarized in Table 1; itemized for Sectors A through D (Figure 1). Transects in Sector A, B, and C were drawn at random, while those for Sector D represent a systematic design. Finalized tracklines that were flown will be discussed in the 5th quarter report.

5. Data collected or analyzed.

To be reported on in the 5th quarter report.

Table 1. Sample tracklines for random transects in the northern Bering Sea south (Sector A), east (Sector B) and north (Sector C) of St. Lawrence Island, and systematic tracklines west of St. Lawrence Island (Sector D) planned for the 15-25 March 1976 survey period (see figure 1).

Sector	Track No.	Beginning		Ending	
		Latitude	Longitude	Latitude	Longitude
A	1	62°37'	169°00'	62°37'	172°00'
	2	62°34'	"	62°34'	"
	3	62°19'	"	62°19'	"
	4	62°00'	"	62°00'	"
	5	62°39'	"	62°39'	"
	6	62°14'	"	62°14'	"
	7	61°50'	"	61°50'	"
	8	61°29'	"	61°29'	"
	9	62°44'	"	62°44'	"
	10	62°16'	"	62°16'	"
	11	61°40'	"	61°40'	"
	12	61°19'	"	61°19'	"
B	1	64°20'	166°24'	62°37'	168°00'
	2	62°00'	169°00'	64°20'	165°49'
	3	64°20'	166°25'	62°39'	168°00'
	4	61°29'	169°00'	64°20'	165°16'
	5	64°20'	166°29'	62°44'	168°00'
	6	61°10'	169°00'	64°20'	165°11'
C	1	64°58'	167°00'	64°58'	170°10'
	2	64°50'	"	64°50'	"
	3	64°25'	"	64°25'	"
	4	64°15'	"	64°15'	"
	5	63°57'	"	63°57'	"
	6	63°42'	"	63°42'	"
	7	65°37'	168°10'	63°47'	171°27'
	8	63°49'	171°35'	65°40'	168°18'
	9	65°42'	168°25'	63°51'	171°40'
	10	63°55'	171°53'	65°46'	168°36'
D	1	63°57'	173°35'	64°44'	176°24'
	2	64°30'	176°41'	63°28'	173°17'
	3	63°16'	173°44'	64°16'	177°03'
	4	64°01'	177°25'	62°56'	173°53'

ADDENDUM

Sample Annotated Bibliography

Research Unit 69

Bibliographic citations listed may apply to one or more research units. In the final report (1 October 1970) each RU will have listed a comprehensive annotated bibliography covering the appropriate geographic region(s) for which each RU is responsible.

SAMPLE ANNOTATED BIBLIOGRAPHY: RU 69

Annual Report, FY 1976

Bailey, Alfred M. and Russell W. Hendee. 1926. Notes on the mammals of northwestern Alaska. J. Mammal. 7(1): 9-28.

Recounts an expedition of 15 months in 1921-22, visiting King and St. Lawrence Islands, Wainwright, Point Hope, Demarcation Point, and points on the Siberian coast. Includes observations on: polar bear, largha seal, bearded seal, ringed seal, walrus, bowhead whale, gray whale, killer whale and harbor porpoise.

Burns, John J. 1965. The Walrus in Alaska. Vol. V, Fed, Aid in Wildlife Restoration Project Report covering investigations completed by Dec. 31, 1963. Alaska Department of Fish and Game. 48 pages.

The history of walrus exploitation, economic role in Alaska, and recent and current research are discussed. Some of the early chronicles, and nearly all scientific investigators are listed and referenced in the bibliography. Original research reported was collected for walrus observations to determine migration and distribution patterns. Most females start to breed around age 6, males about the same. Most mature females bear one calf every 2 years Major food species are Mya truncata and Clinocardium nuttalli (clams). Walrus predation on seals is discussed. Minimum population is estimated at 90,000. Migration and known distribution is given, by season, combining published and unpublished observations. Collected observations of hauling out areas are given, including the Walrus Islands in Bristol Bay and Punuk Islands. Collected behavioral observations are given

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Burns, John J. 1965. Marine Mammal Report. Vol. VI, Annual Project Segment Report, Federal Aid in Wildlife Restoration Project. Alaska Dept. of Fish and Game. 45 pages.

Covers calendar year 1964. Major spring migration of walrus through

Bering Strait occurred during the last week in May and the first week of June. This was at the same time as during previous years, in spite of an unusually slow retreat of the pack ice. Forty-one adult females examined were 64% parturient, 24% pregnant, and 12% barren. Parturition rate was found to be one calf every 2.02 years, among twenty-nine animals. Also contains short sections on migration (including notes on correlates of ice movement), segregation of sexes, and foetal development, in addition to reproductive investigations.

Notes that 10 or 12 whales, mostly grays, were taken at Barrow during the summer. Bearded seal biology is given in detail. Nursing period is short, 12-18 days, and by weaning time the pup has reached 69% of adult length. Migration is generally concurrent with the seasonal advance and retreat of the pack ice, although young seals are sometimes found where there is no ice.

Burns, John J. 1965. Marine Mammal Investigations in northwestern Alaska. Paper presented at the 45th Annual Conference of the Western Association of State Game and Fish Commissioners, Anchorage, AK, July 8, 1965. 10 pages.

Discusses biology and management of walrus and bearded seal, with concise presentation of natural history.

Burns, John J. 1966. Marine Mammal Report. Vol. VII Annual Project Segment Report, Fed. Aid in Wildlife Restoration. Alaska Dept. of Fish and Game. 47 pages.

Walrus teeth were examined from known age walruses, and the tooth interpretation method previously used was found valid. Reproductive tracts of 160 mature females from nursery herds were examined; 71 percent were newly parturient, 21% were pregnant, 8% were barren. Females first breed at age five or six, and calve from then on an average of once every 2.2 years. Adult female Pacific walrus reach a weight of about 2,100 pounds. The main migration moved through Bering Strait from 20 May - 18 June. Some positions and dates of walrus concentrations are noted. 21,015 seals were harvested and bountied from just south of Nunivak Island to Barrow, by 512 hunters: 13,590 ringed, 3,430 bearded, and 3,995 harbor seals.

Burns, John J. 1967. Marine Mammal Report. Vol. VIII, Annual Project Segment Report, Federal Aid in Wildlife Restoration Project. Alaska Dept. of Fish and Game. 44 pages.

Analysis of the age composition of 353 male walrus taken at Savoonga indicated an annual mortality rate of about 12 percent (maximum) for year classes 14 through 28, and about 14 percent (maximum) for year classes 14 through 33. Size of population is apparently continuing to increase. Walrus observations are reported from Nushagak Bay (May) Round Island in Bristol Bay (May-June), Big Diomede island and the Punuk Islands (early December). Eighty percent of the walruses harvested were taken by the villages of Gambell, Savoonga, Diomede and King Island. It is noted that some male walrus winter, singly or in small herds, much further north than the main groups (occassionally as far north as Lat. 70° in late February). Concentrations of animals were moving through the Bering Strait from May 28 to July 4. Five species of pinnipeds in the northern Bering Sea are discussed: ringed, ribbon, bearded and harbor seals, and walrus. A map gives the distribution of these species in April-early May, and the distribution is discussed as it corresponds to their different adaptations.

Burns, John J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51(3): 445-454.

Author's abstract: "Five species of pagophilic (ice-loving) pinnipeds live in the Bering and Chukchi seas: *Odobenus rosmarus*, *Phoca* (Pusa) *hispida*, *Phoca* (Histriophoca) *fasciata*, an ice-breeding population of *Phoca* (Phoca) *vitulina*, and *Erignathus barbatus*. Breeding adults of these species are mostly separated from each other during late winter and early spring, when throughout the pupping and subsequent mating periods, *P. vitulina* and *P. fasciata* occupy the edge-zone of the seasonal pack ice, *E. Barbatus* and *O. rosmarus* are mainly farther north within the heavier pack ice, and *P. hispida* occupies areas of extensive land-fast ice. This paper discusses differences in body structure, ecological adaptation, and behavior in relation to distribution of the five species.

Burns, John J. and Samuel J. Harbo, Jr. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25(4): 279-290.

Flights were made to survey the land-fast ice from Point Lay to Barter Island, from 8-15 June 1970, to establish baseline distribution and density of ringed seals. The density of seals in sectors east of Point Barrow was low and relatively uniform (2. 23, 1. 06, 1. 38 and 2. 43 seals/mi^2.) Within sectors southwest of this point, density was substantially higher (5. 36 and 3. 70 seals/mi^2). The minimum population was estimated at 11, 612 animals. Areas of previous seismic oil exploration within the survey area were compared to undisturbed portions and no appreciable difference in ringed seal occurrence was found. 4 figs., 3 tables.

Burns, John J. and James E. Morrow. 1973. "The Alaskan arctic marine mammals and fisheries", paper given at the Fifth International Congress of the Fondation Francaise D'Etudes Nordiques, called "Arctic Oil and Gas: Problems and Possibilities", at LeHavre, May 2-5, 1973. 22 pages.

Author discusses fishes and marine mammals of the Chukchi Sea, the arctic coast of Alaska and the northern Bering Sea with respect to offshore oil development. Toxicity of crude or refined oil to fishes is known and extreme toxicity to eggs and larvae is noted. Oil spilled in arctic waters will persist, due to the low temperature and slower decomposition. Seismic exploration by several different concerns often involves a succession of explosions in the same areas which destroy fish. Epontic algae grows on the under surface of the ice. Accidental or chronic gradual discharge of oil would spread under the ice, be trapped there for long periods of time, and either kill the algae there or be incorporated into the food chain from there on up. The same results can occur among benthic organisms when oil is deposited on the bottom. The occurrance of all arctic marine mammals is discussed.

Clarke, Robert. 1957. Migration of marine mammals. Norsk Hvalfangsttidende 46(1): 609-630.

A general review of migrations of the large whales and of small numbers of small cetaceans, fur seals, phocid seals, and walruses. Notes lack of understanding of mechanisms of migration. 11 figs., 76 refs.

Fay, Francis H. 1974. The role of ice in the ecology of marine mammals of the Bering Sea. In D. W. Wood and E. J. Kelley (Eds.), "Oceanography of the Bering Sea". Inst. of Marine Sci., U. of Alaska, Fairbanks. Pages 383-399.

Describes different kinds of ice; describes seasonal changes of ice and corresponding movements of marine mammals. Lists 25 species of marine mammals in 3 categories according to contact with ice. Good detail. Good understanding of habitats. Insights into evolution are discussed.

Fiscus, C.H. and W.M. Marquette. 1974. Report on Bowhead Whale Studies in Alaska, 1974. National Marine Fisheries Service. 29 pages. (unpublished manuscript)

Whaling catch records and sighting data for Bowhead and Belukha at various eskimo whaling camps along the coast of the Chukchi and Beaufort Seas are discussed. Spring and fall sightings of all marine mammals are also documented.

Foote, D.C. 1964. Observations of the Bowhead Whale at Point Hope, Alaska. 78 pages (unpublished manuscript).

Describes the occurance and distribution of bowheads in relation to the shore leads off Point Hope, and the frequency of age classes. The author describes ocean currents, sea ice conditions, migration routes and herd composition, calving and copulation as well as general bowhead behavior.

Klinkhart, Edward. 1966. The Beluga Whale in Alaska. Vol. VII, Project Report, Fed. Aid in Wildlife Restoration, Alaska Dept. of Fish and Game. 11 pages.

A general article drawn from about 25 sources. Nearly all concentrations of belugas occur in shallow bays or estuaries of large rivers north of Lat. 40°N (have been seen up to 60 miles upstream from the mouth of the Yukon River). Population in Bristol Bay, (which appears

to be resident throughout the year) is estimated at 1,000-1,500. Population in Cook Inlet is estimated at 300-400. Populations which winter in the Bering Sea may be those which summer in the western Canadian arctic and eastern Siberian arctic.

Nasu, Keiji. 1960. Oceanographic investigation in the Chukchi Sea during the summer of 1958. Sci. Rpts. Whales Res. Inst. 15: 143-158.

Nineteen stations were occupied in the area between Point Hope and the Kolyuchin Gulf and southward to the Bering Strait, during 5 days in August. Oceanographic data were presented. Marine productivity appears to increase in the western part and decrease in the eastern part. A map shows their sightings of gray whales, 2 right whales, a fin whale, and an unidentified whale, and also shows some previous sightings of gray whales in the Bering Sea. 11 figs.

Nasu, Keiji. 1963. Oceanography and whaling ground in the subarctic region of the Pacific Ocean. Sci. Rpts. Whales Res. Inst. 17: 105-155.

Data was obtained by whaling factory and whale marking boats in the North Pacific Ocean and Bering and Chukchi Seas. Extensive oceanographic data collected. Usual whaling grounds for blue, fin, humpback, sei, and sperm whales are discussed. Areas north and south of Unalaska are particularly productive for all species except perhaps blue. 51 figs.

Nishiwaki, Masahuru. 1966. Distribution and migration of marine mammals in the North Pacific area. Eleventh Pacific Science Congress, August 24, 1966.

Maps and short discussions on present knowledge of distribution of each species of marine mammal (excluding polar bear) found in the North Pacific, Bering Sea and waters north of Bering Strait. Thirteen pinnipeds, fifty-three cetaceans.

Omura, Hideo. 1958. North Pacific Right Whale. Sci. Rpts. Whales Res. Inst. 13: 1-52.

Reports data of two kinds: (1) the physical descriptions of 2 right whales taken near Japan in 1956, and (2) collected right whale sightings from the years 1925-34, 41, 48-57, in the coastal waters of Japan and the North Pacific. Black right whales appear in the Bering Sea in June and stay all summer. Of all sightings, 68% were of single individuals. Largest group seen was four. 8 plates, 27 figs. including 25 photos.

Omura, Hideo, Seiji Ohsumi, Takahisa Nemoto, Keiji Nasu, and Toshio Kasuya. 1969. Black Right Whales in the North Pacific. Sci. Rpts. Whales Res. Inst. 21: 1-78.

Gives detailed anatomical descriptions of 13 black right whales, including 2 previously reported by Omura, in 1958. Distribution is shown in maps, by month from April to September, based on Japanese whaling ship's records and Sleptsov's 1962 article. Extensive comments made on movements in the Aleutian area, and Gulf of Alaska, and the Bering Sea. 27 figs., 18 plates.

Pike, Gordon C. 1962. Migration and feeding of the gray whale (Eschrichtius gibbosus). J. Fish. Res. Bd. Can. 19(5): 815-838.

Observations of gray whales from the coasts of British Columbia, Washington and Alaska are combined with published accounts in an effort to define the timing and route of the migration, and feeding areas in the Bering and Chukchi Seas. Uncertainty remains as to the route between British Columbia and the Bering Sea. Feeding observations, particularly around St. Lawrence Island, are given. 4 figs., 2 are maps.

Scammon, C.M. 1874. The Marine Mammals of the Northwestern Coast of North America, John H. Carmany and Co., San Francisco and G.P. Putnam's Sons, New York. 319 pages.

The first major account of marine mammals in Alaska coupled with detailed descriptions of each species encountered. The book is written in three sections: I. Cetacea, II. Pinnipedia, and III. The American Whale-fishery.

Wilke, Ford, and Clifford H. Fiscus. 1961. Gray whale observations. J. Mammal. 42(1): 108-109.

Reports observations off Washington, off Kodiak and in the Chukchi Sea, Bering Sea and Gulf of Alaska. Includes thoughts on route of migration and observations of feeding.

ANNUAL REPORT

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ABUNDANCE AND SEASONAL DISTRIBUTION OF BOWHEAD WHALES AND BELUKHA

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March 15, 1976

I. Summary of objectives, conclusions, and implications with respect to OCS oil and gas development.

Bowhead (Balaena mysticetus) and belukha (Delphinapterus leucas) whales are thought to be associated with the ice front and polynya systems during the winter in the northern Bering Sea. They migrate northward in the spring to summer feeding areas in the Chukchi and Beaufort Seas. These areas and areas where animals can be found throughout the year, must be defined so that population estimates can be obtained providing a basis for evaluating conservation efforts, and to provide information necessary for management of the populations.

The Beaufort Sea "Basin" oil-gas lease sites are in the pathway of migrating bowhead and belukha whales. Oil spills and other disturbances of the marine environment could drastically affect migrating animals, especially in shore leads, even if pollution is kept local to lease sites. The effects of oil development on the biology and ecology of these animals at this critical time in their annual cycle must be evaluated before any rational oil lease development plan can be implemented.

II. Introduction.

A. General Nature and Scope of Study.
The number of bowheads that inhabit the Beaufort Sea is unknown but probably is small. Speculations have been made that the belukha stock numbers 3500± animals.

The bowhead, followed by the belukha, moves northward from the Bering Sea in late March or early April as leads begin to open. By late April in the Chukchi Sea there is a shore lead (usually within 1 to 5 miles off the coast) of open water extending from the Bering Strait northward to Pt. Hope and northeasterly to Pt. Barrow. Other leads open farther offshore but no information exists as to whether animals use these leads to migrate into the northern Chukchi Sea rather than the eastern Beaufort Sea.

Our general objectives then are to ascertain seasonal abundance and distribution. Data on all marine mammals in the survey area also will be reported.

B. Specific Objectives.
To determine what effect oil spills might have on these species during

critical periods we must determine if their spring migration is restricted to the shore lead or if there are animals using offshore leads. The assumption then is that shore leads are more vulnerable to oil related perturbations than offshore leads. This may not, however, be true. Information on the numbers of animals comprising these stocks is needed, and data on the migratory patterns both in spring and fall are necessary to determine times when the movement of vessel traffic and attendent dangers of petroleum development are minimal.

During the first year we designed a sampling program which will be tested during the 5th quarter, to obtain specific data on migratory patterns. Six surveys will be flown, three in May and three in June, 1976; and perhaps one additional flight in September, 1976. Weather conditions in the survey areas greatly influence the success and value of flights. We anticipate a need for 5 years of survey flights, coupled with several years of observations from the fast ice at the edge of the lead, to provide data on the numbers of animals comprising these stocks. Even then, reliable population estimates may not be possible. Knowledge gained in the first year will be used to develop programs in succeeding years.

C. Relevance to problems of petroleum development.
Results obtained from this study will provide a basis for evaluating the impact of oil-related activities on the whales. General location of whale movements related to site selection of potential drilling operations and transportation activities will be determined.

Extent of use of shore and offshore leads by bowheads and belukhas can thus be related to the temporal and spatial requirements of petroleum development and operations.

III. Current State of Knowledge.

Bowhead whales pass along the shore of the Chukchi and Beaufort Seas in leads and open water from April to October. Apparently belukhas migrate with the bowhead, or follow shortly thereafter. In the spring, bowheads appear to migrate in stages; early migrants (April) are younger and smaller animals, migrants in early May may represent an intermediate size-age category, while in late May and June adult females with calves and breeding bulls move past the whaling stations at Pt. Hope and Pt. Barrow. The movements of belukha are assumed to parallel those of the bowhead, however, data are lacking.

The specific grouping and composition of bowhead and belukha populations is unknown, as is the lack of information on abundance figures. Stock assessment and total geographic movements of bowheads and belukhas cannot be made adequately from aboard ships nor from the shore leads. Vessels undoubtedly cannot work effectively in the lead systems without altering the movements of whales, also it is not likely that a vessel can traverse enough area to assess geographic distribution and abundance in one season (e.g., late April - mid June). Land base observations have limitations as some animals undoubtedly pass undetected (without the use of hydrophones). An integration of aerial and land and/or shipboard censusing would probably achieve the best census results.

IV. Study Area.

The study area includes the Chukchi Sea north from Point Hope into the Arctic Ocean and east into the Beaufort Sea to the United States - Canadian border. Specifically, this area is bounded by Lat. 68°N. to the south, Lat. 71°N. to the north, Long. 169°W. to the west and Long. 141°W. to the east.

V. Sources, methods and rationale of data collection.

A. Sources.

1. A literature search and annotated bibilography is being prepared and will be completed by 1 October, 1976. Published and unpublished data will be gathered of catch statistics, distribution, abundance, and timing of migration.
2. The first aerial survey of the Beaufort and northeastern Chukchi Seas was made from 2 September to 7 October. The survey aircraft was a DeHaviland Twin Otter provided by the Naval Arctic Research Laboratory at Barrow, Alaska. All flights were made from Barrow. The scientific party included:

Willman M. Marquette	National Marine Fisheries Service Marine Mammal Division Principal Investigator, RU 70
Robert D. Everitt	National Marine Fisheries Service Marine Mammal Division

Geoffry M. Carroll

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Marine Mammal Division

B. Methods.
Twelve flights were made on approximately 3, 300 miles of random transect lines over the survey area which included the coastal leads and open water, and various ice covers ranging from little ice to solid ice pack. Photographs (135 mm high speed Ektachrome color film) were made of the target species.

C. Rationale of Data Collection.
1. Data Processing.
Techniques and methods used for the survey were standardized where possible with those of other investigations. Several methods of data analysis are planned for this program, and through consultation with NWFC biometricians and outside consultants, the most suitable will be selected. Statistical analysis of the data will be carried out after the 1976 spring field season and reported on in the final report (1 October 1976).

The numbers and location of all species of marine mammals sighted during the surveys will be available on computer cards and magnetic disc-storage. Charts showing sighting locations will be prepared for inclusion in reports of survey results.

2. Data or sample exchange interface.
The investigators involved in OCS research programs are in contact with each other, and in most cases several programs will use the same platform and perform the research cooperatively. Raw data obtained on transects will be available on work sheets almost immediately upon conclusion of a flight and then placed on punch cards. Sighting reports of species other than bowheads and belukha may be needed by other principal investigators, i. e. Estes RU 14, and can be made available within a short time after each survey.

VI. Results.

A literature search is in progress and ground work on preparation of an annotated bibliography with standardized format will be completed at the end of the FY76 contract period. A sample annotated bibliography is included in this report as an Addendum.

Methods for recording data have been prepared and data processing begun. The data will be entered on cards on final approval of a format by the OCSEAP Data Management Program.

Few marine mammals were observed during the fall 1975 survey. Only two bowheads, and no belukhas were observed (Table 1). The tracklines flown are shown in Figure 1. A detail of the tracklines and exact locations of animals surveyed will be reported on in the final report (1 October 1976). A summary of marine mammals spotted by other OCS and non-OCS investigators is reported in Table 2, according to species location.

VII. Discussion.

Photographs and data obtained during the September and October survey are being examined and will be analyzed together with the spring 1976 survey. Data collected and reported by other agencies during the last year such as in Table 2 will be included in the final report. Other species observed during the September-October 1975 aerial survey will be forwarded to interested Principal Investigators.

Fog, high winds, rain and other factors all affect the success of survey flights. Where necessary during flights, tracklines are changed to obtain the best weather conditions over each survey area. In future planning sufficient time will be allowed for delays caused by weather. The ice pack remained up against the land much of the fall, hence, few surveys of leads could be made successfully.

The GNS 500 navigational aid in the Twin Otter was not working properly and correct positions had to be obtained by use of radio beacons and Dewline station fixes. This reduced the effectiveness of our transect effort, causing the reliability of our transect theory to be reduced.

A detailed analysis of data obtained during the 1975 and 1976 fall surveys, and spring 1976 surveys will be reported on in the final RU 70 report.

VIII. Conclusions.

None at this time.

Table 1. A summary of live and dead marine mammals sighted during an aerial survey from Point Lay (Lat. 69°48'N. Long. 163° 00'W.) to Herschel Island (Lat. 69°38'N. Long. 139°00'W.) from 2 September to 7 October 1975.

Species	Animals Observed	
	Live	Dead
Bowhead (Balaena mysticetus)	2	0
Unidentified whale	1	2
Belukha (Delphinapterus leucas)	0	0
Walrus (Odobenus rosmarus)	462	3
Bearded seal (Erignathus barbatus)	2	0
Polar Bear (Ursus maritimus)	2	0
Unidentified seal	0	1

Figure 1. Tracklines flown from 2 September to 7 October 1975 from Point Lay (Lat. 09°48'N. Long. 163°00'W.) to Herschel Island (Lat. 69°38'N. Long. 139°00'W.) surveying shore leads for marine mammals.

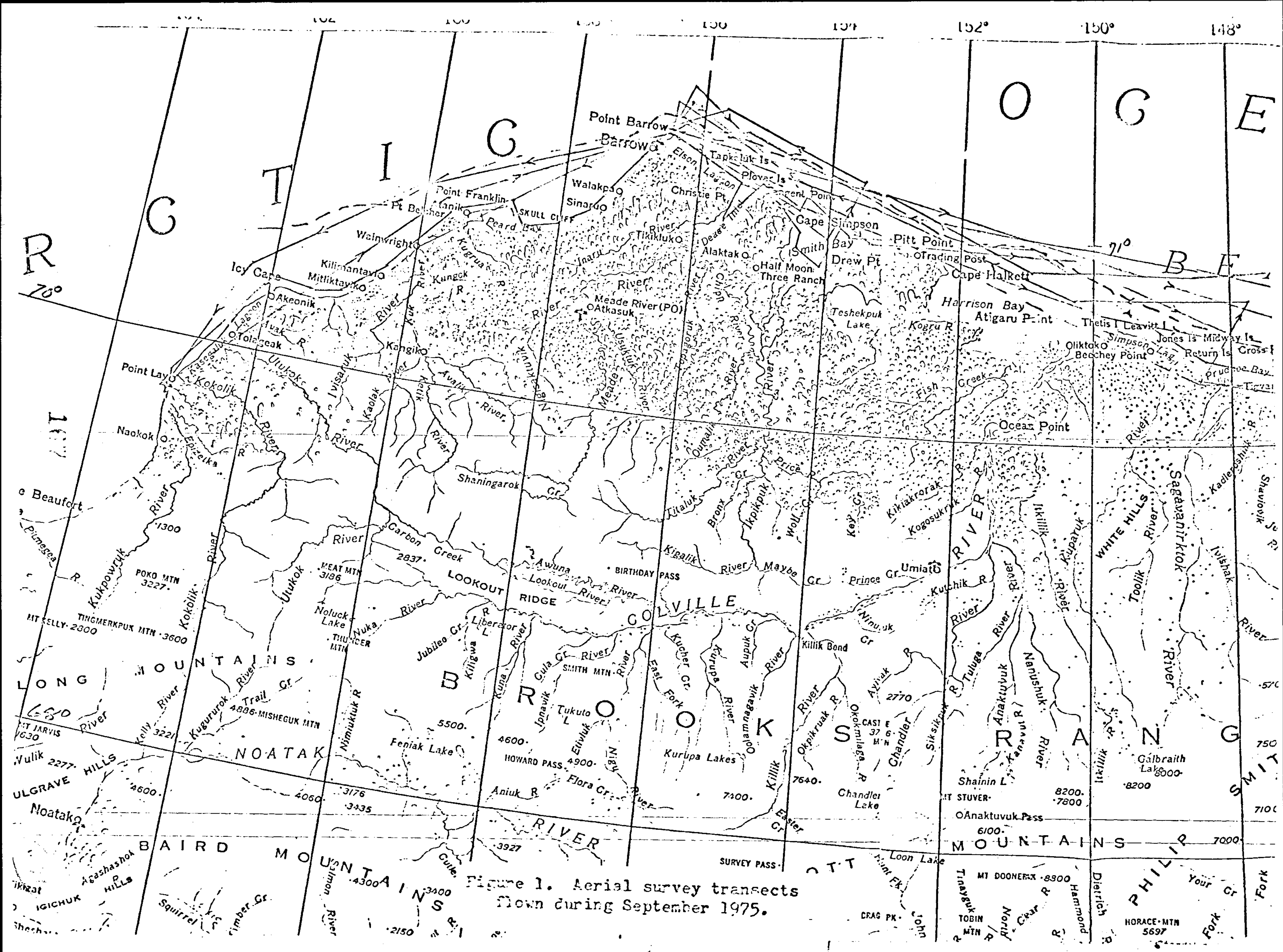
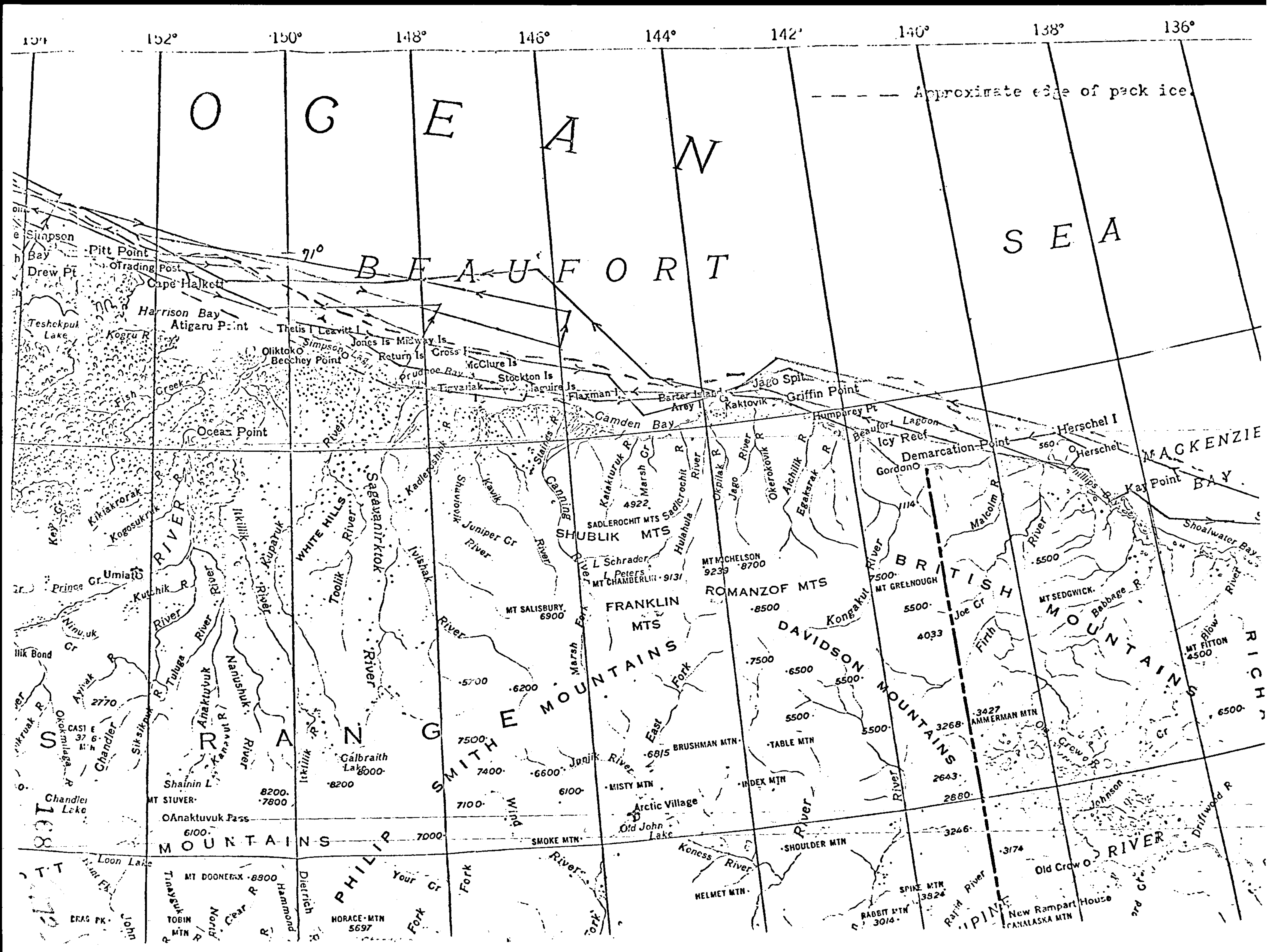


Figure 1. Aerial survey transects flown during September 1975.



152°
150°
148°
146°
144°
142°
140°
138°
136°
Approximate edge of pack ice.
OCEAN
BEAUFORT SEA
71°
Simpson
Pitt Point
Trading Post
Drew Pt
Cape Halkett
Harrison Bay
Atigaru Point
Teshekpuk Lake
Kogru R
Thetis I
Leavitt I
Simpson Lag
Jones Is
Midway Is
Return Is
Cross I
McClure Is
Oliktok
Beechey Point
Prudhoe Bay
Stockton Is
Tigvariak
Maguire Is
Flaxman I
Barter Island
Arey I
Kaktovik
Jago Spit
Griffin Point
Camden Bay
Humphrey Pt
Beaufort Lagoon
Icy Reef
Demarcation Point
Herschel I
Herschel
MACKENZIE BAY
Kay Point
Shoalwater Bay
Fish Creek
Ocean Point
Kikiakrorak
Kogosukruk
COLVILLE RIVER
Itkillik
Kuparuk
WHITE HILLS
Sagavanirktok
Kadleroshilik
Shaviovik
Kavik
Canning
Staines R
Katakturuk R
Marsh Cr
Sadlerochit
Hulahula
Okpilak R
Jago River
Okerokovik R
Aichilik R
Egaksrak R
Gordon
Malcolm R
Firth River
Babbage R
Juniper Cr
SADLEROCHIT MTS
SHUBLIK MTS
L Schrader
L Peters
MT CHAMBERLIN 9131
MT MICHELSON 9239 8700
ROMANZOF MTS
FRANKLIN MTS
MT SALISBURY 6900
MT GREENOUGH
BRITISH MOUNTAINS
MT SEDGWICK
MT FITTON 4500
DAVIDSON MOUNTAINS
Kongakut River
Joe Cr
Umiat
Prince Cr
Kutchik R
Toolik
Ivishak
Tuluga River
Anaktuvuk R
Nanushuk
Chandler
Siksikpuk R
Okokmilaga R
Chandler Lake
Galbraith Lake
Itkillik
Shainin L
MT STUVER
Anaktuvuk Pass
BROOKS RANGE
PHILIP SMITH MOUNTAINS
MOUNTAINS
East Fork
Marsh Fork
Junjik River
BRUSHMAN MTN
TABLE MTN
MISTY MTN
INDEX MTN
Arctic Village
Old John Lake
SMOKE MTN
SHOULDER MTN
Koness River
HELMET MTN
SPIKE MTN 3824
RABBIT MTN 3014
Rapid River
HAMMERMAN MTN
Old Crow R
Johnson
Driftwood R
Old Crow
RIVER
New Rampart House
CANALASKA MTN
Loon Lake
MT DOONERAK 8800
Dietrich
Hammond
Wind
Your Cr
HORACE MTN 5697
TOBIN MTN
CRAG PK
Tinayguk

Table 2. Marine mammals sighted by various OCSEAP and non-OCS observers in the RU 70 aerial survey area, during 1-30 September 1975.

Date/ Time	Numbers	Position	Observer	Comments
Unidentified Whales				
8 Sep 75	1	Lat. 70°47'N. Long. 160°57'W.	J. Estes (USF&W)	P2V fall aerial survey
11 Sep 75	2	Lat. 70°49'N. Long. 159°43'W.	D. Miller	Off Pt. Belden, 1-2 miles, gray-blueish color
18 Sep 75 0900	2	Lat. 71°23'N. Long. 155°57'W.	D. Miller	Whales heaaed NNW dark in color, almost black
	5	Lat. 70°58'N. Long. 158°55'W.	D. Miller	Whales traveling SW lc 4/8
Gray Whales (Eschrictius robustus)				
1 Sep 75	1	Lat. 70°28'N. Long. 161°07'W.	J. Estes	Off Wainwright P2V fall aerial survey
Bowhead Whales (Balaena mysticetus)				
1 Sep 75	3	Lat. 69°20'N. Long. 136°00'W.	Pat Doyle (Bradley Air Service, Canada)	Observed from helicopter
	1-2	Lat. 69°30'N. Long. 137°00'W.	"	"

Table 2. (cont'd)

Date/ Time	Numbers	Position	Observer	Comments
Bowhead Whales (cont'd)				
7 Sep 75 (approx)	1	Lat. 70°07'N. Long. 143°23'W.	Herman Ishanon (Kaktovik native)	Small bowhead 3-4 miles east of Porter Island
8 sep 75	1	Lat. 71°02'N. Long. 158°57'W.	J. Estes	Off Pt. Franklin P2V fall aerial survey.
14 Sep 75	4	Lat. 69°03'N. Long. 137°42'W.	Pat Doyle	12 miles west of Shingle Pt. and 1/2 mile off shore.
16 Sep 75 1600	1	Lat. 71°24'N. Long. 56°27'W.	M. Densley (NARL)	50 yards off Pt. Barrow heading W
17 Sep 75	1	Lat. 71°20'N. Long. 156°46'W.	S. Paktohok (Whaling crew)	
20 Sep 75	3	Lat. 70°08'N. Long. 143°19'W.	Koktovik whalers	Whalers reported total of 3 whales during 13-20 Sep 75.
28 Sep 75	1	Lat. 71°28.3'N. Long. 156°15.5'W.	M. Densley	From Burton Island heading SW
Belukha Whales (Delphinapterus leucas)				
3 Sep 75	?	Lat. 70°38'N. Long. 160°10'W.	J. Aiken (NARL pilot)	Off Wainwright - Numerous (?) belukha
5 Sep 75	10	?	Barrow native	Between Pt. Barrow & Plover Is. 100-200 yds offshore headed NW

Table 2. (cont'd)

Date/ Time	Numbers	Position	Observer	Comments
Belukha Whales (cont'd)				
8 Sep 75	3	Lat. 71°47'N. Long. 157°30'W.	J. Estes	P2V fall aerial survey
	1	Lat. 71°27'N. Long. 158°08'W.		
	11	Lat. 71°15'N. Long. 158°28'W.		
	1	Lat. 71°13'N. Long. 158°30'W.		
	3	Lat. 71°15'N. Long. 158°55'W.		
	1	Lat. 71°31'N. Long. 158°55'W.		
11 Sep 75	3	Lat. 70°46'N. Long. 159°55'W.	D. Miller	Between Wainwright and Pt. Barrow 2-3 miles off shore
13 Sep 75 1330	3	Lat. 71°00'N. Long. 158°00'W	J. Mellos (NARL)	3-5 miles offshore in Pearl Bay
Walrus (Odobenus rosmarus)				
18 Sep 75	100-200	Lat. 70°58'N. Long. 158°55'W.	D. Miller	lc 1-2/8
21 Sep 75	Many (?)	Lat. 70°53'N. Long. 159°23'W.	D. Miller	Between Pt. Franklin & Pt. Belcher

Table 2. (cont'd)

Date/ Time	Number	Location	Observer	Comments
Unidentified Seal or Walrus				
22 Sep 75	1	Lat. 70°20'N. Long. 157°24'W.	D. Miller	15 miles S of Barrow, 10 miles offshore
Polar Bear (*Ursus maritimus*)				
18 Sep 75	3	Lat. 71°31°N. Long. 156°36'W.	D. Miller	10 miles N of Barrow running north.

IX. Needs for further study.

The NMFS has prepared and submitted a proposal to OCSEAP for the establishment of an ice-based census station at Barrow, Alaska. The purpose of the ice-based station is to obtain a count of all whales migrating past Barrow during the spring. Observations on the ice should allow us to make more reliable estimates of whale movements, group compositions and abundance. Our ability to count animals passing by a counting station would be greatly increased if a hydrophone were available to our census personnel.

X. Summary of 4th quarter operations.

A. Ship or laboratory activities.
1. Ship or field trip schedule - None.
2. Scientific Party - None.
3. Methods
    a. Sampling methods were developed (to be reported on the 5th quarter report) which are designed to minimize the variance in estimating population abundance. The survey scheme will include replicated samples perpendicular to the shore lead to: (1) avoid duplicate counts of animals passing certain areas along the coast; and (2) identify group composition as animals migrate past the trackline.
    b. Coordination efforts for ground truth between the ice-based station at Pt. Barrow and the aerial survey team have been developed and are expected to be implemented in April, May, and June.
4. Sample localities - None.
5. Data collected or analyzed.
    a. No data collected from 1 Jan to 31 March 1976.
    b. Data collected in September 1975 was summarized and will be put into OCS data management format during the 5th quarter. Results of this survey are covered in VI.

ADDENDUM

Sample Annotated Bibliography

Research Unit 70

Bibliographic citations listed may apply to one or more research units. In the final report (1 October 1976) each RU will have listed a comprehensive annotated bibliography covering the appropriate geographic region(s) for which each RU is responsible

SAMPLE ANNOTATED BIBLIOGRAPHY: RU 70

Annual Report, FY 1976

Bailey, Alfred M. and Russell W. Hendee. 1926. Notes on the mammals of northwestern Alaska. J. Mammal. 7(1): 9-28.

Recounts an expedition of 15 months in 1921-22, visiting King and St. Lawrence Islands, Wainwright, Point Hope, Demarcation Point, and points on the Siberian coast. Includes observations on: polar bear, largha seal, bearded seal, ringed seal, walrus, bowhead whale, gray whale, killer whale and harbor porpoise.

Burns, John J. 1965. The Walrus in Alaska. Vol. V, Fed, Aid in Wildlife Restoration Project Report covering investigations completed by Dec. 31, 1963. Alaska Department of Fish and Game. 48 pages.

The history of walrus exploitation, economic role in Alaska, and recent and current research are discussed. Some of the early chronicles, and nearly all scientific investigators are listed and referenced in the bibliography. Original research reported was collected for walrus observations to determine migration and distribution patterns. Most females start to breed around age 6, males about the same. Most mature females bear one calf every 2 years Major food species are Mya truncata and Clinocardium nuttalli (clams). Walrus predation on seals is discussed. Minimum population is estimated at 90,000. Migration and known distribution is given, by season, combining published and unpublished observations. Collected observations of hauling out areas are given, including the Walrus Islands in Bristol Bay and Punuk Islands. Collected behavioral observations are given

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Burns, John J. 1965. Marine Mammal Report. Vol. VI, Annual Project Segment Report, Federal Aid in Wildlife Restoration Project. Alaska Dept. of Fish and Game. 45 pages.

Covers calendar year 1964. Major spring migration of walrus through

Bering Strait occurred during the last week in May and the first week of June. This was at the same time as during previous years, in spite of an unusually slow retreat of the pack ice. Forty-one adult females examined were 64% parturient, 24% pregnant, and 12% barren. Parturition rate was found to be one calf every 2.02 years, among twenty-nine animals. Also contains short sections on migration (including notes on correlates of ice movement), segregation of sexes, and foetal development, in addition to reproductive investigations.

Notes that 10 or 12 whales, mostly grays, were taken at Barrow during the summer. Bearded seal biology is given in detail. Nursing period is short, 12-18 days, and by weaning time the pup has reached 69% of adult length. Migration is generally concurrent with the seasonal advance and retreat of the pack ice, although young seals are sometimes found where there is no ice.

Burns, John J. 1965. Marine Mammal Investigations in northwestern Alaska. Paper presented at the 45th Annual Conference of the Western Association of State Game and Fish Commissioners, Anchorage, AK, July 8, 1965. 10 pages.

Discusses biology and management of walrus and bearded seal, with concise presentation of natural history.

Burns, John J. 1966. Marine Mammal Report. Vol. VII Annual Project Segment Report, Fed. Aid in Wildlife Restoration. Alaska Dept. of Fish and Game. 47 pages.

Walrus teeth were examined from known age walruses, and the tooth interpretation method previously used was found valid. Reproductive tracts of 160 mature females from nursery herds were examined; 71 percent were newly parturient, 21% were pregnant, 8% were barren. Females first breed at age five or six, and calve from then on an average of once every 2.2 years. Adult female Pacific walrus reach a weight of about 2,100 pounds. The main migration moved through Bering Strait from 20 May - 18 June. Some positions and dates of walrus concentrations are noted. 21,015 seals were harvested and bountied from just south of Nunivak Island to Barrow, by 512 hunters: 13,590 ringed, 3,430 bearded, and 3,995 harbor seals.

Burns, John J. 1967. Marine Mammal Report. Vol. VIII, Annual Project Segment Report, Federal Aid in Wildlife Restoration Project. Alaska Dept. of Fish and Game. 44 pages.

Analysis of the age composition of 353 male walrus taken at Savoonga indicated an annual mortality rate of about 12 percent (maximum) for year classes 14 through 28, and about 14 percent (maximum) for year classes 14 through 33. Size of population is apparently continuing to increase. Walrus observations are reported from Nushagak Bay (May) Round Island in Bristol Bay (May-June), Big Diomede island and the Punuk Islands (early December). Eighty percent of the walruses harvested were taken by the villages of Gambell, Savoonga, Diomede and King Island. It is noted that some male walrus winter, singly or in small herds, much further north than the main groups (occassionally as far north as Lat. 70° in late February). Concentrations of animals were moving through the Bering Strait from May 28 to July 4. Five species of pinnipeds in the northern Bering Sea are discussed: ringed, ribbon, bearded and harbor seals, and walrus. A map gives the distribution of these species in April-early May, and the distribution is discussed as it corresponds to their different adaptations.

Burns, John J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51(3): 445-454.

Author's abstract: "Five species of pagophilic (ice-loving) pinnipeds live in the Bering and Chukchi seas: Odobenus rosmarus, Phoca (Pusa) hispida, Phoca (Histriophoca) fasciata, an ice-breeding population of Phoca (Phoca) vitulina, and Erignathus barbatus. Breeding adults of these species are mostly separated from each other during late winter and early spring, when throughout the pupping and subsequent mating periods, P. vitulina and P. fasciata occupy the edge-zone of the seasonal pack ice, E. Barbatus and O. rosmarus are mainly farther north within the heavier pack ice, and P. hispida occupies areas of extensive land-fast ice. This paper discusses differences in body structure, ecological adaptation, and behavior in relation to distribution of the five species.

Burns, John J. and Samuel J. Harbo, Jr. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25(4): 279-290.

Flights were made to survey the land-fast ice from Point Lay to Barter Island, from 8-15 June 1970, to establish baseline distribution and density of ringed seals. The density of seals in sectors east of Point Barrow was low and relatively uniform (2.23, 1.06, 1.38 and 2.43 seals/mi^2.) Within sectors southwest of this point, density was substantially higher (5.36 and 3.70 seals/mi^2). The minimum population was estimated at 11,612 animals. Areas of previous seismic oil exploration within the survey area were compared to undisturbed portions and no appreciable difference in ringed seal occurrence was found. 4 figs., 3 tables.

Burns, John J. and James E. Morrow. 1973. "The Alaskan arctic marine mammals and fisheries", paper given at the Fifth International Congress of the Fondation Francaise D'Etudes Nordiques, called "Arctic Oil and Gas: Problems and Possibilities", at LeHavre, May 2-5, 1973. 22 pages.

Author discusses fishes and marine mammals of the Chukchi Sea, the arctic coast of Alaska and the northern Bering Sea with respect to offshore oil development. Toxicity of crude or refined oil to fishes is known and extreme toxicity to eggs and larvae is noted. Oil spilled in arctic waters will persist, due to the low temperature and slower decomposition. Seismic exploration by several different concerns often involves a succession of explosions in the same areas which destroy fish. Epontic algae grows on the under surface of the ice. Accidental or chronic gradual discharge of oil would spread under the ice, be trapped there for long periods of time, and either kill the algae there or be incorporated into the food chain from there on up. The same results can occur among benthic organisms when oil is deposited on the bottom. The occurrance of all arctic marine mammals is discussed.

Clarke, Robert. 1957. Migration of marine mammals. Norsk Hvalfangsttidende 46(1): 609-630.

A general review of migrations of the large whales and of small numbers of small cetaceans, fur seals, phocid seals, and walruses. Notes lack of understanding of mechanisms of migration. 11 figs., 76 refs.

Fay, Francis H. 1974. The role of ice in the ecology of marine mammals of the Bering Sea. In D. W. Wood and E. J. Kelley (Eds.), "Oceanography of the Bering Sea". Inst. of Marine Sci., U. of Alaska, Fairbanks. Pages 383-399.

Describes different kinds of ice; describes seasonal changes of ice and corresponding movements of marine mammals. Lists 25 species of marine mammals in 3 categories according to contact with ice. Good detail. Good understanding of habitats. Insights into evolution are discussed.

Fiscus, C.H. and W.M. Marquette. 1974. Report on Bowhead Whale Studies in Alaska, 1974. National Marine Fisheries Service. 29 pages. (unpublished manuscript)

Whaling catch records and sighting data for Bowhead and Belukha at various eskimo whaling camps along the coast of the Chukchi and Beaufort Seas are discussed. Spring and fall sightings of all marine mammals are also documented.

Foote, D.C. 1964. Observations of the Bowhead Whale at Point Hope, Alaska. 78 pages (unpublished manuscript).

Describes the occurance and distribution of bowheads in relation to the shore leads off Point Hope, and the frequency of age classes. The author describes ocean currents, sea ice conditions, migration routes and herd composition, calving and copulation as well as general bowhead behavior.

Klinkhart, Edward. 1966. The Beluga Whale in Alaska. Vol. VII, Project Report, Fed. Aid in Wildlife Restoration, Alaska Dept. of Fish and Game. 11 pages.

A general article drawn from about 25 sources. Nearly all concentrations of belugas occur in shallow bays or estuaries of large rivers north of Lat. 40°N (have been seen up to 60 miles upstream from the mouth of the Yukon River). Population in Bristol Bay, (which appears

to be resident throughout the year) is estimated at 1,000-1,500. Population in Cook Inlet is estimated at 300-400. Populations which winter in the Bering Sea may be those which summer in the western Canadian arctic and eastern Siberian arctic.

Nasu, Keiji. 1960. Oceanographic investigation in the Chukchi Sea during the summer of 1958. Sci. Rpts. Whales Res. Inst. 15: 143-158.

Nineteen stations were occupied in the area between Point Hope and the Kolyuchin Gulf and southward to the Bering Strait, during 5 days in August. Oceanographic data were presented. Marine productivity appears to increase in the western part and decrease in the eastern part. A map shows their sightings of gray whales, 2 right whales, a fin whale, and an unidentified whale, and also shows some previous sightings of gray whales in the Bering Sea. 11 figs.

Nasu, Keiji. 1963. Oceanography and whaling ground in the subarctic region of the Pacific Ocean. Sci. Rpts. Whales Res. Inst. 17: 105-155.

Data was obtained by whaling factory and whale marking boats in the North Pacific Ocean and Bering and Chukchi Seas. Extensive oceanographic data collected. Usual whaling grounds for blue, fin, humpback, sei, and sperm whales are discussed. Areas north and south of Unalaska are particularly productive for all species except perhaps blue. 51 figs.

Nishiwaki, Masahuru. 1966. Distribution and migration of marine mammals in the North Pacific area. Eleventh Pacific Science Congress, August 24, 1966.

Maps and short discussions on present knowledge of distribution of each species of marine mammal (excluding polar bear) found in the North Pacific, Bering Sea and waters north of Bering Strait. Thirteen pinnipeds, fifty-three cetaceans.

Omura, Hideo. 1958. North Pacific Right Whale. Sci. Rpts. Whales Res. Inst. 13: 1-52.

Reports data of two kinds: (1) the physical descriptions of 2 right whales taken near Japan in 1956, and (2) collected right whale sightings from the years 1925-34, 41, 48-57, in the coastal waters of Japan and the North Pacific. Black right whales appear in the Bering Sea in June and stay all summer. Of all sightings, 68% were of single individuals. Largest group seen was four. 8 plates, 27 figs. including 25 photos.

Omura, Hideo, Seiji Ohsumi, Takahisa Nemoto, Keiji Nasu, and Toshio Kasuya. 1969. Black Right Whales in the North Pacific. Sci. Rpts. Whales Res. Inst. 21: 1-78.

Gives detailed anatomical descriptions of 13 black right whales, including 2 previously reported by Omura, in 1958. Distribution is shown in maps, by month from April to September, based on Japanese whaling ship's records and Sleptsov's 1962 article. Extensive comments made on movements in the Aleutian area, and Gulf of Alaska, and the Bering Sea. 27 figs., 18 plates.

Pike, Gordon C. 1962. Migration and feeding of the gray whale (Eschrichtius gibbosus). J. Fish. Res. Bd. Can. 19(5): 815-838.

Observations of gray whales from the coasts of British Columbia, Washington and Alaska are combined with published accounts in an effort to define the timing and route of the migration, and feeding areas in the Bering and Chukchi Seas. Uncertainty remains as to the route between British Columbia and the Bering Sea. Feeding observations, particularly around St. Lawrence Island, are given. 4 figs., 2 are maps.

Scammon, C.M. 1874. The Marine Mammals of the Northwestern Coast of North America, John H. Carmany and Co., San Francisco and G.P. Putnam's Sons, New York. 319 pages.

The first major account of marine mammals in Alaska coupled with detailed descriptions of each species encountered. The book is written

in three sections: I. Cetacea, II. Pinnipedia, and III. The American Whale-fishery.

Wilke, Ford, and Clifford H. Fiscus. 1961. Gray whale observations. J. Mammal. 42(1): 108-109.

Reports observations off Washington, off Kodiak and in the Chukchi Sea, Bering Sea and Gulf of Alaska. Includes thoughts on route of migration and observations of feeding.

Annual Report

Contract #
Research Unit #194
Reporting Period:
1 July 75 to 31 March 76
Number of pages: 51

MORBIDITY AND MORTALITY OF MARINE MAMMALS - BERING SEA

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31 March 1976

ANNUAL REPORT

I. Summary

The objectives of this study are:

(1) To determine the number (by species, sex, and age) of stranded marine mammals along a sample of the Alaskan Bering Sea coast,

(2) To determine the pathological conditions and agents that caused or contributed to the moribund condition or death of those animals, and

(3) To determine the major causes of natural morbidity of certain species of Bering Sea marine mammals through selective collection and study of sick and moribund individuals.

Surveys in 1975 of somewhat more than 20 per cent of the Alaskan coast of the Bering Sea-Bering Strait region yielded 223 relatively fresh carcasses of whales, walruses, and seals, weighing some 675 tons in all. Such carcasses provide a significant amount of food for terrestrial and marine organisms that inhabit the coastal zone. As such, they seem to be an important link in the feedback, not only of nutrients and energy, but of pollutants and disease agents from the marine to the terrestrial system. Their distribution is determined in large part by both offshore and near-shore currents, relative to the normal distribution of the living populations. A large proportion that strands in close proximity to human settlements is the product of current hunting practices, rather than of the health of the animal

populations or of the system in which they reside.

Since marine mammals are top level consumers, to monitor their health and welfare is to monitor that of the marine ecosystem itself. Their very existence is finely tuned to certain dependable characteristics of their environment, and their response is likely to be swift to any major perturbation or pollution of it, as well as to simple physical disturbance of themselves. One sensitive measure of such response is the rate of occurrence and condition of stranded moribund and dead individuals.

II. Introduction

A. General nature and scope of study

This study is designed to provide baseline information on the incidence and causes of pathological conditions in marine mammal populations of the Bering Sea that will be useful in evaluating future impacts of petroleum-related activities in that region. Primary emphasis is placed on surveys of distribution and numbers of beached carcasses of moribund and dead animals and on necropsy of such specimens for determination of causes of illness and death.

B. Specific objectivies

(1) to determine the number (by species, sex, and age) and location of stranded marine mammals on selected segments of the Alaskan Bering Sea coast,

(2) to determine the pathological conditions and agents thereof that caused or contributed to the death of those mammals, and

(3) to determine the causes of natural morbidity in certain species of Bering Sea marine mammals through selective collection and examination of sick and moribund individuals.

C. Relevance to problems of petroleum development

Marine mammals are the top level consumers in the Bering Sea trophic system. On that account, to monitor their health and welfare, including the incidence of diseases and other pathological conditions, is to monitor the "health" of the marine ecosystem itself, since they are the ultimate recipients of all changes that take place within the system, from perturbation and pollution to simple physical disturbance. Because they tend to be long-lived, they provide a cumulative historical record of past conditions, e.g. in their overall growth and the growth of certain body parts, such as the tusks of walruses and the vibrissae of seals and sea lions, and in their stores of certain pollutants, such as heavy metals, pesticides, and mineral hydrocarbons. But they are also responsive to short-term changes, in that their nutrition and the nurture and survival of their young are finely tuned to certain environmental requirements that are easily disrupted by man-made changes in the system itself.

III. Current state of knowledge

At the inception of this project, there was very little published information on either the rates of occurrence of moribund and dead marine mammals or the causes thereof in any part of the Alaskan O.C.S. area. Fragmentary reports of mass strandings of walruses (Odobenus rosmarus) on St. Lawrence Island (Schiller, 1954) and the nearby Punuk Islands (Murie, 1936) provided little reliable data on the nature or causes of these incidents. In the first case, from his examination in January 1952 of 17 of the 52 carcasses (mostly adult females) that washed up in October 1951, and from the reports of Eskimos who had examined some of the others, Schiller (1954:209) concluded that they probably had been killed by "a great and sudden external pressure," possibly "by concussion resulting from an [underwater] explosion." However, the reported signs (intestinal prolapse, free blood in the abdomen, and mutilated appendages) could just as easily have been due to putrefactive postmortem changes; none of the known diagnostic signs of implosive damage (as described by Rausch, 1973) was recognized in the animals examined. In the second case, Murie (1936), Collins (1940), and Cahalane (1947) reported that the flattened, hairless condition of the multitudes of walrus carcasses found on the Punuk Island was indicative of their having died from being crushed by the weight of other walruses, stampeded perhaps by the threat of preying killer whales (orcinus orca). In this instance, also, the reported signs were by no means diagnostic, for the carcasses were not fresh and could easily have attained their condition through long-term putrefaction.

Hanna (1920, 1923) reported on 8 walrus carcasses examined by him on St. Matthew and the Pribilof islands, noting that "in each case death had been caused by crushing of the body cavity" (1923:213). Kenyon (1961) reported that two Cuvier's beaked whales (Ziphius cavirostris) which stranded on Amchitka Island in the Aleutians had been killed by rifle bullets. Jellison (1953) reported a Stejneger's beaked whale (Mesoplodon stejnegeri) stranded on the Pribilof Islands, and Moore (1963) reported two others from the Nushagak Peninsula and the Kasilof River, but no pathological information was provided for any of these. There are several other isolated records of occurrence of such unusual or rare specimens, but these have provided no real basis for appreciation of the normal abundance of carcasses of the more common species.

The best and most useful information on morbidity-mortality rates and the causes thereof has been obtained in connection with intensive studies of the northern fur seal (Callorhinus ursinus) populations on the Pribilof Islands and of sea otter (Enhydra lutris) populations at Amchitka Island. Of some 700,000 to 1,000,000 fur seal pups born each year on the Pribilofs, about 75 per cent dies by age 5 years, mainly from natural causes (Roppell et al., 1965). While predation by killer whales and sharks is certainly an important factor in this mortality, its extent is unknown (Baker et al., 1963). Other contributing factors are parasitism, e.g. the stomach nematode Phocanema decipiens is known to cause stomach ulcers and resulting peritonitis (Neiland, 1961) and nasal mites (Orthohalarachne spp.) impair breathing through damage and blocking of the nasal passages (Keyes, 1965; Dunlap et al., 1976), and toxins, e.g. in September 1962 on St. George Island, some 275 seals of all ages and a few marine birds and arctic foxes were found dead, apparently from having ingested mollusks containing lethal doses of toxins, possibly derived from the dynoflagellate Gonyaulux sp. or a related form (Keyes, 1965). Other conditions, e.g. renal fibrosarcoma (Brown et al., 1975), and agents of disease, e.g. Leptospira sp. (Smith et al., 1974), viruses of the psittacosis group (Eddie et al., 1966), and vesicular exanthema viruses (Madden et al., 1975), have been recognized, but their significance as causes of death is not yet understood. The mortality of pups on the rookeries has been studied in greatest detail. Of the 40 to 120 thousand pups that die each year on the Pribilof rookeries (Roppell *et al.*, 1965), the most frequent primary cause of death is malnutrition (37.6%; Keyes, 1965), followed closely by trauma (17.4%: *Ibid.*), hookworm infections (12%: *Ibid.*; Lyons, 1963; Brown *et al.*, 1974), bacterial invasion of open wounds (11%: Keyes, 1965), and gastrointestinal problems (4.6%: *Ibid.*; Jellison and Milner, 1958).

Kenyon (1969) has indicated that there is a substantial mortality of sea otters in the Aleutian Islands in winter and early spring and that this involves mainly the youngest age classes and more often the males than the females. The ultimate cause of death, in most cases, is malnutrition, which seems to be the result most often of dental problems coupled with severe weather as a deterrant to normal feeding. Gastrointestinal conditions, associated with helminthic infestations (especially *Phocanema decipiens*) and bacterial agents (*Clostridium* spp.) seem to be common contributors. A liver disease of unknown etiology and various other conditions occur infrequently and are probably relatively unimportant. Predation seems not to be an important cause of death.

IV. Study Area

The basic study area is the coast of the eastern Bering Sea, from the western end of the Alaska Peninsula to Bering Strait, including the islands, since the primary effect is directed toward enumeration and examination of beached carcasses. This amounts to some 2,800 miles of coastline, hence we elected to sample about 20 per cent of it on an annual basis. The locations of the sampling areas is shown in Fig. 1; these include most of the northern side of the Alaska Peninsula and most of St. Lawrence Island, each of which was selected because of its accessibility and known productivity and its relationship to centers of abundance of marine mammals and to major currents and eddies in the adjacent sea. In addition, a sampling area north of Bering Strait was selected for evaluation of the outflow of carcasses from the Bering Sea. Other Bering Sea areas are sampled opportunistically but not on a regular basis.

V. Sources, Methods, and Rationale of Data Collection

Data are collected on an annual basis, about one month after the breakup of sea ice in the vicinity of the sampling areas. Data from earlier and later surveys have indicated that this is the optimal timing for obtaining near-maximal counts and for access to the greatest number of specimens in relatively fresh condition. For the Alaska Peninsula, this means late May to mid-June; for St. Lawrence Island, late June to mid-July; and for the Bering Strait area, early to late July. With allowance for weather, about three weeks of work are required in each area.

Each area is worked by a 2-man survey team, including one senior scientist and one technician. In the Alaska Peninsula and

Fig. 1. The study area and primary sampling areas (heavy lines), showing the principal ocean currents over the shelf.

Bering Strait areas, the mode of transportation for the team is a Supercub aircraft with extra-large balloon tires for beach landings; on St. Lawrence Island, a combination of all-terrain vehicles and small boats is utilized. In the areas covered via aircraft, the survey is begun with a complete coverage of the sampling area (preferably, all in one day), noting the kinds of carcasses and moribund animals and marking the location of each on suitably large-scale aerial charts. Thereafter, the team works out from various camps along the way, landing near each carcass and examining it in accordance with the procedures outlined in the established manual for postmortem examination (Appendix I). At St. Lawrence Island, the modes of transportation necessitate that the survey of numbers and locations is conducted simultaneously with the examinations.

Materials collected during the examinations are transported back to the home base (University of Alaska-Fairbanks) at the end of the survey for processing, analysis and, as necessary, distribution to various specialists for further analysis. These comprise (1) photographs for identification (mainly of cetaceans), (2) bones and teeth for identification and age determination, (3) preserved tissues for histopathological examination, and (4) microbiological isolates.

VI. Results

Due to late approval and funding of this project in 1975, the proposed field activities could not be fully scheduled and were, therefore, carried out much later and in a much shorter period of time than was intended initially. Thus, while each of the surveys was completed (albeit late), the examinations of the carcasses were necessarily greatly abbreviated. The findings were, however, sufficient to indicate clearly the kinds, numbers and locations of carcasses and to provide excellent background for planning a more effective program for the 1976 spring-summer field season.

A. Alaska Peninsula

The northern coast of the Alaska Peninsula was surveyed by Associate Investigator R. Dieterich via chartered aircraft, from 22 to 25 July, 1975, covering the area from Bechevin Bay (C. Krenitzin) on the west to the mouth of the Naknek River on the east. Ten landings were made along the way for more detailed examination and/or autopsy of the more intact carcasses. Additionally in this area, in connection with another project, the PI surveyed the eastern shore of Kuskokwim Bay, between Chagvan and Jacksmith Bays, on 15 and 20 July via aircraft, and a smaller segment, from C. Pierce to the southeastern part of C. Newenham, on 18 July, on foot.

The Alaska Peninsula survey covered about 754 km (406 mi) of coast, on which were found the remains of 11 small gray whales, Eschrichtius gibbosus, and 1 minke whale, Balaenoptera acutorostrata), 17 adult walruses (Odobenus rosmarus), 12 young and adult harbor seals (Phoca richardsi), and 3 adult sea otters

(*Enhydra lutris*). About one-fourth of these were old, dried, and tattered remains, left from previous years; three-fourths were judged to have stranded no more than 3 months prior to the survey. The degenerate condition of most of the latter precluded useful autopsy.

The Kuskokwim Bay supplement, which amounted to about 103 km (64 mi), yielded no carcasses at all, and the C. Pierce - C. Newenham segment, of about 10.5 km (6.5 mi), yielded only one fresh carcass of an adult male Steller's sea lion (*Eumetopias jubatus*) and an assortment of much older remains of walruses (2 adult, 2 subadult males), larga and harbor seals (*Phoca largha* and *P. richardsi*, 2 adults), and 1 each of gray and minke whales, 1 killer whale (*Orcinus orca*) and 1 Baird's beaked whale (*Berardius bairdi*).

The distribution of these carcasses is shown in Fig. 2.

The major findings from examination of 10 of the carcasses on the Alaska Peninsula are given in Table I.

B. St. Lawrence Island

The coast of St. Lawrence Island was surveyed by the PI and Biological Technician E. Knudtsen from 4 to 23 August, 1975. About one-third of the area was covered on foot and one-third via chartered small boat. The outlying Punuk Islands had been surveyed earlier (18-23 June) by technician L. Shults in connection with another, related project.

About 267 km (166 mi) of the coast of St. Lawrence Island were surveyed, yielding 37 whales (24 grays and 4 minkes, 4 bowheads,

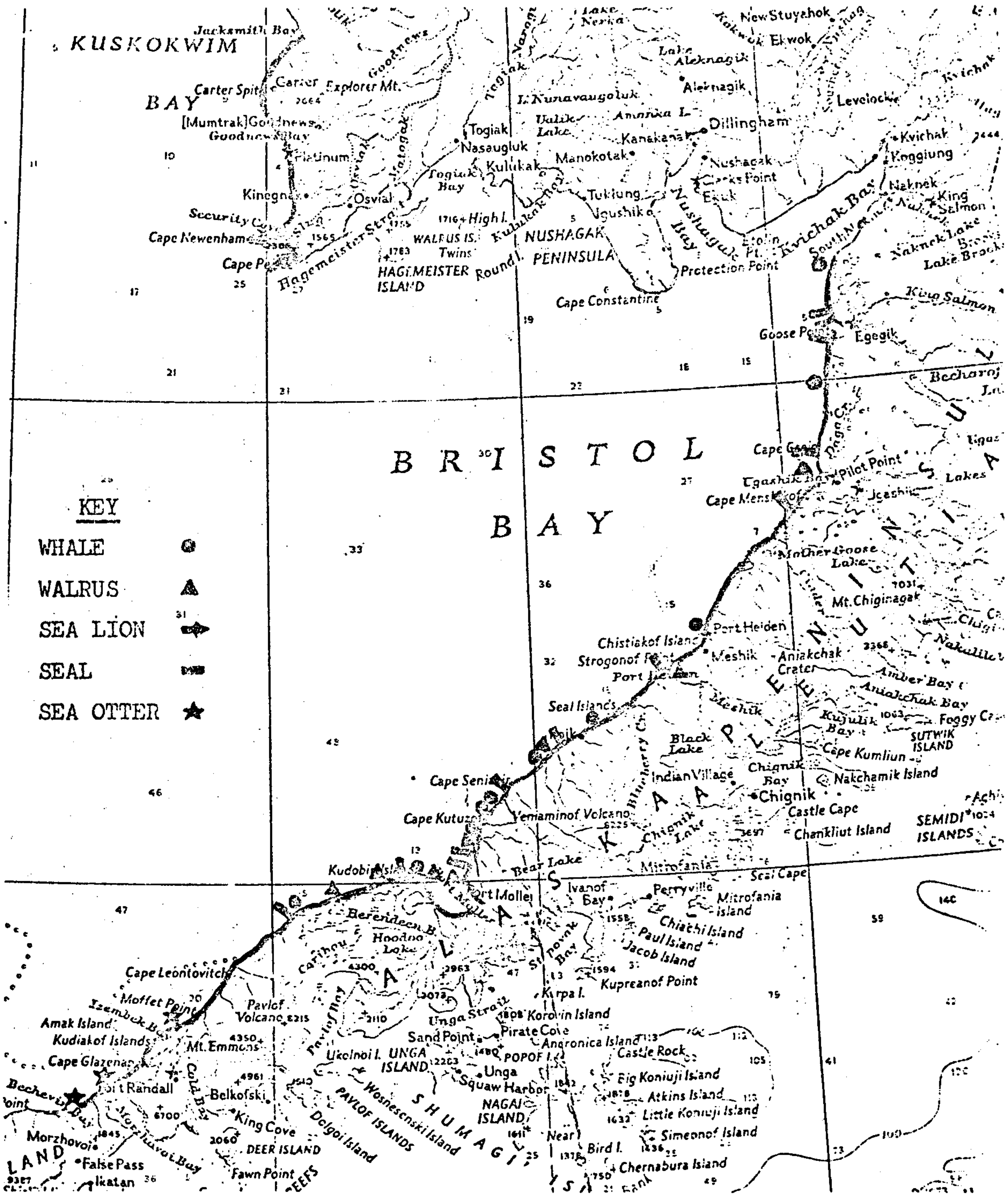

Fig. 2. Locations of marine mammal carcasses on the Alaska Peninsula, July 1975. Only those that had stranded within the previous three months are shown. The distribution of older remains was similar. Heavy line indicates the parts of the coast that were surveyed by project personnel.

TABLE 1

Major pathological findings in ten marine mammal carcasses necropsied on the Alaska Peninsula, July 1975.

Field No.	Species	Findings	Diagnosis
9701	*Odobenus rosmarus*	Dry, too decomposed; bones intact; probably not shot	(Natural causes?)
9702	" "	No evidence of bullet wounds	same
9705	" "	As in 9701	same
9706	" "	As in 9702	same
9703	*Phoca richardsi*	Badly decomposed; shot in head	Died from bullet
9704	" "	Shot in head; aspirated blood in lungs; heart, spleen, kidney normal; liver shows focal necrosis.	Died from bullet; hepatitis may have contributed.
9710	" "	Spleen: Capsule thickened, much fibroblastic activity; many giant cells and phagocytes w/hemosiderin Liver: Capsule thickened, much fibroblastic activity Lung: Vessels distended; congestion of alveolar walls Urachis: Moderate fibroblastic activity	Peritonitis (primary), omphalitis, pulmonary congestion
9707	*Enhydra lutris*	Stomach: Mucosal ulcerations with monocytic infiltration Uterus: Mucosal congestion, focal hemorrhage, with abundant leucocytes (PMN's) in surface exudate.	Gastric ulcers (probably secondary, stress-related), and hemoendometritis (probably the primary illness)
9708	" "	Bones only	(Unknown)
9709	" "	Spleen: Engorged w/blood, extreme hemosiderosis Lung: Alveolar septa edematous; bronchial exudate; vascular cuffing of arterioles Liver: (enlarged, rounded, probable focal necrosis; sections not yet examined)	Probable hepatitis (primary) with secondary interstitial pneumonia

Balaena mysticetus, and 1 finback, *Balaenoptera physalus*, and 4 unidentified), 3 Steller sea lions, 94 walruses, 4 harbor seals, 4 bearded seals (*Erignathus barbatus*), 20 ringed seals (*Phoca hispida*), and 1 ribbon seal (*Phoca fasciata*). Three-fourths of the whales, nearly half of the walruses and all of the sea lions had stranded more than 8 months earlier; most of the rest of the carcasses were judged to have stranded no more than 3 months prior to the survey. The cause of death was determined in two whales, four walruses and thirteen seals; the remainder had been excessively scavenged or was too advanced in autolysis for diagnosis of cause of death.

The Punuk Island supplement yielded 61 additional walruses, 7 of which had lain there for about 6 months and the remainder for much longer. These tiny islands (total area about 1/4 sq mi) are well known hauling grounds for walruses during the southward migration in autumn, and a high natural mortality is a predictable annual event here. As yet, there has been little opportunity to determine the extent or the causes of that mortality.

The distribution of carcasses in the St. Lawrence Island area is shown in Fig. 3.

The major findings from examinations of those carcasses are given in Table II.

C. Bering Strait

The northwestern coast of the Seward Peninsula, from Cape Prince of Wales to Cape Espenberg, was surveyed by Biological

TABLE II

Major pathological findings in marine mammal carcasses necropsied on St. Lawrence Island, August 1975

Field No.	Species	Major findings	Diagnosis
9020	<u>Eschrichtius robustus</u>	Dead less than 48 hrs; tongue, throat, part of breast removed, severely lacerated. Multiple, parallel lacerations (tooth marks) about throat, flippers, flukes and caudal pedunkle.	Killed and eaten by killer whales.
9022	" "	Dead more than 1 month; headless; throat, flippers, caudal pedunkle severely lacerated, as in 9020.	Killed and eaten by killer whales.
9019	<u>Odobenus rosmarus</u>	Left tusk root w/draining abcess; lungs ca. 95% hepatized w/much necrosis; ca. 6 liters milky ascitic fluid w/curds in thorax; pericardium greatly thickened, adhered to lungs.	Probable pulmonary involvement from inhalation of material from dental abcess. Acute pneumonitis.
9027	" "	Skull fractured by bullet.	Gunshot
9057	" "	Skull fractured, parts missing.	Probably gunshot
9095	" "	Skull shattered, hemorrhaged.	Probably gunshot
9065	<u>Erignathus barbatus</u>	Skull shattered, parts missing.	Probably gunshot
9106	<u>Phoca largha</u>	Skull shattered, parts missing.	Probably gunshot
9017	<u>Phoca hispida</u>	Moribund; hair matted; skin lesions on hind flippers, perianal area. Skin: Invasion of epidermis & sebaceous glands by filamentous rods & spores; focal epidermal necrosis, excess of sebum Lymph node: Depletion of lymphoid sinuses, proliferation of RE cells, some hemorrhage; hemolytic <u>Streptococcus</u> isolated.	Dermatomycosis (probably primary), lymphadenitis

TABLE II

(Continued)

9036	Phoca hispida	Skull shattered, parts missing.	Probable gunshot
9043	" "	same	same
9064	" "	same	same
9071	" "	same	same
9099	" "	same	same
9100	" "	same	same
9103	" "	same	same
9104	" "	same	same
9107	" "	same	same
9108	" "	same	same
9109	" "	same	same

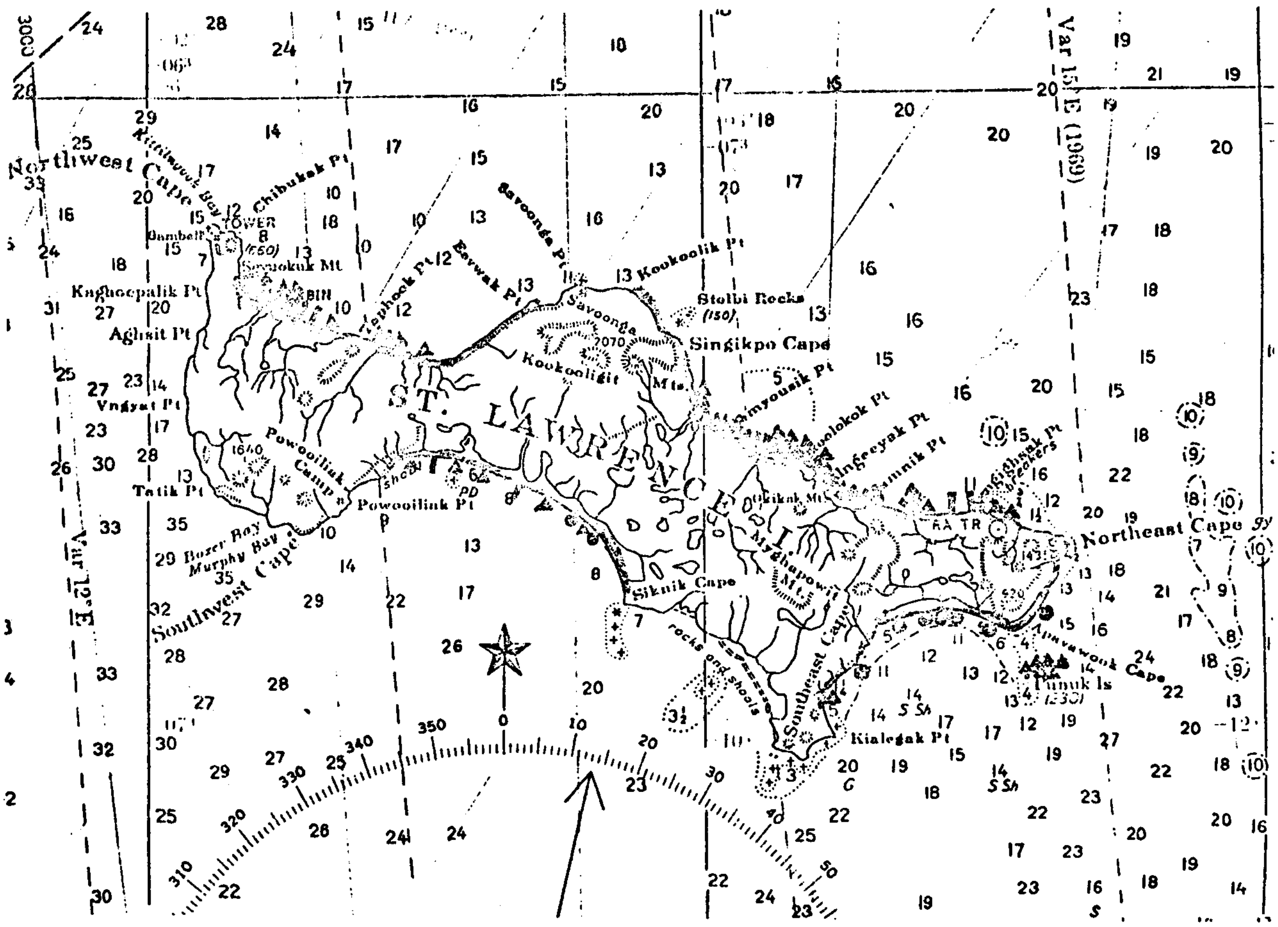

Fig. 3. Locations of marine mammal carcasses in the St. Lawrence Island area, August 1975. Only those that had stranded in the previous 3 months on St. Lawrence Island and 9 months on the Punuk Islands are shown. The distribution of older remains was similar. Symbols are as in Fig. 2.

Technician L. Shults from 16 to 25 July, 1975, via chartered aircraft. In addition, the inner parts of Kotzebue Sound and its northern coast, from Sheshalik to Point Hope, also were surveyed. Several beach landings were made for closer inspection and collection of diagnostic samples from some of the carcasses.

These surveys covered a total of 740.4 km (459.9 mi), of which about 235 km (146 mi) were in the principal sampling area (Wales-Espenberg). The latter yielded counts of 7 gray whales, 91 walruses, 1 bearded seal, and 12 ringed and larga seals, each of which was relatively fresh (older material from previous years was noted but not counted). Conversely, the supplementary 505 km of inner and northern Kotzebue Sound yielded only 3 walruses and 8 seals, more than half of which were old, tattered remains from previous years.

The locations of the newer carcasses are shown in Fig. 4.

Three walruses, one bearded seal, and one ringed seal were necropsied and found, in each case, to have died from gunshot wounds.

D. Miscellaneous Laboratory Activities

A total of 113 photos for confirmation and/or identification of the specimens sighted were processed. Some examples of these are shown in Figs. 6 to 9. Identification was by comparison with known specimens in the University of Alaska reference collection and with plates, photographs, and drawings in various published references.

The largest series of teeth for age determination was obtained from 50 of the walrus carcasses on the Punuk Islands; 43 more were obtained from walruses on St. Lawrence Island proper. Only 8 were obtained from the walruses in other localities, where most of the carcasses were headless. Teeth were obtained also from 2 sea lions, 8 seals, and 3 sea otters; diagnostic bones (skull fragments, scapulas, innominates) were obtained from most of the other seals. Tooth sections (longitudinal) were cut on a jewelers saw and the ages determined from numbers of cementum layers. Bones were compared with those from known-aged reference specimens.

Identification to species of most of the fresher specimens (less than 3 months in situ) in the field by experienced project personnel was unequivocal. Confirmation of many of these and certain identification of nearly all of the other carcasses and fragmentary remains was achieved by the PI from photographs and/or collected bones. The only specimens that remain unidentified to species are some of these sighted from aircraft and not photographed or closely examined. The age information gained from the walrus teeth is shown graphically in Fig. 10, where it is compared with two other reference samples. Most of the other pinnipeds examined were very young animals, in their first or second year of life, as were most of the cetaceans. The sea otters were all old adults.

VII. Discussion

The data obtained on numbers and distribution of stranded carcasses of marine mammals in the Bering Sea-Bering Strait area are the first and only (to our knowledge) substantive data of their kind for the region. They indicate that the rate of occurrence of such material is very high in certain areas and that the total for the region may amount to more than 1,000 individuals per year and contribute more than 3,000 tons of high-grade protein to the coastal zone marine and terrestrial systems. The ultimate fate of this material is not certainly known and may not be difficult to quantify. In areas such as the Alaska Peninsula, various terrestrial scavengers (brown bears, foxes, eagles) are known to consume large quantities of it, if not most of it; in Bering Strait and the St. Lawrence Island area, much of it is consumed by gulls, polar bears, arctic foxes, and man (Eskimos). Thus, in all areas there seems to be a substantial transfer of energy and nutrients from the marine to the terrestrial system, as well as a contribution to the coastal and near-shore marine communities.

It is of some considerable interest that the carcasses found in the course of the 1975 surveys were of species that occur commonly in the nearby waters, and not of those that occur hundreds of miles away. For example, all of the seals found in the Alaska Penisula survey were of the local <u>Phoca richardsi</u> phenotype, rather than of <u>P. hispida</u> or <u>P. largha</u>, which are centered 200 miles or more to the northwest. Conversely, those at St. Lawrence Island were mainly of

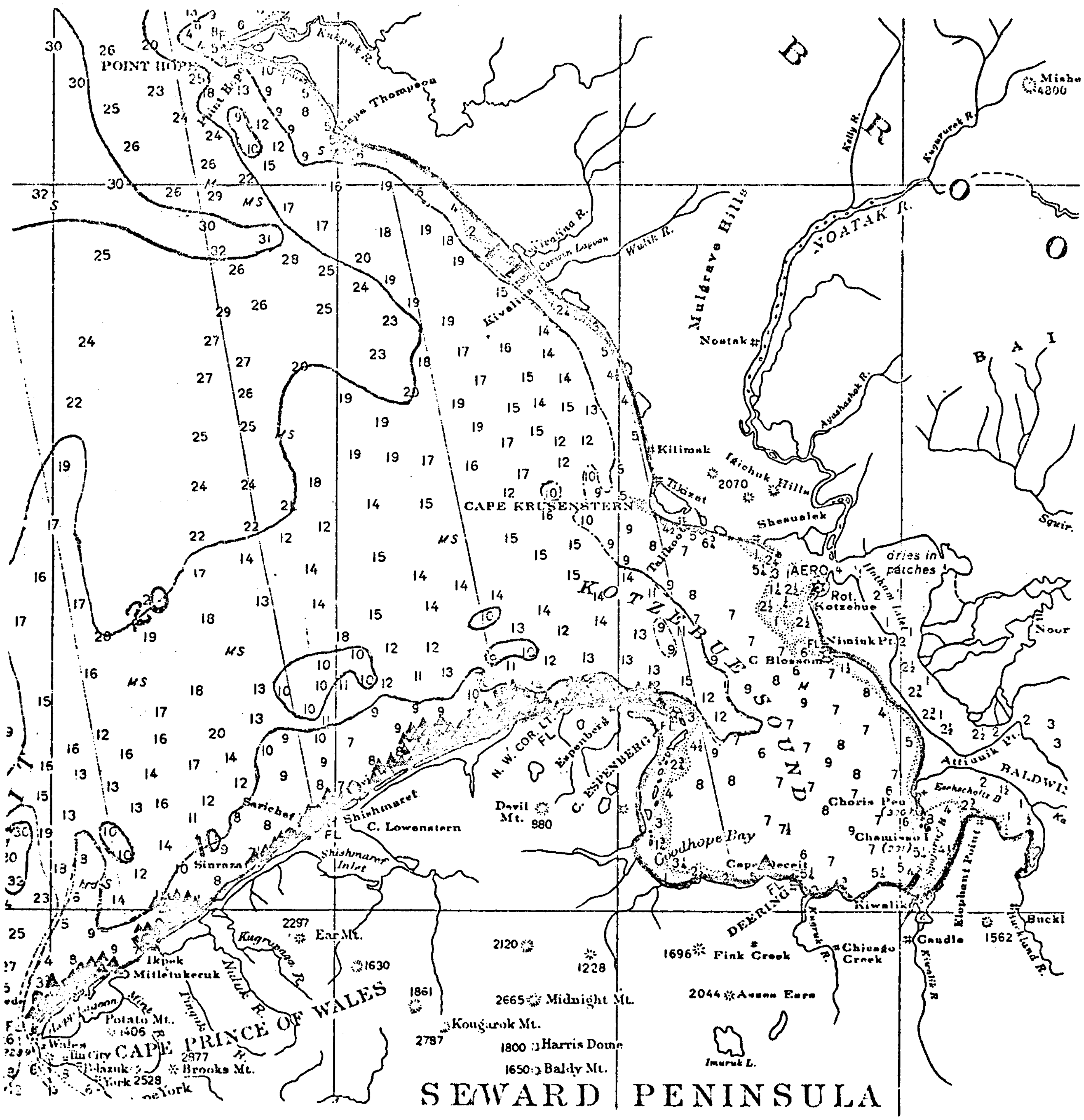

Fig. 5. Locations of marine mammal carcasses in the Seward Peninsula-Kotzebue Sound area, July 1975. Only those that had stranded in the previous month are shown; the distribution of older remains was similar. Symbols are as in Fig. 2.

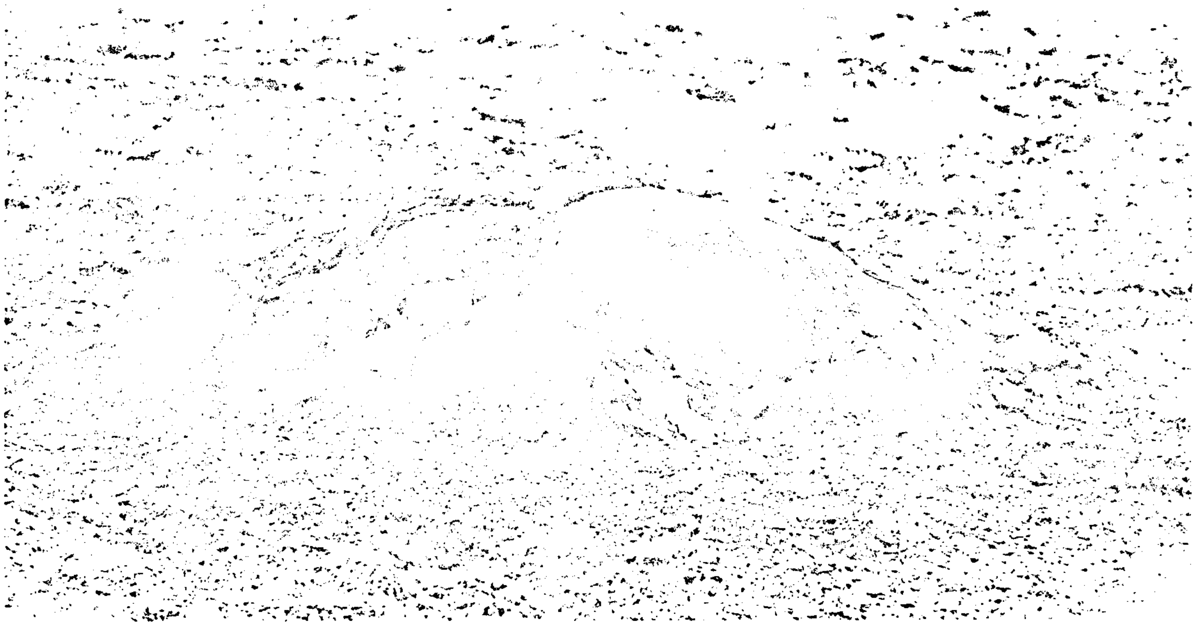

Fig. 6. Walrus carcass that had stranded about 2 months prior to the survey on St. Lawrence Island (Field no. 9026, female, age 7). About 200 lb of meat and skin had been salvaged from it by local Eskimos; much of the limbs had been eaten by scavenging foxes.

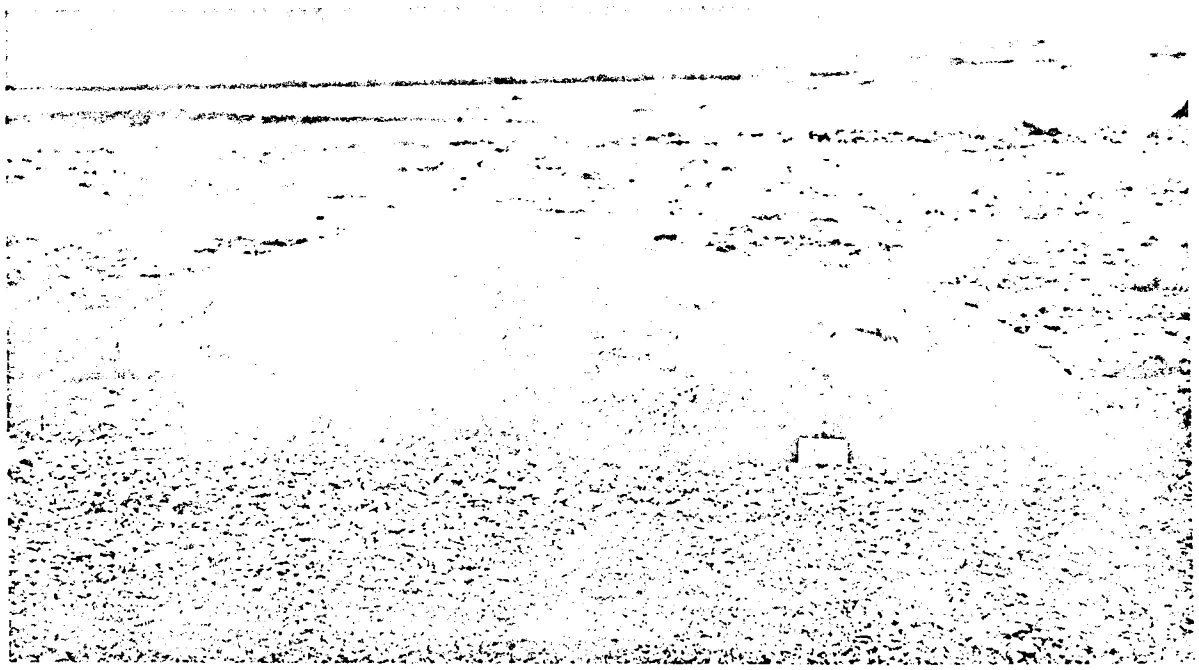

Fig. 7. Walrus carcass that had stranded 1 to 2 months prior to the St. Lawrence Island survey (Field no. 9027, male, age 12). Though of about the same "vintage" as that in Fig. 6, this specimen's skin was entire except for a hole in the right shoulder and, therefore appeared to be in fresher condition. (The hole was not a bullet hole.)

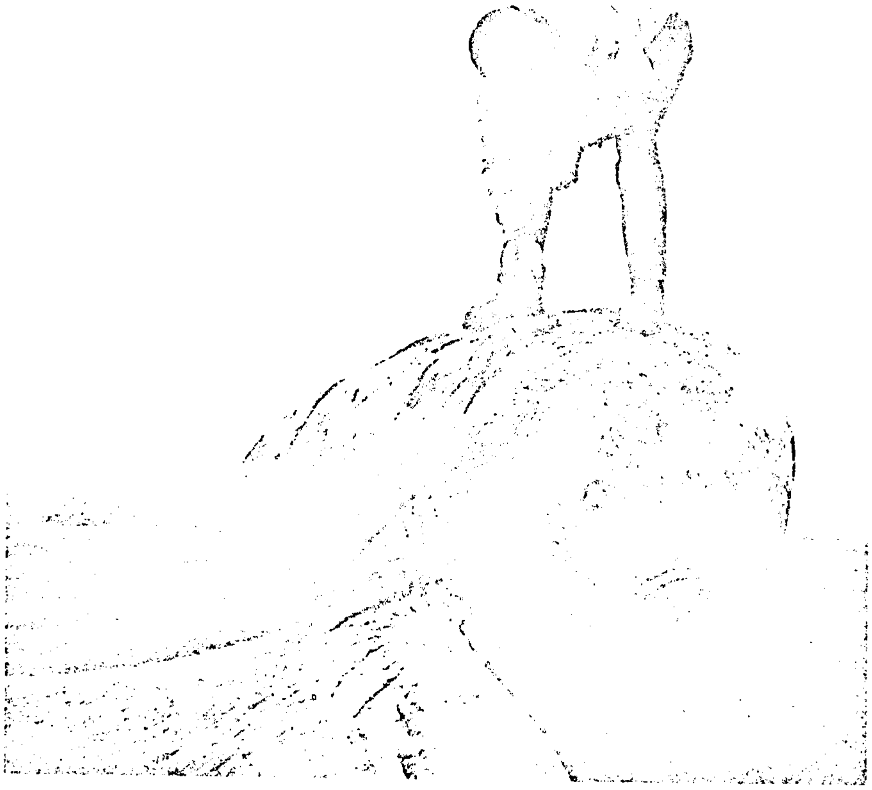

Fig. 8. Examination of a young gray whale killed and partially eaten by killer whales. Note tooth marks on caudal area. (St. Lawrence Island: Field no. 9020).

Fig. 9. Necropsy of walrus 9027, St. Lawrence Island. Findings indicated death from gunshot wounds in the head.

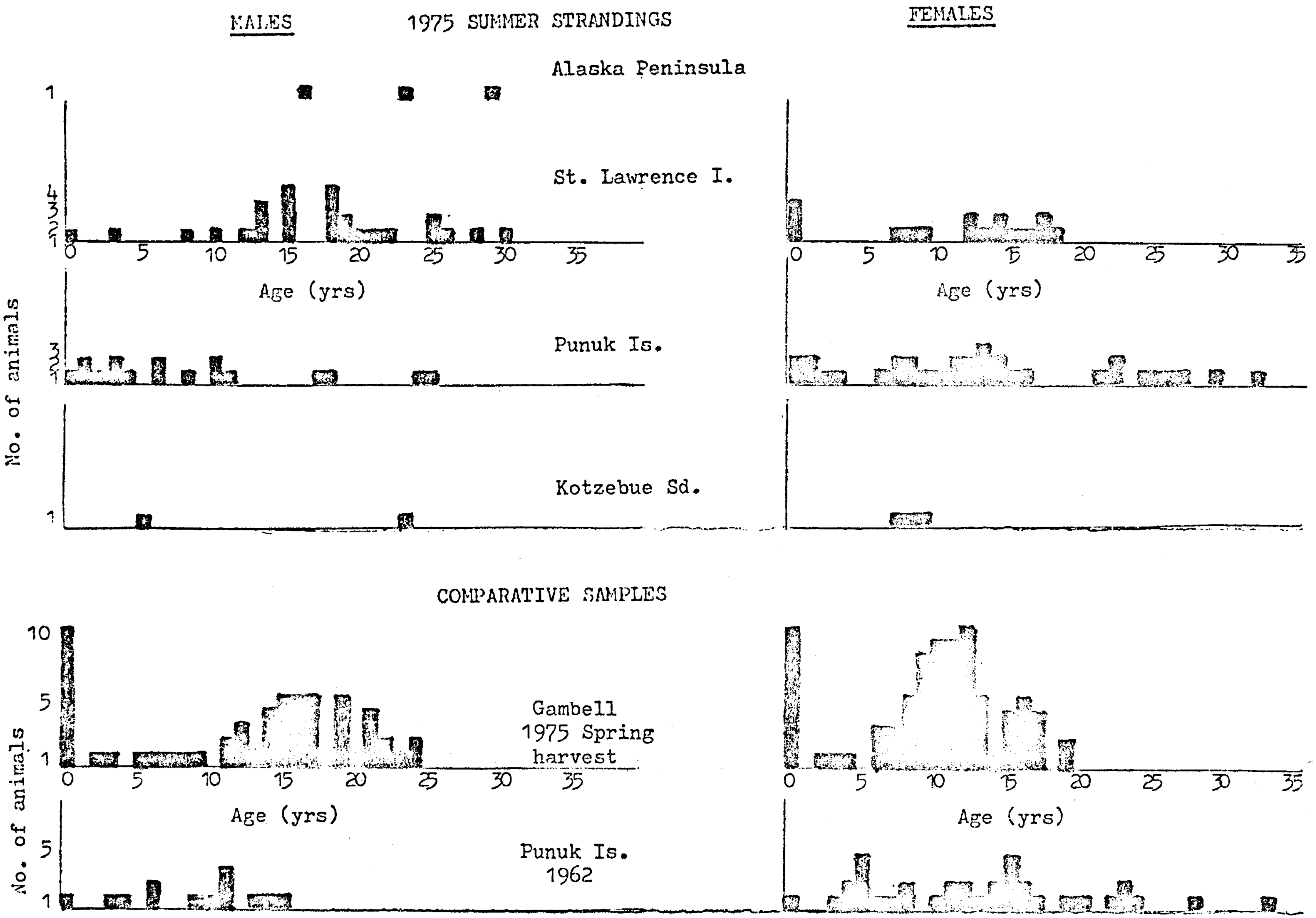

Fig. 10. Frequency distributions of age classes of walruses in the 1975 strandings, as compared with local subsistence harvests and an earlier series of strandings on the Punuk Islands.

the latter two kinds and not of the richardsi kind. Similarly, no fur seals were found in either area, though they occur (and die) in enormous numbers only a few hundred miles away. Many other examples could be mentioned. The implication of this is that, whereas the water currents and winds may be favorable for transporting such carcasses over great distances, the carcasses themselves do not persist long enough in the open sea to reach remote places.

The age composition of the walrus carcasses stranded on St. Lawrence Island and in Kotzebue Sound compared very favorably with that of walruses taken in the subsistence harvest. This suggests that most of the animals that stranded in those two localities were products of the harvest, i.e. that they were animals that had been killed or wounded by the subsistence hunters and not immediately retrievable. Our inspections and autopsies also indicated that many of them had indeed died from gunshot wounds. Conversely, the animals stranded on the Alaska Peninsula and the Punuk Islands evidently had died of natural causes, and the age composition of those samples was strikingly different from that of the highly selective harvests.

Nearly all of the cetaceans found in the 1975 summer survey were gray whales, Eschrichtius robustus. The gray whale population, which has been recovering since the 1930's from near extirpation, now numbers about 11,000 animals and is believed to have reached its upper limit. These animals reside en masse in the Bering and Chukchi seas from June to October each year and apparently suffer a large part of their annual mortality there. Our surveys and those contributed by personnel of other projects covered no more than 20 per cent of the shores of that region and yielded 24 dead gray whales, suggesting that the total mortality there was on the order of at least 100 animals in 1975, or about 1 percent of the population. Conceivably, this will increase somewhat over the next few years, as the population achieves stability.

VIII. Conclusions

A. The annual mortality of marine mammals that inhabit the outer continental shelf of the Bering Sea is represented by a substantial number of carcasses that drift ashore there, each year.

B. Such carcasses provide a significant amount of nutritive material to both terrestrial and marine organisms that inhabit the coastal zone and, as such, could be an important link in the transfer of marine contaminants (pollutants, disease agents) from sea to land.

C. The distribution of those carcasses is probably determined largely by both offshore and nearshore currents, relative to the normal distribution of the living populations.

D. A large proportion of the carcasses, particularly of pinnipeds, seems to be the product of subsistence hunting by local Eskimos and, therefore, is more reflective of current hunting practices than of the health of the animal populations and of the system in which they reside.

IX. Needs for Further Study

The deposition of carcasses on the shores of the Bering Sea-Bering

Strait region is an annual event, subject to some variation as a consequence of the influence of several natural phenomena. The findings outlined in the preceding pages describe its basic characteristics for only one year. To obtain sufficient data for predictive purposes will certainly require several more years of data collection; a conceivably minimum would be three consecutive years. It seems reasonable to expect that at least a general view of the normal extent of variation will be revealed in that time, whereas the assessment of maximal variation might require continual monitoring over ten years or more and is probably unnecessary at this time.

It has become apparent that the breakdown and utilization of the carcasses by both terrestrial and marine scavengers is rather rapid, and that they are moved about by the tides and surf considerably, as well. Some study of this degradation and movement is called for, in order to determine, at least in a general way, the fate of these carcasses and their role in the coastal zone marine and terrestrial systems.

Some aerial surveys of other parts of the Bering Sea coastal zone for an expanded view of the kinds and quantities of carcasses would be particularly useful for evaluation of the representativeness of the present primary sampling areas. We have reason to suspect that the St. Lawrence and Bering Strait areas, for example, are unusually productive, relative to the Yukon-Kuskokwim area or Norton Sound, and that long stretches of sandy or gravelly beaches are more productive than precipitous or rocky coasts. However, some tests of these suspicions are required.

X. Summary of 4th quarter operations

A. <u>Ship or laboratory activities</u>

1. Ship or field trip schedule

a. 15 March - 1 May ZAGORIANE (Soviet sealer-TINRO sponsorship)

b. 14 March - 25 April SURVEYOR (NOAA)

c. 25 May - 15 June Alaska Peninsula survey

d. 25 June - 15 July St. Lawrence Island survey

2. Scientific party

a. ZAGORIANE: PI and Howard Ferren (graduate student, Institute of Marine Science, University of Alaska-Fairbanks)

b. SURVEYOR: Biological Technician L. Shults

c. Alaska Peninsula: Associate Investigator R. A. Dieterich and Biological Technician L. Shults

d. St. Lawrence Island: PI and technician to be designated

3. Methods

a. ZAGORIANE: Necropsy of selectively collected sick and moribund walruses and seals, in conjunction with marine mammal/ice observations (O.C.S.E.P., R.U. #248) and joint US-USSR investigations of the ecology and biology of Bering Sea pinnipeds.

b. SURVEYOR: Selective collections and necropsy of sick and moribund walruses; necropsy of other pathological specimens as available, in coordination with other O.C.S.

projects.

c. Alaska Peninsula: Survey and necropsy of stranded marine mammal carcasses.

d. St. Lawrence Island: Same as above.

4. Sample localities/ship or aircraft tracklines

a. & b. ZAGORIANE & SURVEYOR: ice front of southeastern Bering Sea and Bristol Bay

c. & d. Alaska Peninsula & St. Lawrence Island: as shown in Fig. 1.

5. Data to be collected or analyzed

a. & b. ZAGORIANE & SURVEYOR: See Appendix I. Tissue samples for histopathological study; helminthologica, bacterial, and viral isolates; serum and blubber samples.

c. & d. Alaska Peninsula & St. Lawrence Island: As above, plus survey data on numbers, locations, cause of death of stranded carcasses.

Literature Cited

Baker, R. C., F. Wilke, and C. H. Baltzo. 1963. The northern fur seal. U. S. Fish Wildl. Serv., Circ. 169:1-22.

Brown, R. J., A. W. Smith, M. C. Keyes, W. P. Trevethan, and J. L. Kupper. 1974. Lesions associated with fatal hookworm infections in the northern fur seal. J. Am. Vet. Med. Assn., 165:804-805.

Brown, R. J., A. W. Smith, and M. C. Keyes. 1975. Renal fibrosarcoma in the northern fur seal. J. Wildl. Dis., 11:23-25.

Cahalane, V. H. 1947. Mammals of North America. New York: Macmillan.

Collins, G. 1940. Habits of the Pacific walrus (odobenus divergens). J. Mammal., 21:138-144.

Dunlap, J. S., R. C. Piper, and M. C. Keyes. 1976. Lesions associated with Orthohalarachne attenuata (Halarachnidae) in the northern fur seal (Callorhinus ursinus). J. Wildl. Dis., 12:42-44.

Eddie, B., W. J. L. Sladen, B. K. Sladen, and K. F. Meyer. 1966. Serological studies and isolation of Bedsonia agents from northern fur seals on the Pribilof Islands. Am. J. Epidemiol., 84:405-410.

Hanna, G. D. 1920. Mammals of the St. Matthew Islands, Bering Sea. J. Mammal., 1:118-122.

Hanna, G. D. 1923. Rare mammals of the Pribilof Islands, Alaska. J. Mammal., 4:209-215.

Jellison, W. L. 1953. A beaked whale, Mesoplodon sp., from the Pribilofs. J. Mammal., 34:249-251.

Jellison, W. L., and K. C. Milner. 1958. Salmonellosis (bacillary dysentery) of fur seals. J. Wildl. Mgt., 22:199-200.

Kenyon, K. W. 1961. Cuvier beaked whales stranded in the Aleutian Islands. J. Mammal., 42:71-76.

Kenyon, K. W. 1969. The sea otter in the eastern Pacific Ocean. U. S. Fish Wildl. Serv., No. Amer. Fauna No. 68.

Keyes, M. C. 1965. Pathology of the northern fur seal. J. Am. Vet. Med. Assn., 147:1090-1095.

Lyons, E. T. 1963. Biology of the hookworm, Uncinaria lucasi Stiles, 1901, in the northern fur seal, Callorhinus ursinus., on the Pribilof Islands, Alaska. Colo. St. Univ., unpubl. PhD thesis.

Madin, S. H., A. W. Smith, and T. G. Akers. 1975. Current status of calciviruses from marine mammals and their relationship to calciviruses of terrestrial animals. Univ. Calif., Berkeley, Manuscript.

Moore, J. C. 1963. Recognizing certain species of beaked whales of the Pacific Ocean. Amer. Midl. Nat., 70:396-428.

Murie, O. J. 1936. Notes on the mammals of St. Lawrence Island, Alaska, pp. 337-346. In Archaeological excavations at Kukulik, St. Lawrence Island, Alaska, by O. W. Geist and F. G. Rainey. Misc. Publ. Univ. Alaska, Fairbanks.

Neiland, K. A. 1961. Suspected role of parasites in non-rookery mortality of fur seals (Callorhinus ursinus). J. Parasitol., 47:732.

Rausch, R. L. 1973. Post mortem findings in some marine mammals and birds following the Cannikin test on Amchitka Island. Las Vegas: U. S. Atom. Energy Comm.

Roppel, A. Y., A. M. Johnson, R. E. Anas, and D. G. Chapman. 1965. Fur seal investigations, Pribilof Islands, Alaska, 1964. U. S. Fish Wildl. Serv., Spec. Sci. Rept. Fish. 502.

Schiller, E. L. 1954. Unusual walrus mortality on St. Lawrence Island, Alaska. J. Mammal., 35:203-210.

Smith, A. W., C. M. Prato, W. G. Gilmartin, R. J. Brown, and M. C. Keyes. 1974. A preliminary report on potential pathogenic microbiological agents recently isolated from pinnipeds. J. Wildl. Dis., 10:54-59.

APPENDIX I

POSTMORTEM PROCEDURES FOR EXAMINATION OF ALASKAN MARINE MAMMALS

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OUTER CONTINENTAL SHELF ENERGY PROGRAM

INTRODUCTION

Those who have walked, boated, or flown along the coasts of Alaska with an eye on the shoreline itself are aware that the quantity of beached carcasses of dead marine mammals is prodigious, amounting to hundreds or thousands of tons annually. This abundance of carcasses is reflective of the multitudes of living seals, sea lions, walruses, and whales that inhabit the coastal waters of Alaska, some proportion of which dies each year from various causes and ultimately washes ashore. For many years, the curious have probed lightly into this mass of carcasses, mainly for souvenirs of bone or ivory; for eons, the hungry have depended on it as a natural resource. But until very recently, there was little real interest in its causes or in its relevance to environmental matters or population characteristics. Only now has it become accessible for intensive study.

This manual was developed primarily for use by wildlife veterinarians, game biologists, and associated technicians engaged in an investigation of the natural morbidity and mortality of marine mammals in the Bering and Chukchi seas, under the program of environmental assessment of the outer continental shelf. It was designed mainly for use in necropsy of beach dead animals and of sick and moribund animals taken specifically to provide further insight into the normal causes of illness and death. However, this does not in any way restrict its use, and we have endeavored in its preparation to utilize terminology that can be understood by the layman as well as by those versed in anatomical and veterinary science.

The procedures outlined are based on the assumption that the carcass to be examined is very fresh, and that the circumstances under which the necropsy is to be performed are nearly ideal. In reality, some or, perhaps, many of the steps indicated will not be feasible, due to the condition of the carcass, its location, the time available, or the limitations in facilities and manpower. In that case, the investigator(s) will be obliged to judge the priorities that are consistent with the attendant circumstances.

We do not regard this as a final, finished document. It will be substantially revised from time to time, as our experience and that of other users grows. We would encourage all users to make note of any modifications that they deem appropriate and to notify us of their recommendations. All comments and critiques will be welcomed.

GENERAL CONSIDERATIONS

Clothing & Equipment

It should be borne in mind always that any sick, moribund, or dead animal must be handled with caution, since it is conceivable that the causative agent of disease is a potential pathogen in man and his domestic animals as well. For this reason alone, it is advisable to wear suitable protective clothing such as rubber boots, coveralls or apron, and rubber gloves when performing the examination and to disinfect, boil, or burn such clothing after use. Furthermore, the carcasses of marine mammals are seldom found in fresh condition, in which case the wearing of protective apparel is not only advisable as a safety precaution but as a means to protecting the outer clothing from being soiled by extremely oily, odoriferous material as well. Various kinds of disposable gloves, aprons, and foot coverings are available and most convenient to use in field situations where proper disinfection is not feasible.

A list of the supplies and equipment needed for a thorough necropsy is provided in Appendix I, with indication as to the minimal essential items.

Procedures

Before beginning the actual necropsy, the following points should be considered in order that certain valuable samples will not be lost or destroyed.

The importance of high quality photographs of the specimens for subsequent confirmation of species and sex and evaluation of the general condition of the carcass cannot be overemphasized. Photos also of the pathological conditions encountered may be of great utility for reference later on. Black and white photos, preferably on low speed, fine grained film (e.g. Kodak Panatomic-X) will be most useful. A resumé of the principal diagnostic characters of each species that is likely to occur in Alaskan waters is given in Appendix II for use in preliminary identification.

If the animal is still alive or has just been killed, it is preferable to take a blood sample immediately, at the outset. This can easily be drawn with syringe from the intervertebral venous sinus of pinnipeds, the heart of sea otters, or from one of the larger vessels in the flukes of cetaceans. Alternatively, blood gushing freely from a wound or incision can be caught in a sterile tube or vial. Blood samples (preferably 10 ml or more) should be subjected to minimal agitation and protected from freezing, and should be allowed to stand at room temperature for 12 to 24 hours, if serum is desired. In that time, the cells will separate and clot, and the clear serum can be drawn or decanted off into a clean, sterile container. Centrifugation, if feasible, and further decantation to exclude any remaining cells is desirable. The resulting serum sample should be stored cold or frozen. If whole blood is desired, a suitable anticoagulant, such as E.D.T.A., should be quickly mixed with it in the collection tube or syringe. Sodium flouride may be added to serum or whole blood to stop enzymatic action, if glucose is to be assayed.

Tissue samples preserved in 10% buffered formalin for later histopathological preparation and study should be kept small for optimal fixation. In most cases, these need be no larger than about 5x5x10 mm.

If the carcass is fresh, its helminth parasites probably will be still alive and active. Such living material is best prepared by allowing the helminths to relax fully in tap water in a shallow dish at room temperature for about an hour, then decanting off most of the water, and instantaneously killing and fixing them by pouring in hot (not boiling) 10% formalin. Ideally, after fixation, the nematodes and acanthocephala should be transferred to 70% ethyl alcohol for storage, while the cestodes and trematodes can be left in the same 10% formalin that they were fixed in.

Isolation of potential mycological, bacterial, and viral agents of disease should be attempted whenever feasible. In any but the freshest carcasses, this usually will not be effective, since the spread of contaminants increases dramatically with time after death.

Aseptic technique is essential for both bacterial and viral isolates. Instruments should be sterile, and any organ from which a microbiological sample is to be taken must be exposed carefully to avoid external contamination. If there is some possibility that the surface of the affectedorgan has already been contaminated, the area where the incision is to be made should first be seared with a hot scalpel blade or (less effectively) swabbed with alcohol. For bacterial isolates, dip a sterile swab into the incised, affected area, then immerse the swab in a suitable transport medium (e.g. Amies/DIFCO-0996), seal the vial, and store it in a cold (not frozen) place. Alternatively, a small block of the affected tissue should be removed aseptically and placed in a sterile vial and refrigerated, preferably without freezing.

Tissue samples (2-3 gm each) taken aseptically for potential viral isolation should be sealed in a sterile vial or ampule and stored deep-frozen, preferrbly in liquid Nitrogen.

Mycological samples may be scraped from the affected organ (usually skin) and stored in a vial or cellophane envelope, under refrigeration.

Broken bones are frequently encountered in the course of an autopsy and should be noted. The presence or absence (respectively) of hemorrhage and inflammation of the adjoining tissues will usually indicate whether the fracture occurred before or after death.

Small, finger-sized holes in the body surface also are commonly present. These should not be automatically assumed to be bullet holes, since they are often produced after death, especially by scavenging gulls. Dissect and further examine such holes to determine the kind and extent of tissue damage beneath the surface before diagnosis.

A preliminary, annotated list of the kinds of pathological agents and conditions likely to be encountered in Alaskan marine mammals is given in Appendix III.

NECROPSY PROCEDURE FOR SEA OTTERS AND PINNIPEDS

A. EXTERNAL EXAMINATION

1. Identify SPECIES and SEX, at least tentatively. PHOTOGRAPH whole carcass in dorsal and ventral view, to show COLOR PATTERN, at least one FORE FLIPPER, the HEAD, and the GENITAL-PERIANAL area.

2. With the carcass on its back, straighten the spine as much as possible (e.g. by grasping the head and pulling, to straighten the neck especially). Measure the STANDARD LENGTH (tip of nose to tip of tail flesh, in a straight line) and GIRTH at the axillae. If the carcass is too large to roll or straigaten, measure its length as best you can and note the method employed.

3. Examine the BODY SURFACE, noting the condition of the SKIN and HAIR and the presence of any ECTOPARASITES. Preserve (in alcohol) and label some of the latter and note any unusual abundance (photograph) or gross pathological effects. Describe any HOLES, LACERATIONS, or other LESIONS and any bloody or other DISCHARGES from any orifices.

4. With the carcass on its back, make an incision about 4 to 5 cm long over the sternum, midway between the axillae, cutting through the skin and blubber, and measure the BLUBBER THICKNESS at that point.

B. INTERNAL EXAMINATION

1. Remove the ventral body wall from chin to anus, cutting through the costal cartilages where they join the ribs, and lay it out (skin side down) at one side on a work table. In the case of large, unmanageable carcasses, the skin, blubber, and external musculature can be removed in 50- to 100-lb slabs, and the ribs can be easily disarticulated or sawn out.

2. Examine blubber for HEMORRHAGES, CYSTS, and PARASITES, noting presence and preserving (in formalin) a sample of same. Excise a BLUBBER SAMPLE of at least 50 gm (1/8 lb), wrap it securely in aluminum foil (non-lubricated commercial grade), label, and store cold, preferably frozen.

3. Examine the MOUTH for any signs of FOOD ITEMS, FOREIGN OBJECTS, ABSCESSES, or DENTAL DISEASE. Inspect the anterior nares and nasopharynx for NASAL MITES, noting their abundance and preserving (in alcohol) a sample from each area.

4. If feasible, retain the SKULL and MANDIBLE for future reference and age determination. Alternatively, in animals other than walruses and bearded seals, disarticulate and remove the MANDIBLE and retain and label at least half of it (with canine tooth). In walruses, knock out (with hammer or rock) one or two of the largest lower teeth and retain and label same; in bearded seals, cut off, label, and retain the anterior (maxillary-premaxillary) part of the skull containing the upper canines.

5. Examine the thoracic and abdominal viscera *in situ*, noting the color, consistency, and approximate amount of any free FLUIDS and any gross LESIONS, ADHESIONS, DISCOLORATIONS, or DEFORMITIES.

6. Remove the HEART, LUNGS, and TRACHEA, beginning at the pharynx and working back (leaving the esophagus and diaphragm in place), and lay them out on the removed body wall for inspection. Note COLOR and CONSISTENCY of lungs, palpating them between thumb and fingers to check for any FIRM AREAS. Incise those areas, checking for PARASITES, ABCESSES, TUMORS, or TUBERCULAR LESIONS. Excise, preserve (in formalin), and label one or more samples from such areas, as well as from the apparently normal lung tissue. With scissors, open the trachea and bronchi to the extent possible, noting any CONGESTION, OBSTRUCTIONS, or PARASITES. Preserve (in formalin) and label samples of same.

7. Open the pericardium and note the AMOUNT and COLOR of PERICARDIAL FLUID. Examine the surface of the heart and note any PALE AREAS or HEMORRHAGES. Cautiously open the ventricles and, if possible, draw off a SERUM SAMPLE with a clean syringe; bottle and label same and store cold or frozen. Open the ventricles and atria further, noting the nature of the CLOT or its absence. Examine the interior of the ventricles for HEARTWORMS (filariid nematodes) and, if present, rinse them in water and preserve (in alcohol) and label them. Remove all blood clots, trim off all major vessels, and WEIGH the heart to the nearest gram.

8. Remove the liver and note any DISCOLORATIONS, GRANULARITY of the capsule, ROUNDED MARGINS of the lobes, and any LUMPS or CYSTS within its substance. With a sharp knife, slice it in several places to examine its internal structure. Excise and preserve (in formalin) samples of any abnormalities, as well as of the apparently normal tissue. With scissors, open the gall bladder and major bile ducts to search for HELMINTHS. Preserve same (in formalin). Retain a 50 gm (1/8 lb) sample of the liver, label, and store ("whirl-pak") frozen.

9. Remove the spleen and examine for HEMORRHAGES and other DISCOLORATIONS. Palpate for LUMPS or CYSTS. Trim off excess tissues and WEIGH it or measure its overall LENGTH and greatest WIDTH. Slice it in several places to examine its internal structure. Excise, preserve, and label samples of any abnormalities, as well as of the normal tissue.

10. Remove the esophagus and stomach together, separating the stomach from the intestine at the pylorus. Inspect all surfaces, noting any HEMORRHAGES or ULCERATIONS. With heavy scissors or sharp knife, open the esophagus and stomach, noting contents and any abnormalities of the internal surfaces, as well as the presence of HELMINTHS. Retain and preserve

(in formalin) a sample of the latter, as well as of any abnormal tissues.

11. Separate the pancreas from the small gut and examine it for LUMPS and DISCOLORATIONS. With small scissors, open some of the pancreatic ducts and search for HELMINTHS. Preserve and label same.

12. Remove the entire large and small intestines. If the specimen is fresh, tear or cut the mesentery between the loops to allow the intestine to stretch out, then separate the small from the large intestine by cutting at the iliocaecal junction. Open about 10 feet at a time of the small gut in a plastic dishpan of water, removing PARASITES as they are exposed to view. Then scrape the mucosa and other parasites into the water (by pulling the opened gut between thumb and forefinger), from which they can later be decanted and preserved. Do the same with the caecum and with the large intestine but into separate containers. After cleaning, check the intestinal walls for LESIONS or HAEMORRHAGES, and preserve (in formalin) samples of same. Note approximate numbers of HELMINTHS and preserve (in formalin) a sample of each kind.

13. Examine the kidneys and strip the capsule from them, noting the presence of any ADHESIONS, ABSCESSES, or HAEMORRHAGES. Slice in half and examine internal structure, especially for CYSTS, STONES, or INFARCTS. Open URETERS and BLADDER and note condition of lining. Inspect for possible PARASITES in the bladder. Excise and preserve (formalin) any abnormalities, as well as a sample of the normal tissue. Note color of URINE.

14. Remove the entire reproductive tract of the female and, with a sharp knife or heavy scissors, open it from vulva to oviducts, noting the presence and size of any FOETUS or EMBRYO and any TUMORS, ABSCESSES, or excessive amounts of MUCOUS or other FLUIDS. Note greatest WIDTH and COLOR of any placental scars. Remove and preserve (formalin) both OVARIES. Examine the male reproductive tract by palpation and incision, noting and preserving any abnormalities. Measure the LENGTH of the testes, and retain the BACULUM for age determination, if no teeth are available.

NECROPSY PROCEDURE FOR WHALES, DOLPHINS, AND PORPOISES

A. EXTERNAL EXAMINATION

1. Identify SPECIES and SEX, at least tentatively. PHOTOGRAPH at least one overall view of the carcass to show the COLOR PATTERN, the DORSAL FIN (if any), and at least one FLIPPER. Additional photos of the HEAD to show its PROFILE, the TEETH or BALEEN, the position of the EYE, and any THROAT GROOVES, and of the abdomen to show the GENITO-PERIANAL area, and the FLUKES, could be very useful for identification.

2. Measure the STANDARD LENGTH, from tip of snout to fork of tail, in a straight line, noting the method employed if it is not feasible to straighten the spine. Note the NUMBER and maximal LENGTH of the THROAT GROOVES or folds.

3. Examine the surface of the body, head, and appendages, noting the location of any ECTOPARASITES and preserving (in alcohol) a sample of same. Describe any SCARS and any bloody or other DISCHARGES from any orifices. Note any LESIONS and preserve (in formalin) samples of same.

4. Make an incision through the skin and blubber about midway along the side and measure the BLUBBER THICKNESS to the nearest millimeter. (The incision should be small enough to prevent distortion, but its size will depend on the size of the animal and thickness of its blubber) Then slash through the skin and blubber in several places, noting the presence of any HEMORRHAGES, CYSTS, and PARASITE LARVAE and preserving (in formalin) samples of same. Excise a BLUBBER SAMPLE of about 50 gm (1/8 lb), wrap it securely in aluminum foil (non-lubricated commercial grade), label, and store cold, preferably frozen.

5. Examine the blowhole(s) and dissect open the NASAL AIR SACS, noting the presence of any FLUIDS, OBSTRUCTIONS, or PARASITES. Preserve a sample of same.

6. Note the NUMBER and LOCATION of any TEETH, or if it is a baleen whale, the LENGTH, WIDTH, and COLOR of the BALEEN PLATES. Remove, label, and retain one or two teeth or baleen plates for age determination.

B. INTERNAL EXAMINATION

1. Remove the ventral body wall (or lateral, if necessary) from throat to vicinity of the anus, by cutting away the skin and blubber first, then the muscle layers beneath. Some or all of the ribs may need to be disarticulated in this process, especially if the whale is very large and resting on its belly. Lay one or more of the slabs of skin and blubber to one side for a work surface.

2. Disarticulate the exposed half of the lower jaw, and lay it aside, taking care to avoid damage to the auditory canal and middle ear. Examine the inner surfaces of the mouth and tongue, noting any DENTAL DISEASE, LESIONS, or TUMORS of the mouth, tongue, and pharynx, noting any DENTAL DISEASE, TUMORS, and other LESIONS or SCARS.

3. In a baleen whale, carefully dissect out the AUDITORY CANAL, remove the WAX PLUG from the tympanic end (near the bulla), and fix it in 10% formalin (or pack it gently into a rigid container for transport to the laboratory, then fix in formalin). In a large whale, the plug may be up to 5 or 6 inches in length and 1 to 2 inches in diameter.

4. Remove the BULLA and open the MIDDLE EAR, noting the presence of any NEMATODES. Preserve some.

5. Open the PTERYGOID SINUSES and PALATAL AIR SPACES and note any PARASITES or LESIONS. Preserve samples of same.

6. If the specimen is fresh, sever the head from the body, watching for NEMATODES in the vicinity of the spinal canal. Preserve some. Open the cranium (with axe or chain saw) by removing the occipital bones, and examine the surface of the brain, noting any LESIONS. Slice the brain in several places and preserve (in formalin) samples, especially from any lesions encountered. Watch closely for any HELMINTHS and preserve same.

7. Turning to the thorax, examine the lungs, noting COLOR and CONSISTENCY and any THICKENING or GRANULATION of the pleurae. Palpate for FIRM NODULES, incising them to check for PARASITES, ABSCESSES, or TUBERCULAR LESIONS. Preserve samples of same (in formalin). Open the trachea and bronchi, noting any PARASITES, CONGESTION, or OBSTRUCTIONS.

8. Open the pericardium and note the AMOUNT and COLOR of PERICARDIAL FLUID. Examine the surface of the heart and note any PALE AREAS or HEMORRHAGES. Cautiously open the ventricles and, if possible, draw off a SERUM SAMPLE with a clean syringe; bottle and label same and store cold or frozen. Open the ventricles and atria further, noting the nature of the CLOT or its absence. Examine the interior of the ventricles for HEARTWORMS (filariid nematodes) and, if present, rinse them in water and preserve (in alcohol) and label them.

9. Remove the liver and note any DISCOLORATIONS, GRANULARITY of the capsule, ROUNDED MARGINS of the lobes, and any LUMPS or CYSTS within its substance. With a sharp knife, slice it in several places to examine its internal structure. Excise and preserve (in formalin) samples of any abnormalities, as well as of the apparently normal tissue. With scissors, open the gall bladder and major bile ducts to search for HELMINTHS. Preserve same (in formalin). Retain a 50 gm (1/8 lb) sample of the liver, label, and store ("whirl-pak") frozen.

10. Remove the spleen and examine for HEMORRHAGES and other DISCOLORATIONS. Palpate for LUMPS or CYSTS. Trim off excess tissues and WEIGH it or measure its overall LENGTH and greatest WIDTH. Slice it in several places to examine its internal structure. Excise, preserve, and label samples of any abnormalities, as well as of the normal tissue.

11. Remove the esophagus and stomach together, separating the stomach from the intestine at the pylorus. Inspect all surfaces, noting any HEMORRHAGES or ULCERATIONS. With heavy scissors or sharp knife, open the esophagus and stomach, noting contents and any abnormalities of the internal surfaces, as well as the presence of HELMINTHS. Retain and preserve (in formalin) a sample of the latter, as well as of any abnormal tissues.

12. Separate the pancreas from the small gut and examine it for LUMPS and DISCOLORATIONS. With small scissors, open some of the pancreatic ducts and search for HELMINTHS. Preserve and label same.

13. Remove the entire large and small intestines. If the specimen is fresh, tear or cut the mesentery between the loops to allow the intestine to stretch out, then separate the small from the large intestine by cutting at the iliocaecal junction. Open about 10 feet at a time of the small gut in a plastic dishpan of water, removing PARASITES as they are exposed to view. Then scrape the mucosa and other parasites into the water (by pulling the opened gut between thumb and forefinger) from which they can later be decanted and preserved. Do the same with the caecum and with the large intestine but into separate containers. After cleaning, check the intestinal walls for LESIONS or HAEMORRHAGES, and preserve (in formalin) samples of same. Note approximate numbers of HELMINTHS and preserve (in formalin) a sample of each kind.

14. Examine the kidneys and strip the capsule from them, noting the presence of any ABCESSES or HAEMORRHAGES. Slice in half and examine internal structure, especially for CYSTS, STONES, or INFARCTS. Open URETERS and BLADDER and note condition of lining. Inspect for possible PARASITES in the bladder. Excise and preserve (formalin) any abnormalities, as well as a sample of the normal tissue. Note color of URINE.

15. Remove the entire reproductive tract of the female and, with a sharp knife or heavy scissors, open it from vulva to oviducts, noting the presence and size of any FOETUS or EMBRYO and any TUMORS, ABCESSES, or excessive amounts of MUCOUS or other FLUIDS. Note greatest WIDTH and COLOR of any placental scars. Remove and preserve (formalin) both OVARIES. Examine the reproductive tract of the male by palpation and incision. Measure the length of the testes.

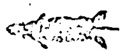
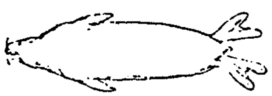
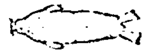
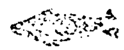
APPENDIX I

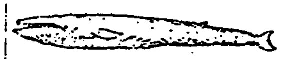
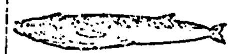
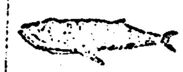
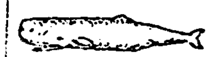
SUGGESTED LIST OF EQUIPMENT AND SUPPLIES FOR NECROPSY
(starred items are most essential)

* Axe
Chain saw
Bone saw
* Knife, 10" blade, pointed
Knife, 6" blade, boning
Knife, fleshing, w/4-ft handle
Meat hook, w/ attached 6-ft line
Scissors, heavy duty
* Scissors, 6", one point rounded
* Scalpel handle, large
* Scalpel blades, sterile
Forceps, 6" mouse-toothed
* Forceps, 8" blunt
Scale, spring, 25 lb
* Tape measure, 5 ft minimum
* Plastic ruler, 15 cm
Syringes, sterile, 20 ml
Needles, sterile, 18 gu, 2½"
Blood tubes, 10 ml
* Vials, 2 dr
Vials, 10 ml
* Bottles, pint
* Whirl-paks, small & medium
* Plastic bags, assorted sizes
* Aluminum foil, non-lubricated, comm. grade
* Freezer tape
* Parchment tags a/o labels
* Copper tags
* Transport medium Amies
* Sterile swabs
Disinfectant soap
Paper towels
* Buffered formalin
* 70% alcohol
* Felt-tip marker
* Pencils
* Ballpoint pens
* Data sheets
Field notebook
* Camera
* Black & white film
Liquid nitrogen

APPENDIX II

PRINCIPAL DIAGNOSTIC CHARACTERS OF MARINE MAMMALS KNOWN TO OCCUR IN ALASKAN WATERS

Polar Bear (*Ursus maritimus*)	Std.L: to 9 ft; Wt: to 1500 lb; uniformly whitish w/elongate neck; blackish, slightly curved claws; mouth bluish w/relatively small postcanine teeth.	
Sea Otter (*Enhydra lutris*)	Std.L: 2 to 5 ft; Wt: 2 to 85 lb; tail 1/4 of std.l.; dense fur dk brown to blackish; hind limbs paddle-shaped, 5th toe longest; forelimbs small, rounded, w/retractile claws.	
Steller's Sea Lion (*Eumetopias jubatus*)	Std.L: 3.5 to 10.5 ft; Wt: 40 to 2200 lb; Short, dense hair, tawny to brownish, w/ very large, blackish, naked flippers; hind flipper about 1/5 of overall length.	
Northern Fur Seal (*Callorhinus ursinus*)	Std.L: 2 to 8 ft; Wt: 10 to 600 lb; dense, soft fur, dark brown to blackish, w/ long, naked, black flippers; hind flipper more than 1/4 of overall length.	
Walrus (*Odobenus rosmarus*)	Std.L: 4 to 11 ft; Wt: 100 to 3500 lb; very large, curved tusks; hair short, sparse, brown to tawny; flippers naked, grayish; hind flipper about 1/5 of overall length.	
Northern Elephant Seal (*Mirounga angustirostris*)	Std.L: 4 to 20 ft; Wt: 75 to 8000 lb; hair short, sparse, grayish to brownish; flippers haired; fore flippers small, pointed, w/ claws ; hind flipper 1/6 of overall length, middle toes much shorter than outer.	
Hooded Seal (*Cystophora cristata*)	Std.L: 3.5 to 10 ft; Wt: 50 to 900 lb; pup silvery w/bluish-gray back; adults silvery-gray w/ scattered black blotches & spots; flippers haired & w/ strong claws; hind flipper about 1/6 of overall length.	
Bearded Seal (*Erignathus barbatus*)	Std.L: 4 to 7.5 ft; Wt: 55 to 800 lb; pup (newborn) dk gray-brown w/ whitish forelimbs and blotches on back; adults pale grayish to buff w/ slightly darker saddle, occasionally rusty head and neck; flippers haired; toes of forelimbs about equal in length w/ very stout, strong claws; four mammae.	
Spotted Seal (*Phoca largha*)	Std.L: 2.5 to 6 ft; Wt: 16 to 250 lb; pup w/whitish, woolly coat; adult hair short, coarse, silvery w/ gray saddle, many small, black spots overall; flippers haired, w/ strong claws.	
Pacific Harbor Seal (*Phoca richardsi*)	Std.L: 2.5 to 6 ft; Wt: 20 to 350 lb; short, coarse hair; color ranging from nearly black overall, w/scattered whitish rings, to pale and spotted like *largha*, but w/some whitish rings on back; hyoid arch usually reduced, not attached to auditory bullae.	
Ringed Seal (*Phoca hispida*)	Std.L: 2 to 5 ft; Wt: 10 to 200 lb; pup w/ whitish, woolly coat; adult grayish w/darker mantle and saddle w/ abundant light rings & few or no spots; foreflippers w/very stout, strong claws.	
Ribbon Seal (*Phoca fasciata*)	Std.L: 2.5 to 6 ft; Wt: 16 to 325 lb; pup w/ white, woolly coat; adult males dark brown to black w/broad silvery bands encircling the neck and head, each forelimb, and the rump and abdomen; female w/similar but much paler, grayish pattern.	

Bowhead Whale, (*Balaena mysticetus*)	L: to 60 ft; mouth 1/4 to 1/3 of total length; baleen slender, black, to 12 ft; 325 plates per side w/anterior gap between sides; body robust, black, usually w/ some white on chin a/o snout; no throat folds; no dorsal fin.	
Pacific Right Whale (*Eubalaena glacialis*)	L: to 56 ft; mouth 1/5 to 1/4 of total length; baleen slender, black, to 7 ft; 300 plates per side w/anterior gap; body robust, black w/whitish, horny "bonnet" on snout; no throat folds; no dorsal fin.	
Blue Whale (*Balaenoptera musculus*)	L: to 85 ft; mouth < 1/5 of total length; baleen broad, blackish, to 5 ft; 3-400 plates per side, continuous around front of mouth; snout broad & flat; 80 to 100 throat folds extending > 1/2 the length of the body; small dorsal fin.	
Fin Whale (*Balaenoptera physalus*)	L: to 70 ft; mouth 1/5 to 1/4 total length; baleen broad, whitish or striped gray & whitish, to 3 ft; 300 plates per side w/ no anterior gap; body very slender w/ prominent, hooked dorsal fin; 60 to 110 throat folds extending to 1/2 the length of the body.	
Sei Whale (*Balaenoptera borealis*)	L: to 55 ft; mouth 1/5 to 1/4 total length; baleen black w/ very fine whitish fringe, to 2 ft; 350 plates per side w/.no anterior gap; body chunky w/ prominent triangular dorsal fin; 30 to 60 throat folds extending 2/5 the length of the body.	
Minke Whale (*Balaenoptera acutorostrata*)	L: to 30 ft; mouth 1/5 total length; baleen yellowish w/ fine fringe, to < 1 ft; up to 300 plates per side w/ no anterior gap; body chunky w/ prominent, hooked dorsal fin; about 50 throat folds extending 1/3 to 1/2 of length of body; broad white band on each flipper.	
Hump-backed Whale (*Megaptera novaeangliae*)	L: to 50 ft; mouth 1/5 of total length; baleen gray-black w/ coarse fringe, to 3ft; 3-400 plates per side w/ no anterior gap; body robust with small dorsal fin; 14 to 20 coarse throat folds extending 1/2 the length of the body; prominent tubercles on snout and lower lip; extremely long, slender flippers.	
Gray Whale (*Eschrichtius robustus*)	L: to 45 ft; mouth to 1/5 total length: baleen yellowish w/coarse fringe, to 1 ft; 150 plates per side w/ anterior gap; dorsal fin inconspicuous or the most anterior of several low humps; 2 to 4 short throat folds.	
Sperm Whale (*Physeter catodon*)	L: to 60 ft; chunky w/ squarish snout and single, anterior blowhole; long, slender lower jaw w/ 20-30 prs conical teeth; no teeth in upper jaw; low, inconspicuous dorsal fin.	
Baird's Beaked Whale (*Berardius bairdi*)	L: to 42 ft; bulging forehead and beak-like snout; 1 to 2 prs of teeth at anterior end of lower jaw only; low triangular dorsal fin; small rounded flippers; often w/ abundant deep scars and lacerations.	

Cuvier's Beaked Whale (*Ziphius cavirostris*)	L: to 26 ft; sloping forehead and short beak, w/ 1 pr of teeth at anterior end of lower jaw; small,-hooked dorsal fin; flippers lanceolate; back & flanks often show many linear scars.	
Stejneger's Beaked Whale (*Mesoplodon stejnegeri*)	L: to 20 ft; sloping forehead w/ long "beak"; 1 pr of large, spatulate teeth about 1/2-way along lower jaw; prominent triangular dorsal fin; flippers lanceolate; body often w/ many linear scars.	
White Whale or Beluga (*Delphinapterus leucas*)	L: to 18 ft; bulbous forehead w/ very short "beak"; 8 to 10 prs curved teeth in upper and in lower jaws; no dorsal fin; flippers rounded; color slate-blue (young) to uniformly creamy white.	
Narwhal (*Monodon monoceros*)	L: to 16 ft; bulbous forehead w/no beak; single, spiralled tusk in male (none in female); no dorsal fin; flippers blunt; whitish ventrally, blotchy gray above.	
Killer Whale (*Orcinus orca*)	L: to 25 ft; robust w/ prominent, high dorsal fin; 10 to 14 prs of conical teeth in upper and in lower jaw; large rounded flippers; white blotch by eye; yellowish to grayish bend behind dorsal fin.	
Pacific Pilot Whale (*Globicephala sieboldi*)	L: to 20 ft; bulbous forehead w/no beak; 7 to 15 prs of teeth in upper and in lower jaw; body chunky, all black above, some white midventrally; prominent low dorsal fin; long, lanceolate flippers.	

Right Whale Dolphin (*Lissodelphis borealis*)	L: to 8 ft; short, slender snout; 40 to 50 prs of teeth in upper and in lower jaw; very slender caudal region; no dorsal fin; long, slender flippers; all black above w/ white ventral stripe.	
White-sided Dolphin (*Lagenorhynchus obliquidens*)	L: to 7 ft; rounded forehead w/nobeak; about 30 prs of teeth in upper and in lower jaw; large, hooked dorsal fin; lanceolate flippers; white below w/ blotch & stripe pattern above.	
Dall's Porpoise (*Phocoenoides dalli*)	L: to 6 ft; sloping snout w/no beak; 25 prs of tiny teeth in upper and in lower jaw; large dorsal fin w/white, hooked tip and prominent dorsal hump in caudal region; contrasting black & white color pattern.	
Harbor Porpoise (*Phocoena phocoena*)	L: to 6 ft; blunt snout; 20 to 30 prs of tiny, spatulate teeth in upper and in lower jaw; triangular dorsal fin; pale below, slaty to blackish above w/black stripe from corner of mouth to flipper.	

APPENDIX III

SOME KNOWN AND POTENTIAL PATHOLOGICAL CONDITIONS IN MARINE MAMMALS IN ALASKAN WATERS

Condition	Associated Agent(s)	Kinds of Marine Mammals Affected
Inflammatory Reactions:		
Dento-alveolar abcess	(?)	Sea otter, pinnipeds, toothed whales
Irritation of nasal mucosa	Nasal mites	Sea otter, pinnipeds
Tonsilitis	(?)	Any
Subeningeal hemorrhage, focal necrosis	Helminths	Whales
Dermatitis	Ectoparasites, Fungi	Any
Vesicular exanthema	Virus	Gray whale, otariids
Pox	Virus	Pinnipeds
Muscular inflammation	Helminths, Bacteria, Broken bones	Any
Focal necrosis of muscles, blubber	Helminths, Bacteria	Any
Myocardial infarct	Helminths	Whales, pinnipeds
Pneumonia, tracheitis, bronchitis, pulmonary granuloma, hepatization	Helminths, Bacteria, Inhalation of foreign materials	Any
Inflammation and fibrosis of subpleural parenchyma	Helminths	Whales
Gastric lesions, ulcers, cysts	Helminths	Any
Hepatic cirrhosis, necrosis, hemorrhage	Helminths, Bacteria	Any
Biliary fibrosis	Helminths	Any
Hemorrhagic enteritis, enterocolitis	Helminths, Bacteria	Any
Osteoarthritis	(?)	Any
Neoplasms		
Fibroma, papilloma of skin, tongue	(?)	Whales*
Neurofibroma, ganglioneuroma, basal lipoma	(?)	Whales*
Hemangioma (liver)	(?)	Whales*
Fibrosarcoma (kidney)	(?)	Pinnipeds*
Malignant granuloma (lymph nodes)	(?)	Whales*
Fibromyomata of uterus	(?)	Whales*
Mucinous cystadenoma (ovary)	(?)	Whales*
Trauma		
Lamprey scars (circular)	Lampreys	Whales
Mandibular fracture	(?)	Whales, pinnipeds
Bullet holes	Man	Any
Crushing	Other, larger pinnipeds	Young pinnipeds
Lacerations	Predators, conspecifics	Any
Other		
Asphyxia	Nasal mites, conspecifics	Pinnipeds, Sea otter
Starvation	Food scarcity, gut obstruction, dental deficiencies	Any
Congenital deformities		Any
Arteriosclerosis	(?)	Whales*
Atherosclerosis	(?)	Whales*
Non-inflammatory hepatic focal necrosis, siderosis	(?)	Whales*
Portal and caval thrombi	Helminths	Whales*

Premature birth	Virus	Pinnipeds*
Hemorrhagic anemia	Helminths (gut)	Pinnipeds*
Walled abscesses (in muscles, liver, abdominal cavity	(?)	Whales*

*Reported only from this group but conceivably could occur in others.

System No.___

Month ______ BK1-12   Year ______ BK67-78

PATHOLOGY REPORT

Species ID# ________________

Sex BK21____Male
BK23____Female

BL0-9	BL10-19	BL20-29	BL30-39	BL40-49	BL50-59	BL60-69
Group	Order	Family	Genus	Species	Subspec.	Location

AGE

BK 26	___	Unknown
BK 27	___	0-less than 1 day
BK 28	___	1 day-less than 1 week
BK 29	___	1 week-less than 2 weeks
BK 30	___	2 weeks-less than 1 month
BK 31	___	1 mo.-less than 2 months
BK 32	___	2 mo.-less than 3 months
BK 33	___	3 mo.-less than 6 months
BK 34	___	6 mo.-less than 9 months
BK 35	___	9 mo.-less than 1 year
BK 36	___	1 yr.-less than 1 1/2 years
BK 37	___	1 1/2 years-less than 2 yrs.
BK 38	___	2 years-less than 3 yrs.
BK 39	___	3 years-and over

DIAGNOSTIC PROCEDURES

BK 57	___	Clinical Diagnosis
BK 58	___	Gross Pathology
BK 59	___	Histopathology
BK 60	___	Hematology-Serology
BK 61	___	Microbiology
BK 62	___	Biochemistry
BK 63	___	Parasitology
BK 79	___	Photo-Gross
BK 80	___	Photo-Micro

Experiment No. ____________

		DIAGNOSTIC CATEGORY	TISSUE SAVED				DIAGNOSTIC CATEGORY	TISSUE SAVED	
BK 81	___	Skin-Pelage Sys.	BK 40	___	BK 89	___	Nervous Sys.	BK 48	___
BK 82	___	Musculo-Skel. Sys.	BK 41	___	BK 90	___	Organs of Spec. Sense	BK 49	___
BK 83	___	Respiratory Sys.	BK 42	___	BK 91	___	Body as a Whole	BK 50	___
BK 84	___	Cardiovascular Sys.	BK 43	___	BK 92	___	Viral. Ricket./PPLO Dis.	BK 51	___
BK 85	___	Hemo./Lymph. Sys.	BK 44	___	BK 93	___	Bacterial Diseases	BK 52	___
BK 86	___	Digestive Sys.	BK 45	___	BK 94	___	Fungal/Mycotic Dis.	BK 53	___
BK 87	___	Urogenital Sys.	BK 46	___	BK 95	___	Parasitism	BK 54	___
BK 88	___	Endocrine Sys.	BK 47	___	BK 96	___	Neoplasms	BK 55	___

HISTORY:

GROSS LESIONS:

HISTOPATHOLOGIC EXAMINATION:

DIAGNOSIS:

CODE: ________

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 8 R.U. NUMBER: 194

PRINCIPAL INVESTIGATOR: Dr. F. H. Fay

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to date as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1			
Alaska Peninsula	7/23/75	7/24/75	4/20/76			
Kotzebue Sound	7/17/75	7/20/75	4/20/76			
Kotzebue Sound	7/22/75	7/24/75	4/20/76			
St. Lawrence Is.	8/8/75	8/22/75	4/20/76			

Note: [1] Data Management Plan has been approved by M. Pelto; we await approval by the Contract Officer and receipt and approval by all parties of the necessary Data Format.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: March 31, 1976

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 8

PRINCIPAL INVESTIGATOR: Dr. Francis H. Fay

Period April 1, 1975 - March 31, 1976* (12 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	39,586.00	19,780.66	19,805.34
Staff Benefits	6,700.00	3,362.71	3,337.29
Equipment	-0-	-0-	-0-
Travel	6,000.00	6,406.67	(406.67)
Other	16,300.00	3,863.20	12,436.80
Total Direct	68,586.00	33,413.24	35,172.76
Indirect	22,643.00	11,314.54	11,328.46
Task Order Total	91,229.00	44,727.78	46,501.22

* Preliminary cost data, not yet fully processed.

Following is part 2 of the quarterly report R.U.# 194 for the period ending December 31, 1975. This was received after the printing of the Quarterly Reports, July - September 1975, therefore is included here.

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OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending December 31, 1975

Project Title: Morbidity and Mortality of Marine Mammals

Contract Number: 03-5-022-56

Task Order Number: 8

Principal Investigator: Dr. Francis H. Fay

Mammal R.U. 194

I. Task Objectives

A. To complete the processing of materials collected from specimens examined during the 1975 summer surveys.
B. To examine any mass strandings of marine mammals during autumn 1975, or, in lieu of that, to undertake aerial surveys of autumn strandings in the summer sampling areas.
C. To continue the literature survey and development of the autopsy manual.

II. Field and Laboratory Activities

A. Field Trip Schedule

No field trips were scheduled for this quarter, other than in response to reports from field contacts in Cold Bay, King Salmon, Gambell, Savoonga, and Kotzebue of major autumn strandings in their areas. All such reports received were negative. Aerial surveys, tentatively scheduled for early to mid November, were also cancelled for lack of aircraft and because earlier than usual icing conditions along the coast precluded useful observations. Aerial survey data were obtained or have been solicited from other investigators who were surveying for other purposes in some of the sampling areas.

B. Laboratory Activities

Materials obtained from the carcasses examined in the 1975 summer surveys were processed and analyzed. These comprised (1) photographs for identification (mainly of cetaceans), (2) bones and teeth for identification and age determination, (3) preserved tissues for histopathological examination, and (4) bacterial isolates.

C. Methods

A total of 113 photos for confirmation and/or identification of the specimens examined were processed. Some examples of these are shown in Figs. 1 to 4. Identification was by comparison with known specimens in the University of Alaska reference collection and with plates, photographs, and drawings in various published references.

The largest series of teeth for age determination was obtained from 50 of the walrus carcasses on the Punuk Islands; 43 more were obtained from walruses on St. Lawrence Island proper. Only 8 were obtained from the walruses in other localities, where most of the carcasses were headless. Teeth were obtained also from 2 sea lions, 8 seals, and 3 sea otters; diagnostic bones (skull fragments, scapulas, innominates) were obtained from most of the other seals. Tooth sections (longitudinal) were cut on a jewelers saw and the ages determined from numbers of cementum layers. Bones were compared with those from known-aged reference specimens.

Tissues for histopathological examination that had been preserved in 10 per cent formalin in the field were dehydrated in ethanol, embedded in paraffin, sectioned on a rotary microtome, stained in hematoxylineosin, mounted in Permount, and studied under a compound microscope. A few sections from one case were stained with Gomori's stain, specific for fungal agents.

In two cases where bacterial agents were suspected to be present, attempts were made, using sterile technique, to collect the agent for subsequent isolation in the laboratory. In the field, the affected organ was incised, swabbed, and the swabs stored in Amies bacterial transport medium. The samples were stored at 4^{o} to 6^{o}C whenever possible and later forwarded to the State/Federal veterinary laboratory at Palmer, Alaska for isolation.

III. Results

Identification to species of most of the fresher specimens (less than 3 months _in situ_) in the field by experienced project personnel was unequivocal. Confirmation of many of these and certain identification of nearly all of the other carcasses and fragmentary remains was achieved by the P.I from photographs and/or collected bones. The only specimens that remain unidentified to species are some of those sighted from aircraft and not photographed or examined.

The age information gained from the walrus teeth is shown graphically in Fig. 5, where it is compared with two other reference samples. Most of the other pinnipeds examined were very young animals, in their first or second year of life, as were most of the cetaceans. The sea otters were all old adults.

Diagnostic histopathological materials from five specimens were studied by R. Dieterich with the following results:

Field No.	Species	Major Findings	Diagnosis
9704	*Phoca richardsi*	Liver: Focal necrosis	Hepatitis
9707	*Enhydra lutris*	Stomach: Mucosal ulcerations monocytic infiltration Uterus: Mucosal congestion, focal hemorrhage, with abundant leucocytes (PMN's) in surface exudate.	Gastric ulcers (probably secondary, stress-related), and hemoendometritis (probably the primary illness)
9709	*Enhydra lutris*	Spleen: Engorged w/blood, extreme hemosiderosis Lung: Alveolar septa edematous; bronchial exudate; vascular cuffing of arterioles Liver: (enlarged, rounded, probable focal necrosis; sections not yet examined)	Probable hepatitis (primary) with secondary interstitial pneumonia
9710	*Phoca richardsi*	Spleen: Capsule thickened, much fibroblastic activity; many giant cells and phagocytes w/ hemosiderin Liver: Capsule thickened, much fibroblastic activity Lung: Vessels distended; congestion of alveolar walls Urachis: Moderate fibroblastic activity	Peritonitis (primary), omphalitis, pulmonary congestion
9017	*Phoca hispida*	Skin: Invasion of epidermis & sebaceous glands by filamentous rods & spores; focal epidermal necrosis, excess of sebum Lymph node: Depletion of lymphoid sinuses, proliferation of RE cells, some hemorrhage	Dermatomycosis (probably primary), lymphadenitis

A beta hemolytic *Streptococcus* was isolated from the lymph node of specimen No. 9017. No pathogens were isolated from the other specimens.

More than 250 publications on marine mammal pathology and parasitology, relevant to the marine mammals of the Bering Sea and northern North Pacific Ocean have been acquired and cataloged. Preparation of an annotated bibliography of these will begin in the next quarter.

A second draft of the field identification and dissection manual for Bering Sea marine mammals is in preparation.

IV. Preliminary Interpretation of Results

The age composition of the walrus carcasses stranded on St. Lawrence Island and in Kotzebue Sound compares very favorably with that of walruses taken in the subsistence harvest. This suggests that most of the animals that stranded in those two localities were mainly products of the harvest, i.e., that they were animals that had been killed or wounded by the subsistence hunters and not immediately retrievable. Our inspections and autopsies also indicated that many of them had indeed died from gunshot wounds. Conversely, the animals stranded on the Alaska Peninsula and the Punuk Islands evidently had died of natural causes, and the age composition of those samples is rather strikingly different, suggesting a more representative cross-section of the population than is taken in the highly selective harvests. Nearly all of the cetaceans found in the 1975 summer survey were gray whales, *Eschrichtius robustus*. The gray whale population, which has been recovering since the 1930's from near extirpation, now numbers about 11,000 animals and is believed to have reached its upper limit. These animals reside *en masse* in the Bering and Chukchi seas from June to October each year and apparently suffer a large part of their annual mortality there. Our surveys and those contributed by personnel of other projects covered less than 10 per cent of the shores of that region and yielded 25 dead gray whales, suggesting that the total mortality there was on the order of at least 300 animals in 1975, or about 3 per cent of the population. Conceivably, this will increase somewhat over the next few years, as the population achieves stability.

V. Problems Encountered/Recommended Changes

No problems this quarter.

In the 1976 and subsequent annual surveys, there will need to be more intensive and extensive effort put forth in examinations and autopsies. This does not necessarily mean that the sampling area should be expanded, but simply that the effort must be increased in the present sampling areas and the scope expended to include sampling for viral as well as bacterial, fungal, and parasitic agents and for background levels of petroleum hydrocarbons (and, perhaps, heavy metals and pesticides to a limited extent).

It has become apparent that the breakdown and utilization of stranded carcasses is rather rapid, even in this cold environment, and that the contribution of high-grade organic matter to both the marine and the terrestrial systems along the coasts is significant and should be at least preliminarily investigated in conjunction with this study. Some 375 metric tons of carcasses were stranded and subsequently utilized in the sampling areas alone in 1975, and the total contribution was easily more than 10 times that amount, from marine mammals alone. We recommend that this re-distribution of nutrients be examined, and we propose to initiate a small pilot study of it in one or two localities in 1976, utilizing student assistants for the field work. A final plan for this will be set forth in the next quarterly report, after we have explored further the possibilities for personnel, field sites, and combination with other littoral-coastal zone projects.

The high rate of occurrence of walrus carcasses on the Punuk Islands, evidently from natural causes, is particularly interesting and would seem to be ideally suited to more intensive study. This mortality seems to take place in the autumn, mainly November, when herds of up to several thousand animals haul out there. Regretably, the islands are not readily accessible at that time, other than via ship and/or helicopter, and the carcasses are mostly too degenerate for useful autopsy by the following spring-summer period. For maximal returns from this site, it would be preferable to establish a small field camp there during the 1976 summer that could be manned by project personnel for about one month in the following autumn, provided that delivery and retrieval of the field team can be assured. The prospects for this will be explored further in the next few months.

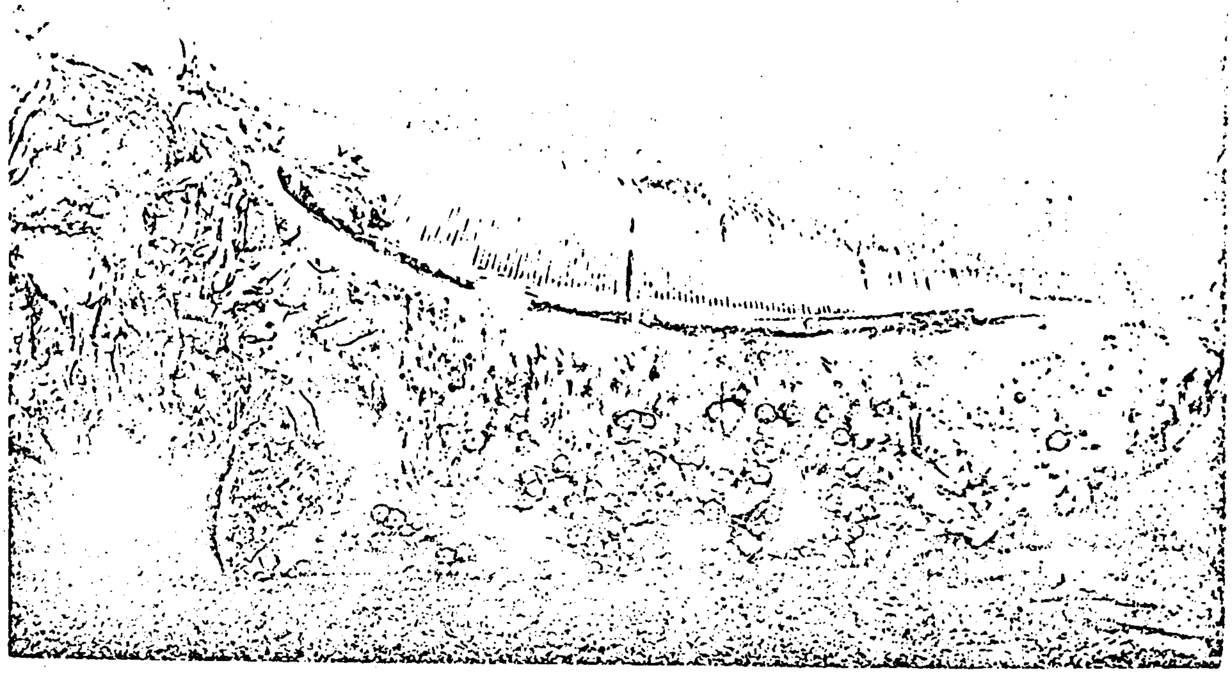

Fig. 1. Inverted rostral portion of the head of a young Gray Whale, Eschrichtius robustus, that had been partially eaten and presumably killed by Killer Whales. The mandible and remainder of the carcass (field no. 9020) lay nearby. Southern coast of St. Lawrence Island.

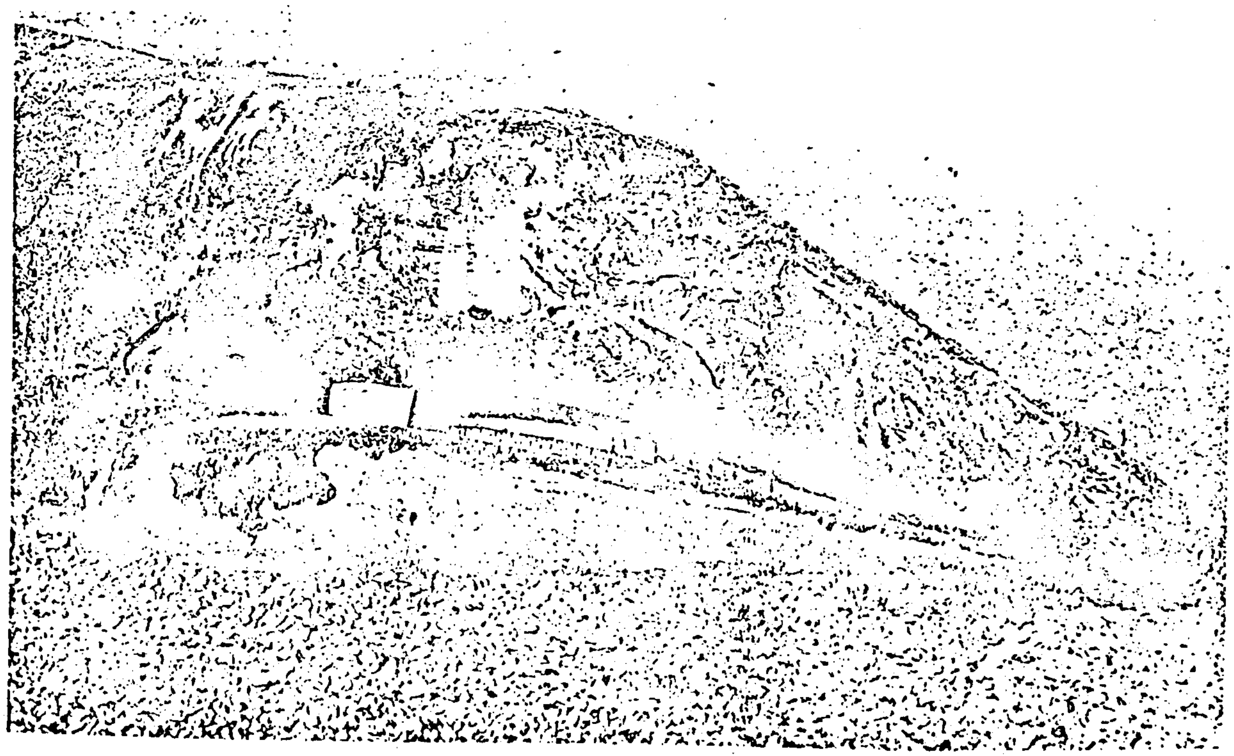

Fig. 2. Head of a 30-ft Gray Whale (field no. 9024) on the southeastern coast of St. Lawrence Island. The animal was intact, except for post-mortem autolytic deterioration and removal of most of the skin by scavenging gulls and foxes.

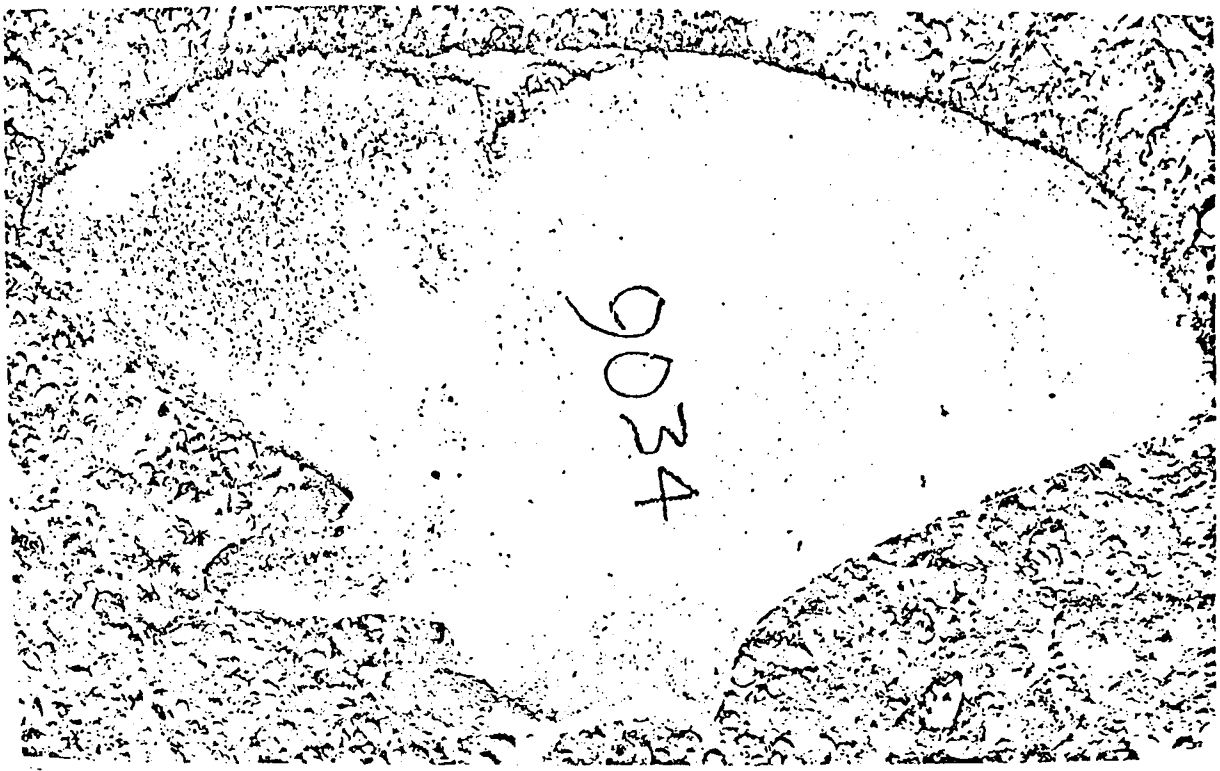

Fig. 3. Scapula of a Minke Whale, Balaenoptera acutorostrata, field number 9034, on the northern coast of St. Lawrence Island. Parts of the skull, vertebrae, and ribs lay nearby.

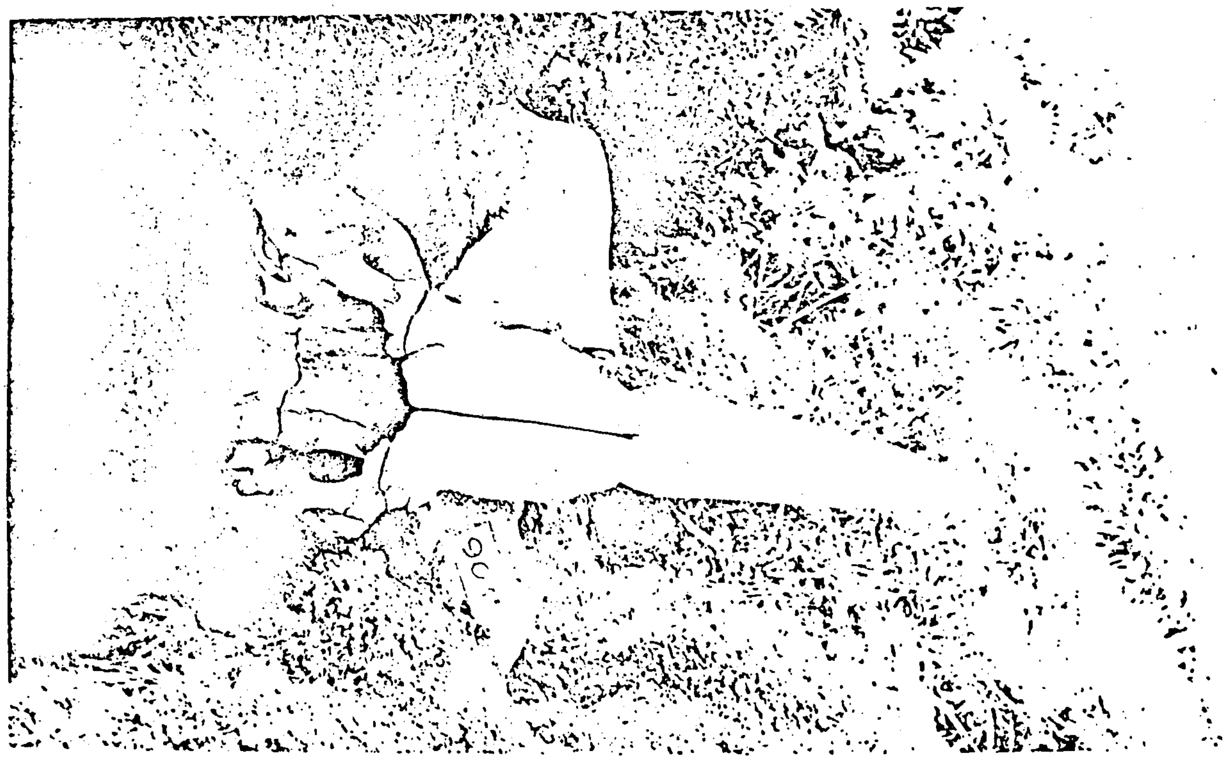

Fig. 4. Ventral view of the skull of a small Minke Whale, Balaenoptera acutorostrata, on the northern coast of St. Lawrence Island. Other parts of this animal (field no. 9035) lay nearby.

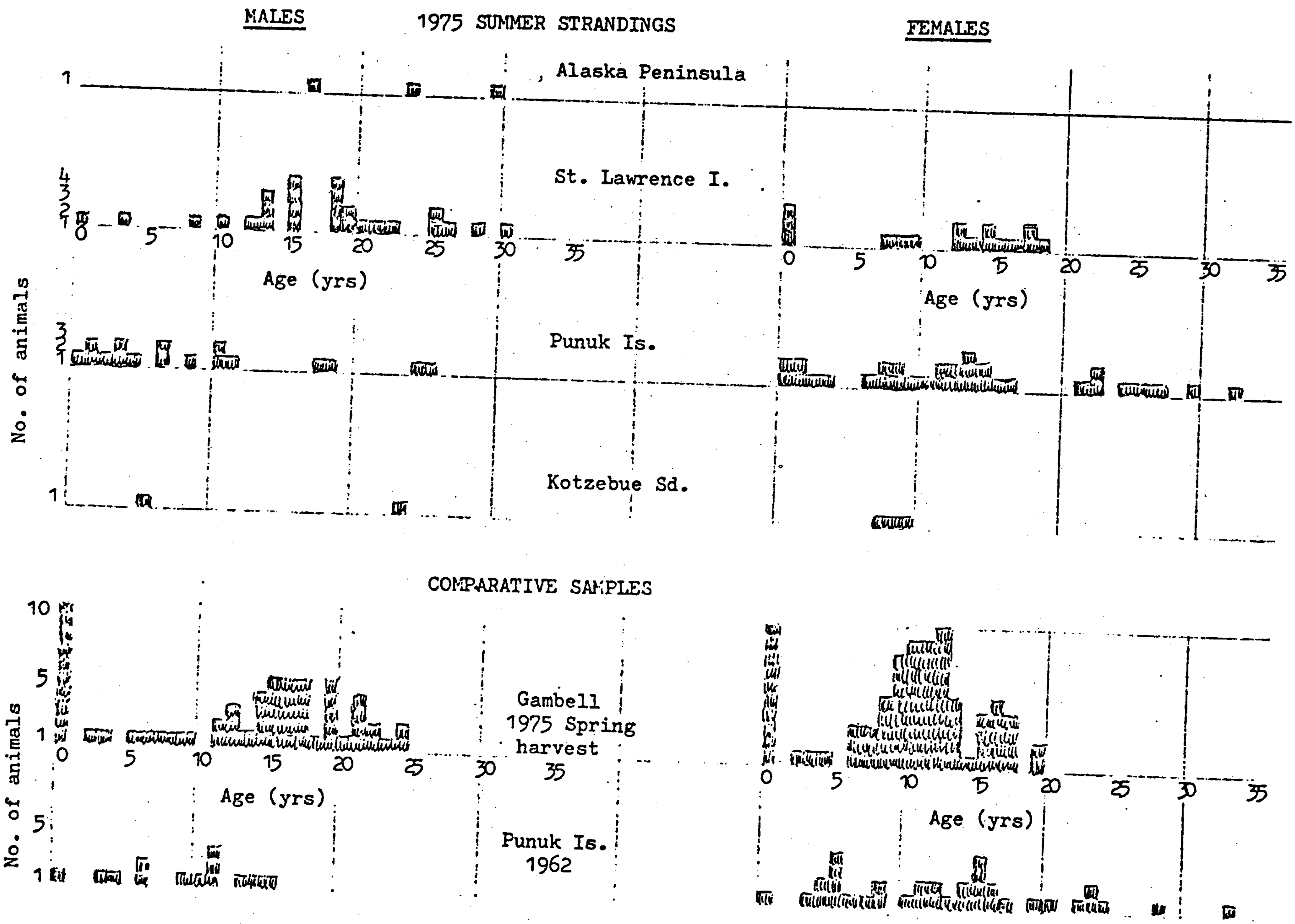

Fig. 5. Frequency distributions of age classes of walruses in the 1975 strandings, as compared with local subsistence harvests and an earlier series of strandings on the Punuk Islands.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 8 R.U. NUMBER: 194

PRINCIPAL INVESTIGATOR: Dr. F. H. Fay

Submission dates are estimated only and will be updated, if necessary, each quarter. Data batches refer to data as identified in the data management plan.

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2		
Alaska Peninsula	7/23/75	7/24/75	3/31/76			
Kotzebue Sound	7/17/75	7/20/75	3/31/76			
Kotzebue Sound	7/22/75	7/24/75	3/31/76			
St. Lawrence Is.	8/8/75	8/22/75	3/31/76			

[1] Estimated submission dates are contingent upon final approval of draft data management plan submitted to NOAA November 20, 1975 and receipt and approval of data format by University of Alaska.

OCS COORDINATION OFFICE

University of Alaska

ESTIMATE OF FUNDS EXPENDED

DATE: December 31, 1975

CONTRACT NUMBER: 03-5-022-56

TASK ORDER NUMBER: 8

PRINCIPAL INVESTIGATOR: Dr. Francis H. Fay

Period April 1 - December 31, 1975* (9 mos)

	Total Budget	Expended	Remaining
Salaries & Wages	39,586.00	12,055.25	27,530.75
Staff Benefits	6,700.00	2,048.89	4,651.11
Equipment	-0-	-0-	-0-
Travel	6,000.00	4,633.62	1,366.38
Other	16,300.00	1,231.77	15,068.23
Total Direct	68,586.00	19,969.53	48,616.47
Indirect	22,643.00	6,895.60	15,747.40
Task Order Total	91,229.00	26,865.13	64,363.87

* Preliminary cost data, not yet fully processed.

ANNUAL REPORT

Contract # 03-5-022-69
Research Unit #229
1 July 1975-1 April 1976
Pages: 1-14

Biology of the harbor seal, *Phoca vitulina richardi*, in the Gulf of Alaska.

Principal Investigators:

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Donald Calkins, Marine Mammals Biologist
Alaska Dept. of Fish and Game
333 Raspberry Road
Anchorage, Alaska 99502

April 1, 1976

I. Summary

This project is investigating several phases of the biology and ecology of the harbor seal in the Gulf of Alaska. Basic objectives include: (1) examination of food habits and trophic relationships, (2) investigation of population productivity and (3) examination of growth, development and seasonal condition. Other objectives include collection of data on population composition, seasonal distribution, sex and age segregation and use of critical habitat.

There are a number of potential adverse effects of oil and gas development on harbor seal populations. These include: (1) direct injury through contact with oil, (2) disturbance, particularly during vulnerable periods such as pupping, (3) increased exposure to environmental contaminants, (4) reduced basic productivity of the food web and (5) direct mortality of prey species.

Members of the family Gadidae are the dominant food items to date making up 65 percent of the identified material. Theragra was most important, composing 46 percent of the total. Other significant prey items included pleuronectids and cephalopods.

The age of sexual maturity in female harbor seals appears to be between 3 and 5 years. By age six virtually all seals are mature and producing pups annually. Reproductive failure sometimes occurs in maturing females. Male harbor seals become sexually mature between 3 and 7 years of age. Mature animals are potent from approximately April until September.

II. Introduction

This project is a basic ecological, life history investigation of the harbor seal in the Gulf of Alaska. Basic objectives are: (1) to determine food habits and trophic relationships in different areas of the Gulf by season, (2) to examine growth rates, development and body condition and (3) to investigate population productivity with emphasis on determining age of sexual maturity and age specific reproductive rates. Peripheral objectives include collection of data on environmental contaminant loads, sex and age segregation, use of critical habitat, seasonal distribution and population composition.

Exploration, development and transportation of petroleum reserves in the Gulf of Alaska have a number of potential deleterious effects on harbor seals. Some of these include:

1. Direct injury to animals through contact with oil.

2. Disturbance, particularly during vulnerable periods of their life cycle such as pupping, when disturbance has been shown to increase pup abandonment thereby increasing juvenile mortality.

3. Increased environmental contaminant levels.

4. Reduced basic productivity of the food web caused by contamination of the marine system.

5. Direct mortality of important prey species by contact with oil.

This study was designed to provide basic information needed for making decisions regarding oil and gas development in the Gulf of Alaska. More specifically, information is being obtained which will delineate areas particularly important to seal populations. It is providing information on seasonal distribution and areas of significant animal concentrations. Information on basic trophic relationships and the importance of particular prey species is being collected. Baseline data on population productivity are being established. Tissue samples are being collected in order to determine predevelopment environmental contaminant levels. A thorough understanding of all phases of the life history of the harbor seal is necessary to fully evaluate potential effects of gas and oil exploration and development.

III. Current state of knowledge.

Bishop (1967) conducted the first meaningful life history study of harbor seals in the Gulf of Alaska. Working both on Tugidak Island and on the coast of the Kenai Peninsula, he used a cementum annuli age determination technique combined with reproductive analyses to gather information on the reproductive cycle. He also collected data on growth and development. On Tugidak Island he gathered some preliminary data on population composition and productivity. His work was a pioneer study and only touched the surface. Imler and Sarber (1947) collected data on food habits on the Copper River Delta during the months of June and July. The Alaska Department of Fish and Game conducted research on Tugidak Island between 1965-1972 but this was mainly related to commercial exploitation. Seasonal distribution studies were conducted in the Prince William Sound area by the Alaska Department of Fish and Game in 1973 and 1974 (Pitcher and Vania 1973 and Pitcher 1975). In 1975 I conducted research on population productivity, growth and development and food habits in Prince William Sound (Pitcher 1975). This project conducted under contract to the Marine Mammal Commission provided the first sizable sample of life history data from any area in the Gulf of Alaska. A general discussion of harbor seal abundance and distribution in the Gulf is presented by Calkins et al (1975).

IV. Study Area

The study area for this project includes the Gulf Coast from Yakutat Bay north to Cape St. Elias, the Copper River Delta, Prince William Sound, the coast of the Kenai Peninsula from Cape Puget to Dangerous Cape, the Barren Islands and the Kodiak Island group including Afognak, Shuyak and the Trinity Islands. Specific collection localities from which we have sampled or plan to sample during this contract period include Yakutat Bay, Icy Bay, Kayak Island-Controller Bay, Middleton Island, Prince William Sound, the Copper River Delta, the Kenai Coast, the Barren Islands and the Kodiak area.

V. Sources, methods and rationale of data collection.

1. Harbor seals are being collected systematically from different areas and habitat types throughout the year. This is being done in order to detect variations in food habits with season, area and habitat type.

2. Weights and standard measurements are taken from each collected animal including: total weight, blubber weight, standard length, curvilinear length, axillary girth, maximal girth, hind flipper length and blubber thickness (Scheffer 1967). These data are being collected to establish growth rates, seasonal condition patterns and assist in making calculations of biomass.

3. Age determinations are being made. This is done by decalcifying a canine tooth from each animal, using a microtome to produce thin sections, staining the sections with hematoxylin and counting the annual growth rings with the aid of a microscope (Johnson and Lucier 1975). Age determinations are necessary for development of growth rates and to determine population structure and productivity.

4. The ovaries and uterus are taken from each female seal and preserved in formalin. Standard laboratory techniques for reproductive analysis are used through which the presence or absence of a conceptus in the uterus is determined and a partial reproductive history is reconstructed by examination of ovarian structures. These data are necessary for determination of ages of sexual maturity and age specific reproductive rates, basic parameters required for population productivity calculations.

5. Testes and epididymides from each male seal are collected and preserved. A microscopic examination is made of epididymal fluid to determine whether sperm are present or not. These data are used for determination of age of sexual maturity and periods of seasonal potency in males.

6. Stomach contents from each seal are preserved in formalin. Weights and volumes are determined for all contents. Identifications of prey species are made by examination of recognizable individuals and skeletal materials of diagnostic value. Frequency of occurrence of prey species is then determined.

7. Intestinal contents from each seal are strained through mesh sieves to recover fish otoliths. Otoliths, which are diagnostic to species, are compared to a reference collection and identified. All otoliths to date have been sent to John Fitch for verification of the identifications (Fitch and Brownell 1968).

8. Tissue samples are being collected and frozen so that baseline levels of heavy metals, pesticide residues and hydrocarbons can be determined.

9. Observations of harbor seals are recorded during collecting cruises and during aerial surveys conducted by other marine mammal projects in the Gulf of Alaska. These data are being compiled and will eventually be of value in delineating areas with high harbor seal concentrations, patterns of seasonal distribution and critical habitat.

VI. Results

Three collecting trips have been completed, one in the southwestern portion of Prince William Sound, one in the Kodiak-Afognak area and the other along the Kenai coast. Collecting activities for the remainder of the contract period are planned for the Barren Islands, Kodiak, Middleton and Kayak Islands, Icy Bay and Yakutat Bay.

To date specimen materials have been analyzed from 29 harbor seals. An additional 18 animals were collected in March but the laboratory analyses have not been completed.

Contents from stomachs and large intestines yielded identifiable food items from 23 of the 29 harbor seals processed to date. Two others contained food items which have not yet been identified while four animals had no food items. For this report the only food habit analysis will be frequency of occurrence of specific food items (Table 1). In the final report, volumes and weights of food items will also be considered. Spalding (1964) stated that percentages based on calculations of frequency of occurrence are the most accurate figures in food habit studies.

Table 1. Frequency of occurrence of harbor seal food items.

Food Items	Number of Occurrences	Percentage of Occurrences
Gadidae (Total)	28	65%
Theragra	20	46%
Gadus	3	7%
Eleginus	2	5%
Microgadus	2	5%
Unid. Gadid	1	2%
Pleuronectidae (Total)	4	9%
Atheresthes	1	2%
Hippoglossoides	1	2%
Lepidopsetta	1	2%
Unid. pleuronectid	1	2%
Osmeridae (Total)	1	2%
Thaleicthys	1	2%
Bathylagidae (Total)	1	2%
Leuroglossus	1	2%
Zoracidae (Total)	1	2%
Unid. zoracid	1	2%
Scorpaenidae (Total)	1	2%
Sebastes sp.	1	2%
Hexagrammidae (total)	1	2%
Hexagrammus c.f. stelleri	1	2%
Cephalopoda (Total)	6	14%

Important findings revealed during laboratory analysis of the female reproductive tracts (Table 2) include a 3-year-old female approaching sexual maturity. This animal had ovulated for the first time but either did not conceive or the blastocyst failed to implant. A 4-year-old female, ovulated probably for the first time, conceived, the blastocyst implanted and then died and was in the process of being resorbed when the animal was collected. Another 4-year-old female apparently ovulated for the first time, conceived, and when collected was supporting a fetus. The six females ages 5 to 10+ were all pregnant.

Table 2. Reproductive status of 12 female harbor seals collected from 28 Oct. 1975 to 13 Feb. 1976.

Number	Age	Pregnant Yes or No	Status	Comments
KOD-3-76	Pup	No	Nulliparous	No follicular activity
KOD-4-76	Pup	No	Nulliparous	No follicular activity
PWS-120-75	1	No	Nulliparous	No follicular activity
PWS-110-75	3	No	Nulliparous	Ovulated apparently first time, degenerate corpus luteum, either didn't conceive or conceptus died.
PWS-108-75	4	No	Nulliparous	Normal appearing corpus luteum, fetus being resorbed, apparent 1st pregnancy - unsuccessful.
PWS-109-75	4	Yes	Primiparous	Implanted 2.3 g fetus, no corpus albicans.
PWS-112-75	5	Yes	Multiparous	Implanted .1 g fetus, one corpus albicans.
PWS-122-75	6	Yes	Multiparous	Implanted 6.5 g fetus, one or two corpora albicantia.
PWS-125-75	9+	Yes	Multiparous	Implanted 12.3 g fetus, two albicantia.
PWS-115-75	10	Yes	Multiparous	Implanted 4.3 g fetus, one corpora albicans.
PWS-117-75	10	Yes	Multiparous	Implanted 5.3 g fetus, two corpora albicantia.
PWS-132-75	10+	Yes	Multiparous	Implanted 0.2 g fetus, two corpora albicantia.

The male reproductive materials collected to date were taken during a period of apparent sexual inactivity (Table 3). Of the 15 animals examined, only an 8-year-old had sperm present and then only a trace.

Table 3. Male harbor seal reproductive analysis.

Number	Age	Date	Testis Volume	Sperm Present
PWS-126-75	Pup	2 Nov. 75	3.5 cc	No
PWS-121-75	1	1 Nov. 75	3.5 cc	No
PWS-128-75	2	2 Nov. 75	6.5 cc	No
PWS-116-75	2	1 Nov. 75	5.5 cc	No
PWS-113-75	3	30 Oct. 75	9.0 cc	No
PWS-119-75	4	1 Nov. 75	15.0 cc	No
PWS-129-75	4	2 Nov. 75	22.0 cc	No
PWS-114-75	4	31 Oct. 75	9.0 cc	No
PWS-131-75	5	4 Nov. 75	16.0 cc	No
PWS-111-75	7	29 Oct. 75	46.0 cc	No
PWS-123-75	7	2 Nov. 75	26.0 cc	No
PWS-124-75	7	2 Nov. 75	36.0 cc	No
PWS-118-75	8	1 Nov. 75	36.0 cc	Trace
PWS-127-75	9	2 Nov. 75	51.0 cc	No
PWS-130-75	11	2 Nov. 75	30.5 cc	No

Growth, development and condition data are summarized in Table 4. These data will be used to develop growth curves and patterns of seasonal condition in various locations in the Gulf of Alaska when sufficient material is collected

During sea otter and sea lion surveys conducted in October 1975 and during collecting activities in February 1976, several observations of harbor seal concentrations were made (Figs. 1 and 2, Table 5). These are not in any way a complete summary of harbor seal concentrations in the area but over a period of time will add to our understanding of seasonal distribution.

VII. Discussion

Members of the family Gadidae (65%), primarily *Theragra* (45%), are by far the dominant food item to date. Pleuronectids representing three genera were found a total of four times. Cephalopods were identified from six animals and at a later date will be more precisely identified. Two species of shrimps, *Pandalus goniurus* and *Crangon dalli*, were found. It was felt they were probably secondary food items as only traces were found in conjunction with well digested *Theragra* remains.

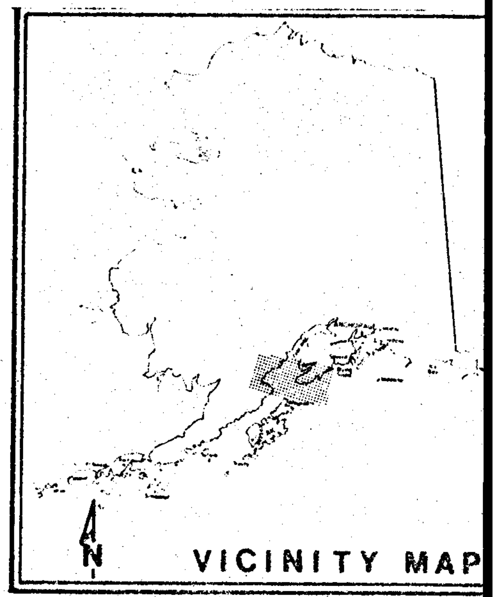
Table 4. Growth and condition data from collected harbor seals.

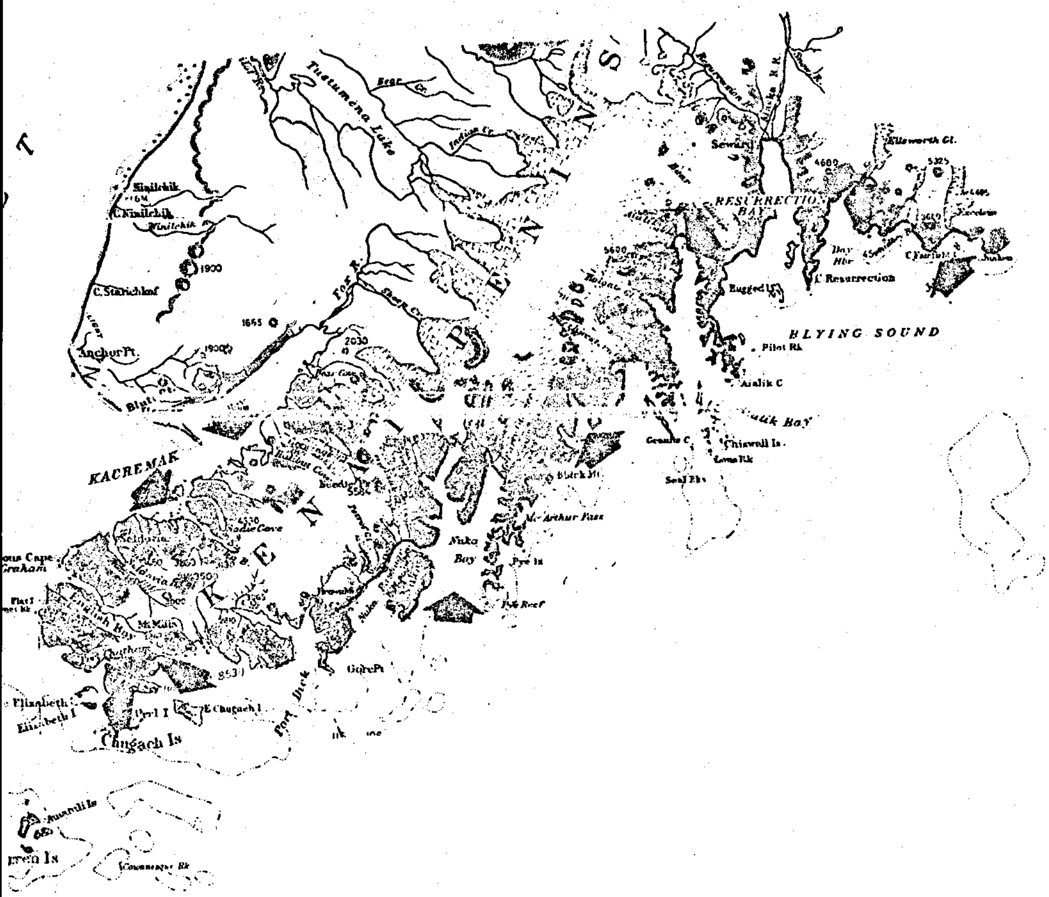
Number	Sex	Age	Weight	Hide and Blubber Wt.	Standard Length	Blubber Thickness
PWS-126-75	Male	5 mos.	25.0 kg	6.8 kg	106.5 cm	2.5 cm
PWS-121-75	Male	1 year	28.2 kg	9.1 kg	109.0 cm	2.1 cm
PWS-116-75	Male	2 years	38.6 kg	14.1 kg	127.3 cm	2.5 cm
PWS-128-75	Male	2 years	40.1 kg	13.6 kg	123.0 cm	2.5 cm
PWS-113-75	Male	3 years	46.4 kg	18.6 kg	132.0 cm	2.5 cm
PWS-114-75	Male	4 years	53.2 kg	18.6 kg	136.0 cm	2.3 cm
PWS-119-75	Male	4 years	63.6 kg	20.0 kg	146.0 cm	2.6 cm
PWS-129-75	Male	4 years	63.6 kg	22.7 kg	144.5 cm	3.6 cm
PWS-131-75	Male	5 years	62.3 kg	23.6 kg	142.0 cm	2.9 cm
PWS-111-75	Male	7 years	74.6 kg	25.0 kg	149.5 cm	2.5 cm
PWS-123-75	Male	7 years	59.1 kg	–	145.0 cm	2.3 cm
PWS-124-75	Male	7 years	66.8 kg	–	152.0 cm	2.5 cm
PWS-118-75	Male	8 years	81.8 kg	29.1 kg	158.0 cm	2.8 cm
PWS-127-75	Male	9 years	86.4 kg	29.6 kg	155.0 cm	3.0 cm
PWS-130-75	Male	11 years	84.1 kg	25.0 kg	159.5 cm	2.5 cm
KOD-1-76	Male	–	91.1 kg	34.5 kg	159.5 cm	4.5 cm
KOD-2-76	Male	–	88.1 kg	32.5 kg	158.0 cm	2.7 cm
KOD-3-76	Fem.	7 mos.	16.4 kg	6.4 kg	92.0 cm	1.6 cm
KOD-4-76	Fem.	7 mos.	21.8 kg	8.6 kg	97.0 cm	2.5 cm
PWS-120-75	Fem.	1 year	27.3 kg	11.4 kg	115.5 cm	2.3 cm
PWS-110-75	Fem.	3 years	43.2 kg	18.2 kg	125.2 cm	3.0 cm
PWS-108-75	Fem.	4 years	46.4 kg	18.2 kg	126.5 cm	2.8 cm
PWS-109-75	Fem.	4 years	55.0 kg	20.5 kg	140.0 cm	2.7 cm
PWS-112-75	Fem.	5 years	54.1 kg	23.5 kg	141.0 cm	3.0 cm
PWS-122-75	Fem.	6 years	64.6 kg	–	144.5 cm	2.2 cm
PWS-125-75	Fem.	9 years	66.4 kg	27.3 kg	148.5 cm	2.1 cm
PWS-115-75	Fem.	10 years	70.5 kg	25.9 kg	147.0 cm	3.2 cm
PWS-117-75	Fem.	10+ years	72.7 kg	30.5 kg	143.0 cm	3.1 cm
PWS-132-75	Fem.	10+ years	54.6 kg	18.6 kg	140.5 cm	2.5 cm

Table 5. Harbor seal observations made during sea otter and sea lion surveys and collecting activities.

Date	Location	Number of Seals
5 Oct. 75	Cape Fairfield	55
5 Oct. 75	Day Harbor	29
4 Oct. 75	Aialik Bay	191
4 Oct. 75	Surok Pt.	25
3 Oct. 75	Nuka Bay	20
3 Oct. 75	East Chugach Island	18
3 Oct. 75	Elizabeth Island	35
2 Oct. 75	Sadie Cover - Tutka Bay	23
2 Oct. 75	Halibut Cove - China Poot Bay	15
6 Oct. 75	Marmot Island - east side	14
6 Oct. 75	Sea Lion Rocks	34
6 Oct. 75	Seal Bay	30
11 Feb. 76	Zachar Bay	18

Figure 1. Locations of harbor seal concentrations along the Kenai coast.





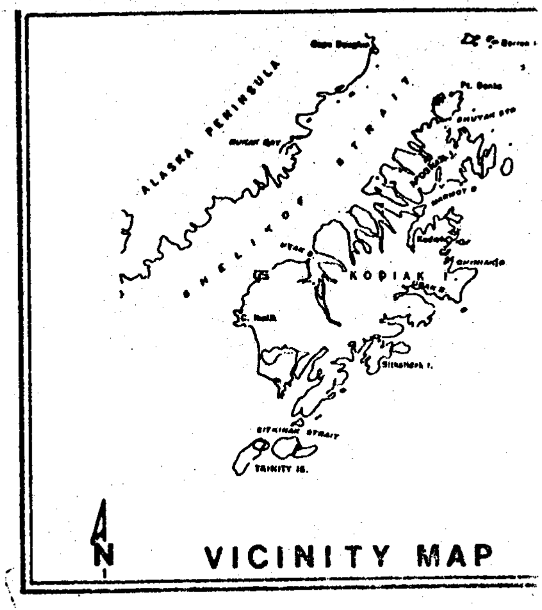
LEGEND

50 — 50 Fathom Curve

Harbor seal concentration

N

Figure 2. Locations of harbor seal concentrations in the Kodiak-Afognak area.



LEGEND

50 Fathom Curve

- Harbor seal concentration

N

SCALE - 1: 1,338,270

KODIAK ARCHIPELAGO

These data compare closely with those from a recent study conducted in Prince William Sound (Pitcher 1975). In that study gadids were dominant at 45 percent, primarily *Theragra* which composed 36 percent of the total. *Clupea* was the second most important item in Prince William Sound making up 19 percent of the observations. Other significant items included: cephalopods - 115, *Gadus* - 6 percent, *Microgadus* - 5 percent and *Mallotus* - 5 percent. On the Copper River Delta, *Thaleicthys* was the dominant food item found in 82 percent of the seals containing food.

The only other significant food habit study in Alaska was conducted in Southeastern (Imler and Sarber 1947). Gadids composed 23 percent of the total with *Theragra* the principal species. *Clupea* composed 16 percent and pleuronectids 11 percent. Shrimp were reported to make up 17 percent of the seals' food while octopus composed 3 percent.

While the female reproductive sample is small, it supports recent findings in Prince William Sound (Pitcher 1975). In that study, 20 percent of the females were pregnant at 3 years, 64 percent at 4 years, 80 percent at 5 years and 100 percent at 6 years and older. It was found that about 33 percent of the females ovulated for the first time at 3 years, 54 percent at 4 years and 22 percent at 5 years. Failure to conceive or intra uterine mortality was found in five maturing females from 3-5 years of age.

Data collected to date in this project plus information from a recent study in Prince William Sound indicate that female harbor seals are becoming sexually mature from 3-5 years of age. Reproductive failure frequently occurs in newly maturing females. Pregnancy rates of animals 6 years old and older are high, with all animals collected to date being pregnant or having evidence of producing a pup.

The male reproductive material analyzed to date was taken during late October and early November when the animals appeared to be sexually inactive. However, when these data are combined with our Prince William Sound material, certain patterns emerge. Sexual maturity occurs as early as 3 years with nearly all males reaching maturity by 7 years. Mature males are potent from about April to September.

VIII. Conclusions

Less than half of the collecting activities were completed so any conclusions are tentative and subject to change after completion of the project.

Gadids (65%), primarily *Theragra* (46%), were the dominant food items. Cephalopods made up 14 percent of the total while pleuronectids made up 9 percent. The results of a recent study in Prince William Sound are similar except that *Clupea* composed 19 percent of the total.

Female harbor seals are becoming sexually mature from 3-5 years of age. By age six, virtually all seals are mature and producing pups annually. Reproductive failure is common in maturing females.

Male harbor seals are becoming sexually mature between 3 and 7 years. Mature animals are potent from approximately April to September.

Insufficient data are available to develop growth curves and seasonal condition patterns.

A number of harbor seal concentrations were located and eventually will add to our understanding of seasonal distribution.

IX. Needs for future study.

1. All aspects of the present study including: population productivity, trophic relationships, growth, development and seasonal condition should continue until a sufficient sample from different localities and different seasons is collected. In the Gulf of Alaska, at the present level of effort, three years should be considered a minimum.

2. In light of recent announcements concerning the location of planned lease sales, investigations into harbor seal density, seasonal distribution and areas of critical habitat should be conducted from Cape St. Elias to Cape Fairweather.

3. The feasibility of radio-tracking harbor seals should be investigated. The successful employment of this technique would provide important data on movements, seasonal distribution, feeding areas, habitat utilization and behavior.

4. Tugidak Island, south of Kodiak, has the largest known concentration of land breeding harbor seals. This concentration probably at times exceeds 10,000 animals. This is an important area of critical habitat and information should be collected on seasonal use, population identity and levels of natural mortality, particularly of juveniles.

5. Research should be directed at the life histories of important harbor seal prey species, i.e., Theragra and Clupea. The effects of oil exposure on various stages of their development should be explored.

X. Summary of fourth quarter activities.

A. Ship and laboratory activities

1. Ship schedule

a. 28 Oct.-4 Nov. 1975 - M.V. "Montague" (ADF&G) - Prince William Sound.

b. 3-13 Feb. 1976 - M.V. "Resolution" (ADF&G) - Kodiak, Afognak, Shuyak.

c 16-23 March 1976 - M.V. "Big Valley" (charter) - Kenai Coast.

2 Scientific party

a. Karl Schneider ADF&G PI #243
b. Don Calkins - ADF&G - PI #243
c. Kenneth Pitcher - ADF&G - PI #229, Co. PI #243
d. Various employees - ADF&G - Field and laboratory assistants.

3 Methods - see Section IV Annual Report.

4 Sample localities

a. Prince William Sound
b. Kenai Peninsula - outside coast
c. Northern Kodiak, Afognak, Shuyak

5 Data collected and analyzed

a. During the Oct.-Nov. 1975 field trip 25 harbor seals were collected in the southwestern portion of Prince William Sound. The Feb. 1976 cruise in the Kodiak area produced four additional animals.
b. Stomach and intestinal contents from the 25 Prince William Sound seals were analyzed for food habit information.
c. Reproductive analyses for the 12 female seals collected during this period were completed.
d. Reproductive analyses for 15 of the 17 male seals were completed during this period.

LITERATURE CITED

Bishop, R.H. 1967. Reproduction, age determination and behavior of the harbor seal, Phoca vitulina L., in the Gulf of Alaska. Msc. Thesis. Univ. Alaska, College, Alaska. 121 pp.

Calkins, D., K. Pitcher and K. Schneider. 1975. Distribution and abundance of marine mammals in the Gulf of Alaska. Unpubl. report prepared by ADF&G, under contract with U.S. Dept. Comm. NOAA. 39 pp.

Fitch, J. and R. Brownell. 1968. Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. J. Fish Res. Bd. Canada. 25(12).

Imler, R. and H. Sarber. 1947. Harbor seals and sea lions in Alaska. U.S. Dept. of Interior. Fish and Wildl. Serv. Special Scientific Report.

Johnson, A. and C. Lucier. 1975. Hematoxylin hot bath staining technique for aging by counts of tooth cementum annuli. Alaska Dept. of Fish and Game. Unpubl. report. 29 pp.

Pitcher, K. 1975. Distribution and abundance of sea otters, sea lions and harbor seals in Prince William Sound. Alaska Dept. of Fish and Game.

____________. In prep. Biology of the harbor seal in Prince William Sound and Copper River Delta area of Alaska. Report to the Marine Mammal Commission. Contract Number - MMC-41.

____________ and J. Vania. Distribution and abundance of sea otters, sea lions and harbor seals in Prince William Sound, Alaska, summer 1973, a preliminary report. Alaska Dept. Fish and Game. Anchorage, Alaska. mimeo.

Scheffer, V. 1967. Standard measurements of seals. J. Mammalogy. 48(3).

Spalding, D.J. 1964. Comparative feeding habits of the fur seal, sea lion and harbor seal. Fish. Res. Board. Canada, Bull 146. 52pp.

Annual Report

Contract #03-5-022-53
Research Unit #230
Reporting Period - August 1975 - April 1976
Number of pages 31

The natural history and ecology of the bearded seal (*Erignathus barbatus*) and the ringed seal (*Phoca* (*Pusa*) *hispida*)

Principal Investigators:

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Assisted by: Bonnie Friedman, Carol Nielsen, Carl Grauvogel, Edward Muktoyuk, Harry Reynolds and Glenn Seaman.

1 March 1976

I. Summary of Objectives, Conclusions and Implications with Respect to OCS Oil and Gas Development

In view of scheduled field work involving committments of ship and aircraft time, this report is based on work accomplished through February 1976. Unfortunately, this conflict has directly affected the completeness of various analyses and reflects a lesser data base than has actually been acquired.

Ringed seals, Phoca hispida and bearded seals, Erignathus barbatus are major components of the marine mammal fauna of the Bering, Chukchi and Beaufort Seas. They have been chosen as target species for investigation based upon criteria including their significance in the ecosystem, importance to people residing along the coast and considerations of timeliness, feasibility and applicability to OCS requirements. This does not overlook the significance of other marine mammal species of the region, some of which are the subjects of other investigations (i.e. walrus, spotted seals, bowhead whales), and some which suggest a lower probability of successful achievement of important task objectives (i.e. ribbon seals or grey whales). All of the marine mammal species of the area will be included in certain kinds of analyses such as that of distribution.

The broad objectives of this project are to obtain baseline information about the natural history and ecology of ringed and bearded seals. These species occupy vastly different ecological niches within the ice dominated marine systems in question.

The ringed seal is a small, widely distributed and very abundant species which mainly occurs in areas of extensive, relatively thick and stable sea ice. It is the only species within our study area that occupies the land fast ice. It is the species taken in largest numbers by Eskimo seal hunters. Ringed seals feed mainly on zooplankton, the smaller shrimp and demersal fishes.

In marked contrast, bearded seals are the largest of our nothern seals. They are also widely distributed, but occur in the drifing ice. They feed almost exclusively on benthic organisms. Annual harvests of bearded seals are much lower than those of ringed seals. However, due to the great difference in size, the amount of usable protein obtained is almost the same. Bearded seals are preferred by coastal residents.

Our intent in selecting these species for investigation was to examine simultaneously the biology of two species which are of significant importance to man, and which depend on vastly different habitats within the marine ecosystem.

The implications with respect to oil and gas development are basically that we will be able to recognize how, when, where and why certain activities may have proximal or ultimate effects on these two important species. As examples, how does seismic exploration in areas of land fast ice affect ringed seals which breed there? What food organisms are these seals utilizing? Are there differences in the susceptibility of prey species to oil pollution--or, which of the seals is most susceptible to significant indirect effects of oil development? How much disturbance will the seals tolerate? Will they avoid areas of intensive human activity? Are there critical migration routes, etc. Answers to almost all of the questions concerning the potential effects of oil and gas development on these seals depend on an understanding of their natural history and ecology.

II. Introduction

Bearded and ringed seals constitute two of the five pinniped species associated with the ice dominated habitat of the Bering, Chukchi and Beaufort Seas. By virtue of numbers and distribution they are of great significance to coastal residents of northern Alaska and Siberia; providing reliable sources of food and usable byproducts. Their importance as significant, functioning elements of the marine environment is not adequately known. Both species occur throughout the seasonally ice covered regions. However, differences in habitat requirements (including food habits) result in an ecological partitioning of the marine system in question. Proposed OCS lease areas in the Bering and Beaufort Seas fall directly within the habitat of these two species.

The primary emphasis of our ecological studies responds to OCSEAP tasks A-1, A-2 and A-3. Information required for accomplishment of objectives A-6 and A-31 is being obtained. Our study (as well as many others) are required in order to eventually achieve objective E-1.

Information required to meet the task objectives include, but are not limited to, such things as natality, mortality, population size, population structure, trophic relationships, detailed understanding of factors determining density, distribution, seasonal movements, critical habitat requirements, relationship to ice habitats, behavior and other biological processes. Historical events indicate that marine mammals, as intelligent, irritable (in the physiological sense) and ecologically specialized organisms have almost always been adversely affected by the activities of man. The proposed exploitation of outer continental shelf resources poses the real threat of habitat alteration. Adverse impacts can be lessened if there is an adequate understanding of the ecosystem and its component parts and types of pertubation that can be anticipated.

Our study of bearded and ringed seals is one of moderate duration which will require about five years to complete. The specific task objectives are:

V. Sources and Methods

A. Schedule

Dates	Location	Activity
April to June 1975	Bering Sea and Bering Straits	Collection of specimens from native hunters - ADF&G funded.
June 1975	Barrow	Aerial survey of ringed seal - ADF&G and OCS funded.
August 1975-January 1976	Fairbanks	Office and laboratory analyses of data.
January 1976	Nome	Collection of specimens and field natural history observations.
February 1976	Fairbanks	Office and laboratory analyses of data.
February 1976	St. Lawrence Island	Collection of specimens and field natural history observations.
March 1976	Cape Lisburne and *Surveyor* Cruise	Collection of specimens and field natural history observations.

B. Methods

This project is dependent upon a sampling program which is to continue, intermittently, throughout the year. It involves acquisition of biological specimens for laboratory analysis and field observation of undisturbed seals. In anticipation of project approval a major sampling program was conducted at Eskimo hunting sites in the Yukon-Kuskokwim region, St. Lawrence Island and Bering Strait (funded by Alaska Department of Fish and Game). Methods of analysis during this first project year are as follows:

1. Existing literature and unpublished data are being reviewed and summarized in the traditional manner including abstracting pertinent papers and reports, and analyzing data already in hand (dating back to at least 1962). An OASIS search was conducted in an attempt to obtain additional references.

2. Acquisition of large amounts of specimen material required for an understanding of the natural history and ecology of these two species is continuing at major hunting

1. Summarization and evaluation of existing literature and available unpublished data on reproduction, distribution, abundance, food habits and human dependence on bearded and ringed seals in the target areas.

2. Acquisition of large amounts of specimen material required for an understanding of food habits in these two species.

3. Acquisition of additional data on productivity and fetal growth rate.

4. Acquisition of baseline data on mortality and morbidity (including parasitology, diseases, predation and human harvest) of ringed and bearded seals.

5. Determination of population structure of bearded and ringed seals as indicated by composition of harvest taken by Eskimo subsistence hunters.

6. Initial assessment of regional differences in density and distribution of ringed and bearded seals in relation to geographic areas and, to a lesser extent, in relation to major habitat conditions.

7. Acquisition of additional information on seasonal migrations.

III. Current State of Knowledge

A considerable amount of general background information concerning bearded and ringed seals is presently available and is being summarized under our task objective 1. Almost all of this information relates to general understanding of aspects such as reproduction, age and growth, gross physical characteristics, general seasonal movements, general distribution and food habits. However, the knowledge presently available remains inadequate for purposes of understanding the dynamic processes of these two species, their impact on and role in the northern marine environment and the probable effects of disturbance both to the species themselves and the environment on which they depend.

IV. Study Area

Beaufort, Chukchi (including Kotzebue Sound) and Bering (including Norton Sound) Seas.

villages. We have emphasized the collection of jaws and claws (for age determination), reproductive tracts, and stomachs. When possible weights and all standard measurements are taken (Table 1). In addition, selective collection by the PI's is utilized to collect animals under specific environmental, temporal or behavioral conditions. Selective collection provides additional data that cannot be obtained from the animals taken at the Eskimo hunting sites (Table 2).

3. The preliminary analysis of food habits of bearded and ringed seals will involve volumetric measurement of total stomach contents, separation and identification of major food items, and determination of frequency of occurrence and volume of prey species (Project RU# 232).

4. The sex of a specimen is determined by examination of the external genitalia or reproductive organs in those cases where the intact animal is not presented.

5. Examination of the claws provides a rapid and accurate means of age determination for seals up to six years of age, as growth rings or ridges are formed on the claw annually. After six years the claws are usually worn so that the initial ring ("constriction of birth") and subsequent rings are worn off.

   The ages of all seals are initially estimated by claw examination. A canine tooth is sectioned for each seal over six years old and the age is determined by enumerating the dentine or cementum annuli (Smith 1973 and Benjaminsen 1973).

6. Fetal, pup and adult growth rates are being based on weight and length measurements correlated with specimen age and date of collection.

7. Species productivity is being determined through laboratory examination of reproductive tracts and correlation of these data with the age of each specimen.

   Testes are weighed to the nearest 0.1g with and without epididymides. Length and width at the middle of the testes are measured to the nearest mm. Testes volume is determined by water displacement. Bacula are cleaned by boiling, air dried and then measured (nearest mm) and weighed (nearest 0.1g).

   The presence of sperm in the epididymides is used to ascertain breeding condition. The epididymides are sliced and a drop of fluid is squeezed onto a slide and examined under 78X or 300X magnification. Sperm presence or absence in the epididymal fluid is quantified as: none found, trace or abundant.

Table 1. Field data collected from seal specimens.

Species

Sex

Date of collection

Location of collection

Gross weight

Curvilinear (zoological) length - measured over curvature of body from tip of nose to end of tail, with head and neck in a natural position.

Standard Length - measured along a straight line on a flat surface, from tip of nose to end of tail, with head and neck in a natural position.

Axillary girth - taken around the body immediately behind foreflippers.

Maximum girth - the largest circumference around the abdomen.

Front flipper length - the distance along the anterior border of the forelimb, from axilla to tip of longest digit (not claw).

Front flipper width - the straight line distance from the tips of the first and last digits (not claws) of the spread flipper.

Hind flipper width - the straight line distance from the tips of the first and last digit (not claws) of the spread flipper.

Naval to anus length - the distance along the curvature of the body from the center of the umbilical scar to the anterior notch of the anus in males and to the vestibule in females.

Penis to anus length - measured along the body contour from the center of the penile orifice to the anterior notch of the anus.

Tail length - measured from the externally visible base of the tail to the end of the tail flesh (not hair).

Blubber thickness - over sternum.

Specimens

- Jaw
- Claws
- Stomach
- Reproductive organs
- Tissue samples

Table 2. Additional field data collected during selective collections and as possible from seals taken by Eskimo hunters.

Time of collection
Habitat type and ice type
Behavior at time of collection
Group size and composition
Tidal stage
Water depth
Selected organ weights and/or measurements
Hide and blubber weight
Heart weight
Lung weight
Liver weight
Kidney weight
Spleen weight
Diaphragm weight
Small intestine length
Large intestine length
Tissue samples
Blubber
Blood serum
Heart
Skeletal muscle
Kidney
Liver
Diaphragm and tongue
Large intestine contents
Small intestine contents

Ovaries are weighed to the nearest 0.1g and then cut into 2mm longitudinal sections. The sections are left joined at the base to preserve their relative position. The sections are examined macroscopically for corpora lutea, corpora albicantia, follicles and ovarian masses or abnormalities. The largest diameter of corpora lutea, corpora albicantia and largest follicle are measured to the nearest mm. Drawings are made of each ovary for later reference. The presence or absence of a fetus is noted at necropsy.

8. All specimens are examined macroscopically for gross pathological conditions. We attempt to conduct a complete necropsy on each seal selectively collected. Time and conditions do not allow complete necropsies of all the specimens obtained in the various villages but we endeavor to examine, at least partially, as many as possible. The following necropsy procedure is used:

   a. The heart is opened so that all four chambers are visible, and the condition of the musculature, valves and pericardium are observed macroscopically.

   b. The pulmonary artery and aorta are opened and examined distally for about 10cm beyond their origins.

   c. The trachea is opened and examined from larynx to bifurcation.

   d. Both aspects of the lungs and their visceral pleura are observed and the organs are palpated to detect any consolidated areas. The primary and secondary bronchi are opened and examined from the tracheal bifurcation to 10-15cm beyond the hibus.

   e. The diaphragm is examined macroscopically and a small sample (about $25cm^2$) is cut out and air dried at room temperature. These dried tissues will be subjected to a digestion procedure to recover possible encysted *Trichinella spiralis* larvae.

   f. Both aspects of the liver and spleen are observed macroscopically and the organs are sliced at 2cm intervals to allow examination of the parynchyma.

   g. The kidneys are both examined macroscopically, then sliced longitudinally through the hibus in the dorso-ventral plane, and the exposed cortex and medulla are examined.

h. The gall bladder is carefully removed from its attachments to the liver together with any remaining parts of the attached bile ducts and is examined macroscopically. In most cases at least half of the bile duct is missing and in several cases the contents of the gall bladder and bile duct have leaked away.

i. The esophagus is opened from larynx to cardia, the mucosa examined and any parasites (primarily ascarids regurgitated from the stomach) are collected.

j. The stomach is tied at the cardiac and pyloric sphincters, severed near these ties, injected with 10 percent formalin and placed entire (and unopened) in a 10 percent formalin solution. Upon subsequent examination the organ is opened, and the contents removed and washed with water onto sieves. The mucosa is also washed to remove any adhering matter. The washed mucosa is then examined.

Larger parasites (primarily anasakids and diphyllobothriids) are washed in 9-mesh (openings 2.00mm) and 16-mesh (openings 1.00mm) sieves and separated from the other stomach contents by workers in conjunction with the food habits study. Water and small suspended materials which pass through the larger mesh sieves are passed through a 60-mesh (openings 0.250mm) sieve and tiny helminths are recovered.

k. The duodenum, small intestine and large intestine are opened separately, the mucosa grossly examined and their contents suspended in saline or water. A small fecal sample may be removed from the distal portion of the large intestine and preserved in 2.5 percent potassium dichromate.

l. Samples (about $125cm^3$) of heart, liver, kidney, skeletal muscle and skin and blubber are wrapped in aluminum foil, labeled and frozen. These tissue samples will be provided to other investigators for microbiological, hydrocarbon, pesticide and heavy metal analyses.

m. The teeth of ringed seal specimens are examined for wear or chipping and those conditions are quantified according to the tooth wear index of Stirling (1969) (Table 3). In addition, ringed seal skulls in museum collections are examined and tooth wear quantified to determine the frequency, severity and ontogeny of oral pathology in Alaskan ringed seals.

Table 3. Tooth wear index.

Description	Score
Tooth chipped or worn	1 point per tooth
Tooth chipped or worn to pulp cavity	2 points per tooth
Abscess in bone <5mm in diameter	2 points per abcess
Abscessed jaw in cheek teeth row	3 points per abcess

9. Tissue and serum samples are being provided to other investigators for microbiological, heavy metal, and hydrocarbon determination.

10. Aerial, ship and ground surveys are being used to determine the distribution and densities of ringed and bearded seals killed by polar bears (Ursus maritimus), wolves (Canis lupus) and Arctic fox (Alopex lagopus). These dead seals are being examined to determine cause of death, physical condition, amount consumed by predator. Specimens are collected for laboratoty analyses. In addition, the geographic location, specific habitat (breathing hole, lead, lair, etc.) and ice type are noted. Standard measurements are made on all seals.

    Teeth and claws are collected to determine the age of the prey. Reproductive tracts are examined for sex and reproductive condition following standard techniques. Blubber, selected organs and tissues, stomach and digestive tract of prey species will be examined for parasites, diseases or pathologic conditions and food habits, and will be provided to cooperators for analyses for pesticides, heavy metals and petro-chemicals.

    Several ecological and behavioral parameters will be investigated to determine factors affecting prey availability and selection and hunting success of predators. For example, polar bears tend to take seals hauled out on the ice or in lairs, therefore, these factors influence hunting success of bears. The numbers and kinds of seals seen on the ice during surveys will be related to ice conditions, weather and seal biology data to obtain environmental and natural history correlates to hauling out behavior.

VI-VII. Results and Preliminary Discussion - Ringed Seal

1. Literature Review

Approximately 250 literature citations concerning ringed seals have been recovered thus far from our searches and those of OASIS and about 100 of these citations have been reviewed and summarized. OASIS searches were not as effective in finding new references as were our own because the OASIS searches did not extend back past 1972 for Biological Abstracts and 1964 for Oceanic Abstracts and Government Report Announcements.

Few studies of ringed seals have been conducted in Alaskan waters (Kenyon 1962; Johnson *et al*. 1966; Burns 1970; Burns and Harbo 1972). Most of the information presently available on Alaskan ringed seals is in the form of unpublished observations and extrapolations or hypotheses based on research conducted in Canada. Quantitative data are definitely lacking in the ringed seal literature. A summary of the literature is presented in the following paragraphs and a partial bibliography is presented in the References section of this report.

A. Distribution and Migration

Ringed seals have a circumpolar distribution in Arctic and Subarctic seas, and they are the most abundant seal found in the Arctic. Polar bears, arctic foxes and ringed seals are the only mammals that have been recorded north of 85°N latitude.

In Alaska, ringed seals inhabit the shorefast and moving pack ice of the northern Bering, Chukchi and Beaufort Seas. Stragglers have been collected at Unalaska Island in the Aleutian Islands (John Burns unpublished data) and on the Pribilof Islands.

The general distribution of ringed seals is limited by the distribution and quality of sea ice; however, some ringed seals are seen during ice-free periods in the Bering and Chukchi Seas. Seals appear at various coastal locations with the formation of shorefast ice in the Fall and then disappear in the Spring with the ice breakup. Seals which winter in the Bering Sea may appear to move farther and are more widely distributed than adult ringed seals. The density of ringed seals varies greatly with the area and the season, but chiefly depends on the stability of shorefast ice for reproduction.

In addition to man, predators of ringed seals include polar bears (the chief predator), Arctic and red foxes (*Vulpes vulpes*), dogs, wolves and ravens (*Corvus corax*).

11. Population structure of ringed and bearded seals is being assessed through sex and age determination of samples obtained at coastal hunting sites and in the course of shipboard work. Eskimo collectors have been established in various villages, with hopes of obtaining jaws and claws and other specimen material from seals killed by the villagers. The collector also maintains a log of dates, species and sex of kills.

12. Regional differences in seal density and distribution are being assessed through aerial and shipboard surveys. Aerial survey techniques that are being used are discussed in detail by Burns and Harbo (1972). Shipboard survey techniques are being developed by us.

    The first aerial survey was conducted in June 1975 from Barrow and was jointly funded by Alaska Department of Fish and Game and OCSEAP. An aerial survey of Norton and Kotzebue Sounds and adjacent areas will be conducted in June 1976 and one or two flights will be flown over the ice near Barrow to recheck seal densities. The Barrow flights will be in June, concurrent with the Norton and Kotzebue Sound survey.

    A shipboard survey will be conducted at the ice edge in the Bering Sea from 13 March to 25 April 1976 aboard the Surveyor.

13. Seasonal migration patterns are being determined through observations at coastal hunting sites, and from shipboard and aerial surveys.

14. Natural history and behavioral observations are obtained from several sources: (1) field observations by the principal investigators, (2) unpublished field observations of other reliable investigators, (3) reports from Eskimos, and (4) observation of captive animals.

    The bulk of the natural history and behavioral observations are recorded by the principal or other investigators while they are on the sea ice, or aboard ships, skin boats or aircraft. These observations are usually made with the aid of field glasses or spotting scopes and are recorded as field notes with appropriate ecological and behavioral conditions.

    Because of the amount of time they spend on the ice pursuing marine mammals, Eskimo hunters can provide a wealth of information concerning behavior and natural history. However, this information is accepted with caution. Interview of several hunters may be required to separate facts from legends, or information given just to please the investigators. Rarely has information been given which is intended to mislead the investigators.

B. <u>General Characteristics</u>

Ringed seals are the smallest of all pinnipeds (seals, sea lions and walruses) with adults in Alaska rarely exceeding 155cm in standard length. There is little difference in size between males and females. Adult ringed seals seldom exceed 90kg in Alaskan waters, however, the weight of the individual varies with the season. Heaviest weights are achieved in the winter and early spring when the seal has a thick layer of fat or blubber under the skin. The blubber provides insulation and is an energy source during the breeding and pupping seasons. The weights of ringed seals appear to decline with the decrease in feeding during the reproductive and molting season.

The color of ringed seals is quite variable, but the basic pattern is a gray back with black spots and a light belly. The black spots on the back are ringed with light marks from which comes the seal's name.

C. <u>Etymology</u>

The generic name <u>Pusa</u> is derived from the name used for seals by the people of Greenland. The specific name <u>hispida</u> is Latin for rough or bristly and appears to refer to the adult pelage (King 1964).

The Inupiat Eskimos refer to the ringed seal as "natchek" and to the Yupik-speaking Eskimos of the Bering Straits it is "niksik".

D. <u>Food Habits</u>

Ringed seals eat a variety of invertebrates and fish. The species eaten appears to depend on availability, depth of water and distance from shore. The important food species are Arctic cod, sculpins and crustaceans (particularly shrimp, mysids, amphipods and euphausiids).

E. <u>Biology</u>

<u>Biology</u>: Females give birth to a single, white coated pup in ice dens (lairs) on both land-fast and drifting pack ice during March and April. The female seals build the lairs on ice pressure ridges or under snow in refrozen leads for protection from predators and severe weather. Lairs are about 10 feet (305cm) long with an entrance from the water located at one end.

There is some evidence that females lacking maternal experience give birth in marginal habitat--drifing pack ice--and may be more subject to polar bear predation. The more experienced females give birth in better habitat, land-fast ice, and may have higher reproductive success.

At birth the average weight of pups is 10 pounds (4.5kg) and the average length is about 24 inches (61 cm). Females nurse pups for about 2 months during which the pup doubles its birth weight, to about 20 pounds (9.0 kg). This gain is due to an increase in blubber thickness which provides the pup insulation to reduce heat loss to the cold water, air and ice, and provides an energy reserve. Weaning usually takes place at ice breakup.

Most females breed again within a month after the birth of the pup. Implantation of the new fetus is delayed 3-1/2 months and occurs in mid-July or early August. Pregnancy lasts about 11 months. The incidence of pregnancy in adult females is about 85 to 90 percent, and a fetal sex ratio of 1:1 has been found in Alaskan specimens. Female ringed seals first ovulate at five or six years of age but successful conception does not appear to take place until the female is seven years old. Males become sexually mature at seven or eight years of age.

Ringed seals have been reported to live to an age of 36 to 40 years in the wild, however, very few animals exceed 10 to 15 years of age.

F. Vocalizations

Until recently the ringed seal has been considered a silent species unlike many of its relatives which produce very melodious and complex "songs." Recent studies have found that ringed seals do emit several types of vocalization underwater and that these vocalizations are not readily audible above water or ice. Although these vocalizations are "heard" all year, if one uses a hydrophone (underwater microphone), the number of vocalizations increases during the breeding season. This may mean that the vocalizations are used to maintain social organization or to defend territories.

G. Behavior

The behavior of ringed seals is poorly understood since both males and females spent the greater part of the year in lairs or in the water. From May and June until ice breakup, ringed seals "haul out" on the shorefast ice on sunny and warm days and undergo a molt (shedding and regrowth of the hairs). Apparently the warmth and rest are required for rapid regrowth of the hairs.

H. Hunting

Ringed seals are hunted by Alaskan coastal residents from Mekoryuk to Kaktovik for human and dog food and skin for clothing, equipment and crafts. The annual harvest for subsistence purposes has ranged from 20,000 in 1964 to 5,000 in 1973, which was the first year after the passage of the Marine Mammal Protection Act.

I. Parasites

Twenty-six parasites have been reported from ringed seals throughout its range (Table 3). However, ringed seal parasites and their associated pathologies have not been intensely investigated in Alaskan waters.

Table 3. Parasites reported from the ringed seal.

Trematoda
- Orthosplanchnus arcticus Odhner, 1905
- Phocitrema fusiforme Goto and Ozaki, 1930
- Pseudamphistomum truncatum (Rud., 1819) Luhe, 1908
- Anophryocephalus anophrys Baylis, 1922
- Trigonocotyle skrjabini Krotov et Delymure, 1955

Cestoda
- Diphyllobothrium fasciatus Krabbe, 1865
- Diphyllobothrium hians Diesing, 1850
- Diphyllobothrium latum (L., 1758) Luhe, 1910
- Diphyllobothrium lanceolatum Krabbe, 1865
- Diphyllobothrium tetrapterus Siebold, 1848
- Pyramicocephalus phocarum (Fabricius, 1780) Monticelli, 1890
- Schistocephalus solidus Muller, 1776

Nematoda
- Contracaecum sp.
- Contracaecum osculatum (Rud, 1802) Baylis, 1920
- Terranova decipiens (Krabbe, 1878) Baylis, 1916
- Phocascaris netsiki Lyster, 1940
- Otostrongylus circumlitus (Railliet, 1899) Bruyn, 1933
- Dipetalonema spirocauda (Leidy, 1858) Anderson, 1959
- Trichinella spiralis (Owen, 1835) Railliet, 1895

Acanthocephala
- Bolbosoma nipponicum Yamaguti, 1939
- Corynosoma sp.
- Corynosoma reductum Linstow, 1905
- Corynosoma semerme (Forsell, 1904) Luhe, 1911
- Corynosoma strumosum (Rud., 1802) Luhe, 1904
- Corynosoma wegeneri Heinze, 1934

Anoplura
- Echinophthirius horridus (Olfers, 1816) Fahrenholz, 1919

2. Specimens

During the 1975 hunting season 520 ringed seals were collected from seven villages (Table 4). Measurements, jaws, claws, stomachs or reproductive tracts were obtained from most specimens. Partial data are available from about 600 additional specimens collected from 1962 to 1974. In 1976, 31 specimens have been collected from 2 villages so far. All of these specimens are being processed as rapidly as possible.

Table 4. Ringed seal specimens collected by Eskimo hunters, 1975.

Location	Male	Female	Unknown	Total
Mekoryuk	9	19		28
Nome	11	6		17
Gambell	1		1	2
Savoonga	209	133		342
Diomede	35	29		64
Shishmaref	17	8		25
Wainwright	17	15		32
Barrow	8	1	1	10
Total	307	211	2	520

3. Food Habits

See Annual Report of "Trophic relationships among ice inhabiting phocid seals" (RU# 232).

4. Productivity and Growth Rates

A knowledge of the factors affecting the productivity of the ringed seal is needed to assess, and, hopefully, lessen possible adverse impacts of outer continental shelf development. Productivity of a species is determined ultimately by fecundity (number of viable ova produced, which is influenced by an array of synergestic parameters) and mortality. On a proximal level we are interested in the various factors which affect: 1) fertility, the number of pups produced; 2) pup survival to breeding age; and 3) mortality and morbidity of the breeding segment of the population.

A. <u>Fetal Growth Rates</u>

The embryonic and fetal development of the ringed seals is one of the parameters that influences fertility. Embryological development is usually considered as a continuous process of growth and differentiation from the formation of the zygote to parturition. Growth and differentiation appear continuous, albeit slow during the 3-1/2 month delay before implantation, but the factors that affect the rate of growth and differentiation are unknown.

Female ringed seals appear to be impregnated in mid-April soon after the birth of the pup. Impregnation is followed by a delay of up to 3-1/2 months before implantation, approximately in August. Additional seal specimens are required from August and September to demonstrate the precise period of implantation and to determine early fetal growth rates.

Thus far, 44 ringed seal fetuses have been examined and measured. A 1:1 fetal sex ratios (22 males and 22 females) has been found. The fetal growth curve for length (Fig. 1) closely resembles those from ringed seals in Canada (McLaren 1958). The growth curve for weight is similar to those for most mammals (Fig. 2). The relative growth of length and weight is more rapid in mid-pregnancy with relative growth rates leveling off in late pregnancy (Fig. 3). No differences in growth rates of males and females were detected, however the sample size was small.

B. <u>Pup Growth Rates</u>

Weights of 44 ringed seal pups (23 male and 20 female and 1 sex unknown) have been obtained thus far (Fig. 4). Ringed seal pups weigh about 4kg at birth. A live pup, two or three days old weighed 5kg while the mean weight of eight full-term fetuses was 3.4kg.

Pup weights increase steadily from birth and appear to level out in August or September. However, our sample size of pups collected after July is very small.

The mean weights of male and female pups collected during specific periods generally do not differ. However, there is more variation in the weights of males than in the females.

Blubber thickness over the sternum increases from a trace at birth to 1.8cm in May. During June and July the blubber thickness decreases to 1.5cm and this decrease in thickness is probably associated with the loss of weight immediately after weaning in late May. By

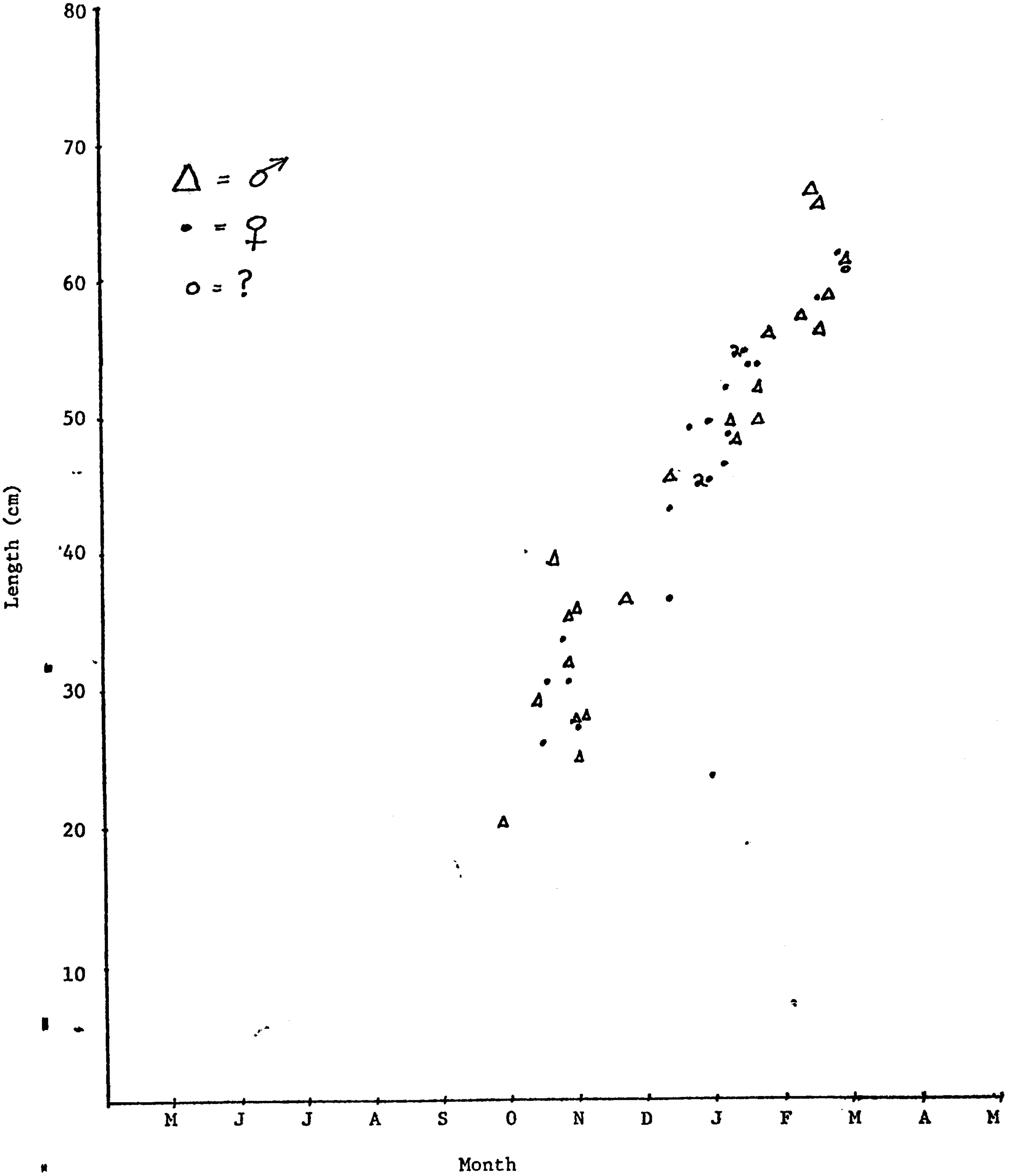

Figure 1. Fetal growth, length in relation to month of collection.

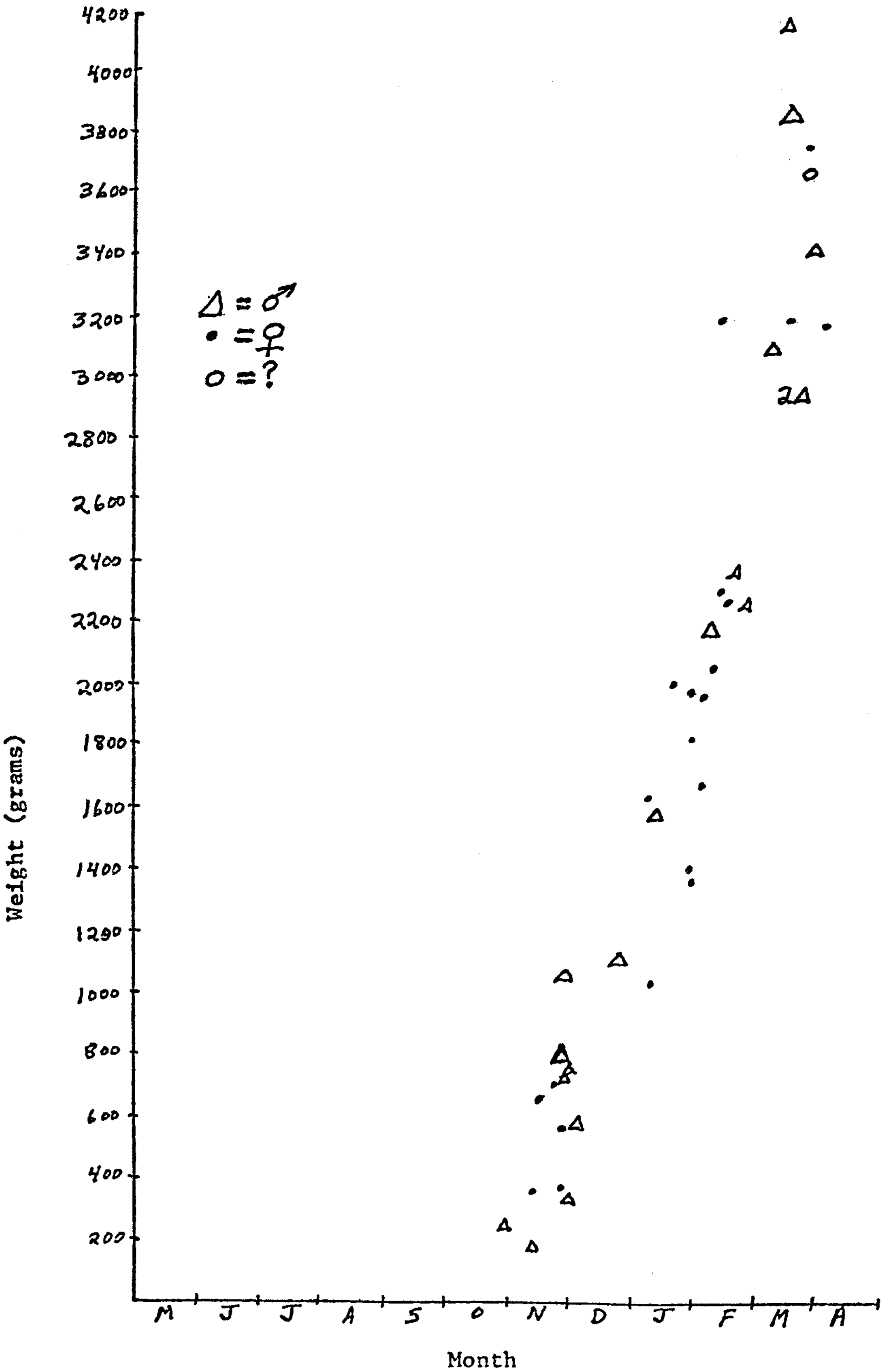

Figure 2. Fetal growth , weight in relation to month of collection.

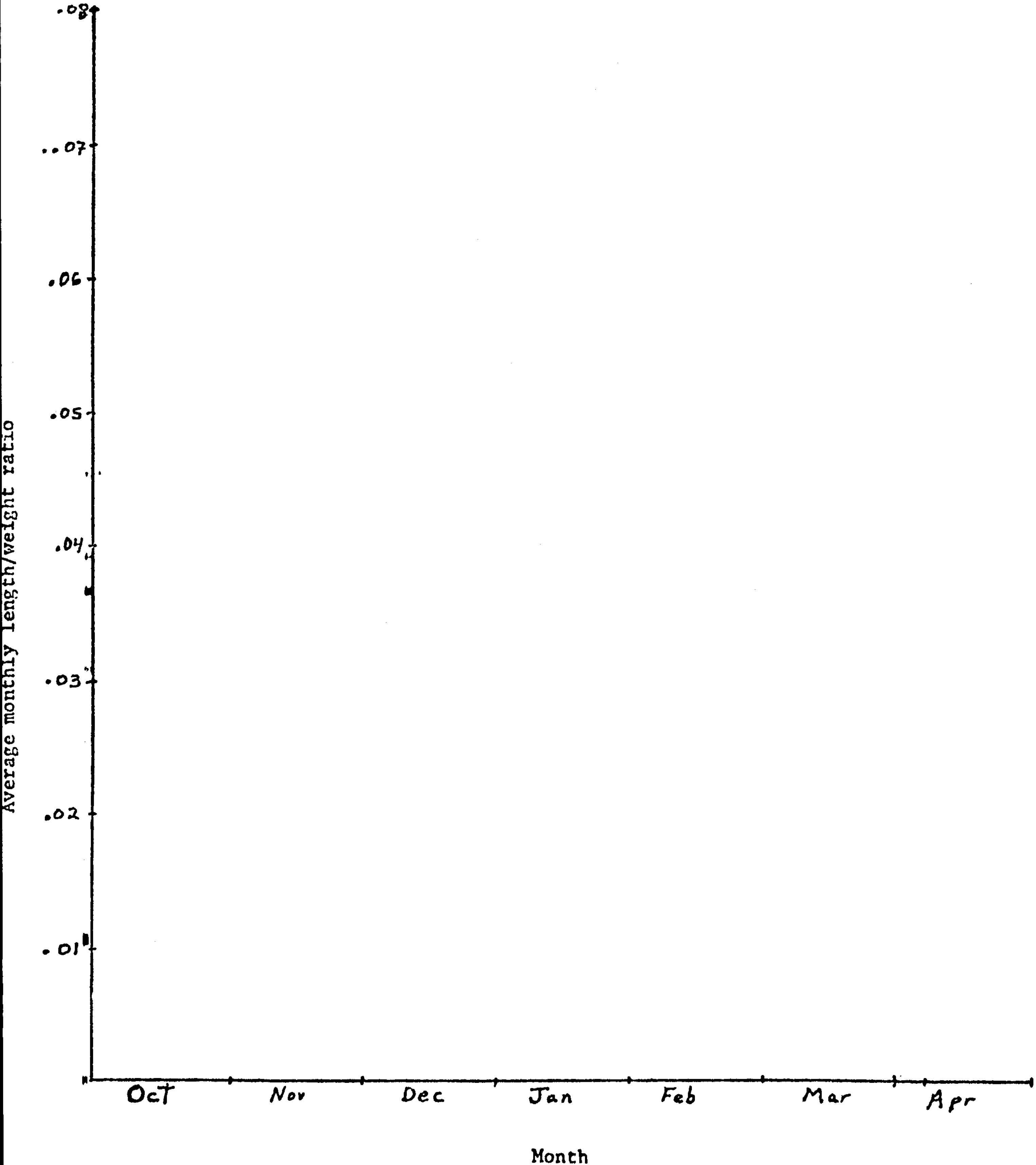

Figure 3. Fetal growth , length in relation to weight.

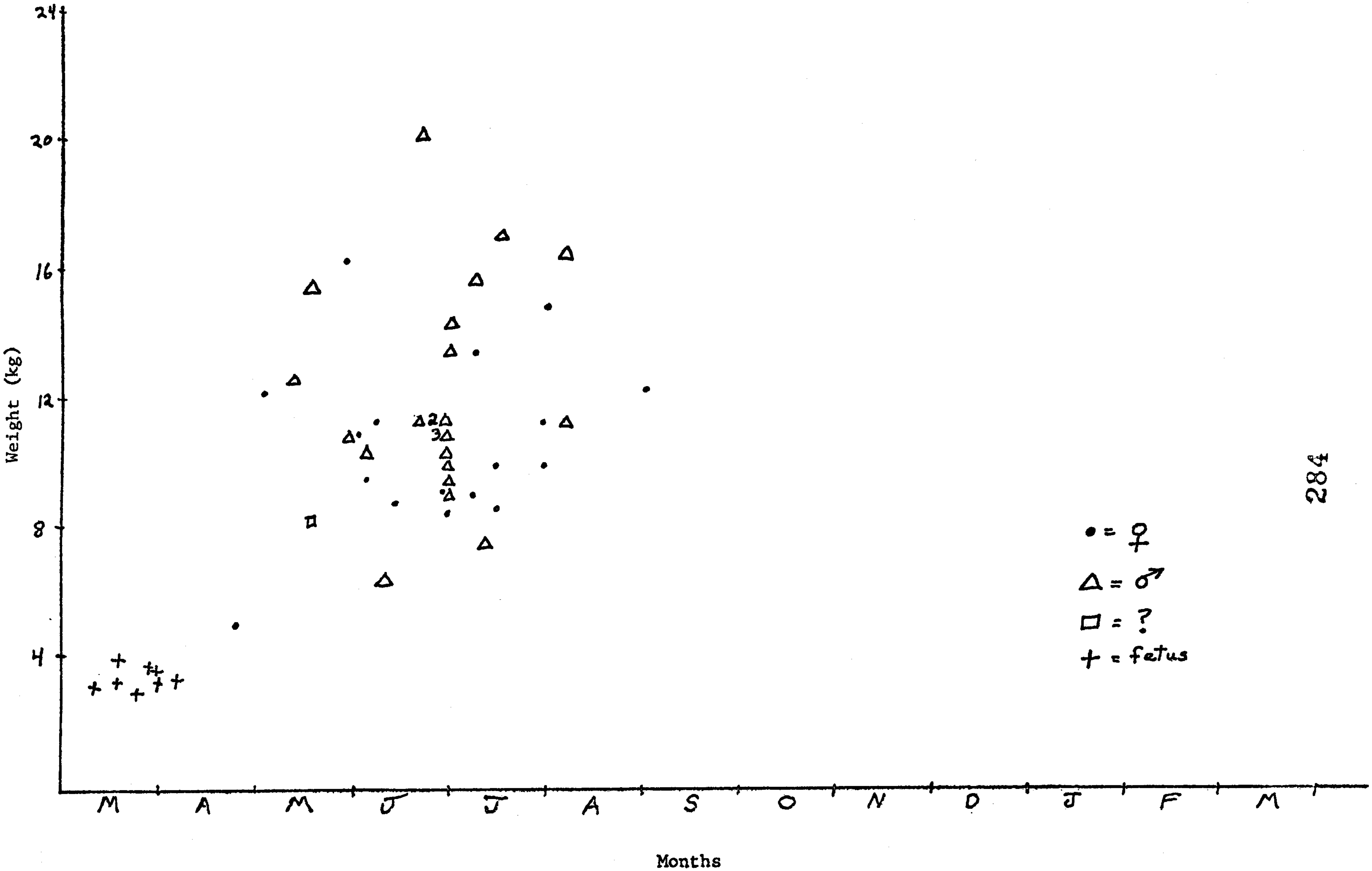

Figure 4. Pup growth, weight in relation to month of collection.

August the mean blubber thickness is about 1.8cm and then increases to 2.5cm in September and 3.1cm in February. There appears to be no difference in blubber thickness between male and female pups.

C. Reproduction

The epididymides of 94 males (representing all age classes and collected during all months) have been examined for the presence of sperm. Active spermatogenesis has been detected only in males seven years old and older and collected during March, April, May and June (Table 5). A trace of sperm was detected in a male collected in July.

Table 5. Sperm presence in the epididymides of males seven years old and older.

Month	Number Examined	Sperm Presence: Abundant (Number)	Trace (Number)	None (Number)
January	3	-	-	3
February	1	-	-	1
March	5	5	-	-
April	6	6	-	-
May	8	8	-	-
June	10	4	4	2
July	5	-	1	4
August	0	-	-	-
September	0	-	-	-
October	2	-	-	2
November	11	-	-	11
December	12	-	-	12

Analyses of the female reproductive tracts have not begun.

5.. Parasitology and Diseases - Ringed Seals

A total of 17 ringed seals were necropsied by the Principal Investigators and/or Mrs. Carol Nielsen. The specimens collected from these seals for later laboratory analyses and study are presented in Table 6. Dipetalonema spirocauda was collected from the heart of the Nome specimen, and this appears to be the first record from ringed seals in Alaskan waters (Margolis and Dailey 1972).

The stomachs of 47 additional ringed seals were examined in conjunction with food habits studies. These stomachs were from seals collected at Barrow, Wainwright, Diomede, Savoonga, Gambell and Mekoryuk during spring and summer 1975. For the 45 ringed seals, the stomachs were processed as described previously, using the 60-mesh sieve to recover tiny helminths. However, for two animals only the larger helminths were recovered (i.e. only those helminths retained in the 9-mesh sieve).

All helminths recovered from the seal stomachs were placed initially in 10 percent formalin and later removed to AFA (alcohol-formalin-acetic acid solution with glycerine). After examination and classification, nematodes and acanthocephala were removed to 70 percent ethanol with glycerine while cestodes were replaced in AFA.

Table 6. Ringed seal necropsy specimens by location and date.

Specimens	Wainwright July-Aug. 1975 n = 6	Barrow Dec. 1975 n = 9	Nome Jan. 1976 n = 1
A. Normal tissue			
Blubber and skin	-	8	1
Heart	-	8	1
Lung	1	8	1
Liver	6	8	1
Kidney	-	8	1
Striated muscle	-	8	1
Duodenum mucosa	1	-	-
B. Pathological tissue			
Diaphragm	6	8	1
Liver	4	-	-
Duodenum mucosa	1	1	-
Small intestine mucosa	1	1	1
Large intestine mucosa	2	1	1
C. Parasite specimens			
Mouth and esophagus	1	-	-
Duodenum	4	1	1
Small intestine	4	2	1
Large intestine	6	3	1
Fecal specimen from rectum	6	2	1
Heart	-	-	1

Parasitology and Diseases - Bearded Seals

A total of 44 bearded seals were examined for parasites and/or diseases. Seals were collected by Eskimo hunters from the villages of Barrow, Wainwright, Diomede, Savoonga, Gambell and Mekoryuk between April and August 1975. Complete necropsies were conducted on nine of the Wainwright seals by J. Burns and Carol Nielsen, ADF&G parasitologist. Only the stomachs of the remaining 35 animals were examined. These stomachs were available in conjunction with the food habits studies. Stomachs were processed as described in methods section 8j. However, eight stomachs were examined for larger helminths only, using a 2.0mm, 9-mesh sieve. All helminths recovered from bearded seals stomachs were preserved as described in the ringed seal section of these results.

Examination and classification of the parasites recovered, nematodes and acanthocephala, is presently underway. Parasitological work on bearded seals is being conducted by C. Nielsen.

6. Population Structure

Ringed seals comprise about 65 percent of the seal harvest by Eskimo hunters in Alaskan waters. The preponderance of ringed seals in the harvest does not necessarily reflect preference by the hunters, rather it indicates the ready availability of ringed seals. Ringed seals can be hunted during almost every month except for late summer in those years when the ice moves far north of Barrow.

The sex composition of our specimens collected under the aegis of OCS (Table 4) and other samples (Burns, unpubl. data; Eley, unpubl. data; Grauvogel, unpubl. data) are weighted towards males. Males constituted 59.3 percent of our sample. Grauvogel (unpubl. data) found that male ringed seals comprised 57.0 percent and 55.6 percent of the 1973 and 1974, respectively, ringed seal harvest in the northern Bering Sea and Bering Straits area.

The predominance of males in the harvest may indicate the true sex ratio. More likely, however, the males may be more mobile due to searching for females or defense of a territory, therefore more likely to expose themselves to a hunter. However, Mech (1973) found a predominance of males in a wolf population at a high density and a preponderence of female wolves in populations that had been heavily exploited. In future studies we will investigate the relationship of age, season and geographic location to the sex ratio.

7. Geographic Variation in Densities

See Annual Report of "The relationship of marine mammal distribution, densities and activities to sea ice" (RU #248/249).

VIII. Conclusion - Ringed Seal

Ringed seals and associated data have been gathered by the Department of Fish and Game personnel since 1962. However, this annual report covers examinations and analyses conducted between 8 September 1975 and 1 March 1976. Most of our sampling and analyses are incomplete at this time and of an on-going nature. Therefore the results and their preliminary interpretation are considered tentative and are not to be quoted without permission of the Principal Investigators.

Adult ringed seals are mainly associated with the shorefast ice of the Bering, Chukchi and Beaufort Seas. By virtue of their nearshore habits and numbers, they are important to the coastal residents as a source of food and usable products. Proposed OCS lease areas in the Bering and Beaufort Seas are within the habitat of the ringed seal and pose a real threat to this species. The objective of our studies are to develop a baseline of ecological and behavioral data in order to prevent or lessen adverse impacts of outer continental shelf development.

1. A literature review is underway and about 250 citations pertaining to ringed seals has been recovered.

2. Few citations pertain specifically to ringed seals in Alaskan waters.

3. A summary of the literature reviewed thus far is presented.

4. Over 500 specimens have been examined under the aegis of OCSEAP but not all of the desired kinds of data could be collected from each one.

5. Specimens from the fall and winter are lacking in our samples.

6. Preliminary analyses of fetal growth rates have begun but our sample is not yet large enough to investigate geographic variation in growth rates.

7. No difference in the growth of male and female fetuses was detected and the sex ratio was 1:1.

8. Preliminary analyses of pup growth rates indicates little difference in the growth rates of male and female pups. However, male pups show greater variation in weights.

9. Active spermatogenesis has been detected only in males seven years old and older and collected during March, April, May and June.

10. Parasitological examinations have begun but identifications of parasites recovered are incomplete.

11. *Dipetalonema spirocanda* was collected from the heart of a seal taken in Nome and this appears to be the first recorded from ringed seals in Alaskan waters.

12. Ringed seals comprise about 65 percent of the seal harvest by Eskimo hunters.

13. The sex composition of ringed seals in the harvest is weighted towards males.

Bearded Seals

Information and specimens were obtained from 162 bearded seals collected at hunting sites from Nunivak Island in the Bering Sea to Wainwright in the northern Chukchi Sea. Analyses of data from these seals and examination of specimens was not completed by the time this report was prepared. The results of analyses and summary of findings will be presented in the next report.

IX. Needs for Further Study - Ringed and Bearded Seals

Our first need for futher work is the examination of additional specimens, especially from the fall and winter and from the Beaufort Sea, so that we can fully address our task objectives.

Secondly we perceive the need, and plan the development, of a behavioral basis for the management of ringed and bearded seals. To accomplish this objective requires, in part, answering some specific questions.

1. What are the "normal" behavioral and activity patterns (including feeding, social organization and migration) of *Pusa* and *Erignathus* and how do these patterns change with varying environmental, temporal, seasonal and geographic conditions?

2. Under what environmental, behavioral or physiological conditions are these animals hauled out on sea ice where they may be assessed by visual or remote sensing techniques?

3. What alterations to normal behavioral and activity patterns are caused by human disturbance and what are the effects of these alterations on the population dynamics, ecology and physiology of these seals?

The acquisition of these behavioral data will allow us to more fully assess the impact of outer continental shelf development on ringed and bearded seals. Adverse impacts may be lessened if we have an understanding of the ecosystem and the suite of factors that directly effect its component parts.

X. Summary of 4th Quarter Operations - Ringed and Bearded Seals

A. Field and laboratory activities

1. Schedule

Dates	Location	Activity
January 1976	Fairbanks	Office and laboratory analyses of data and prepration of data management plans.
January 1976	Nome	Collection of specimens and field natural history observation.
February 1976	Fairbanks	Office and laboratory analyses of data.
February 1976	St. Lawrence Island	Collection of specimens and field natural history observation.
March 1976	Fairbanks	Preparation of annual report.
March 1976	Cape Lisburne and *Surveyor* cruise	Collection of specimens and field natural history observation.

2. Scientific Party

Names	Affiliation	Role
John J. Burns	ADF&G	Bearded seal natural history
Thomas J. Eley	ADF&G	Ringed seal natural history
Lloyd F. Lowry	ADF&G	Ice pinniped trophic relationships
Kathryn Frost	ADF&G	Ice pinniped trophic relationships

Carol Nielsen	ADF&G	Marine mammal parasitology and pathology
Bonnie F. Friedman	ADF&G	Natural history technician
Glenn Seaman	ADF&G	Natural history technician
Harry Reynolds	ADF&G	Area Biologist - Barrow
Carl Grauvogel	ADF&G	Area Biologist - Nome
Edward Muktoyuk	ADF&G	Marine mammal technician

3. <u>Methods</u>

See Annual Report.

4. <u>Sample Localitities</u>

Bering (including Norton Sound), Chukchi and Beaufort Seas.

5. <u>Data Collected or Analyzed</u>

It must be remembered that this report of fourth quarter activities covers only two months (January and February) of the fourth quarter and our major field activities begin in mid-March. In addition, approximately three weeks of this quarter has been taken up with OCSEAP required meetings, particularly data management, and preparation of the Annual Report.
These two activities have severely reduced the time available for completion of work required under the terms of the contract.

The bulk of our analyses consisted of laboratory, graphical or statistical examination of specimens or data collected during the spring and summer of 1975., we emphasized sex composition of the harvest, male reproductive condition, age determination, parasitological collection, pup and fetal growth and literature review. In addition, more samples were obtained from several villages.

References

Addison, R. F. and T. G. Smith. 1974. Organochlorine residue levels in Arctic ringed seals: variation with age and sex. Oikos 25:335-337.

Benjaminsen, T. 1973. Age determination and the growth and age distribution from cementum growth layers of bearded seals at Svalbard. Fisk Dir. Skr. Ser. Hav Unders. 16:159-170.

Burns, J. J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51(3):445-454.

__________. 1967. The Pacific bearded seal. Alaska Dept. Fish and Game, Juneau. 66pp.

__________ and S. J. Harbo, Jr. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25(4):279-290.

Davies, J. L. 1958. Pleistocene geography and the distribution of northern pinnipeds. Ecology 39(1):97-113.

Delyamure, S. L. 1955. Helminthofauna of marine mammals: (Ecology and phylogeny). Israel Program for Scientific Translations, Jerusalem. 552pp.

__________ and V. N. Popov. 1974. Seasonal variation in the helminth fauna of the Okhotsk ringed seal. Parazitologiya 8(2):89-92.

Doutt, K. J. 1942. A review of the genus Phoca. Annals Carnegie Mus. 29:61-125.

Dunbar, M. J. 1941. On the food of seals in the Canadian eastern Arctic. Canadian. J. Res. 19:150-155.

Fedoseev, G. A. 1965. Comparative characteristics of ringed seal populations in the Chukotskii peninsula coastal waters. Fish. Mar. Ser. Transl. No. 3428,1975.

Freuchen, P. and F. Salomonsen. 1958. The Arctic year. G. P. Putnam's Sons, New York. 438pp.

Kenyon, K. W. 1962. Notes on phocid seals at Little Diomede Island, Alaska. J. Mammal. 26(4):380-387.

__________. 1960. A ringed seal from the Pribilof Islands, Alaska. J. Mammal. 41(4):521.

Mansfield, A. W. 1967. Seals of Arctic and eastern Canada. Fish. Res. Bd. Canada Bull. 137:35pp.

__________. 1970. Population dynamics and exploitation of some Arctic seals. pp429-446 in Antarctic Ecology, Vol. 1. (M. W. Holdgate, ed.). Academic Press, London.

Margolis, L. and M. D. Daily. 1972. Revised annotated list of parasites from sea mammals caught off the west coast of North America. NOAA Tech. Rep. SSRF-647. 23pp.

McLaren, I. A. 1958. The biology of the ringed seal (Phoca hispida Schreber) in the eastern Canadian Arctic. Fish. Res. Bd. Canada Bull. 118:97pp.

__________. 1961. Methods of determinimg the numbers and availability of ringed seals in the eastern Canadian Arctic. Arctic 14(3):162-175.

__________. 1966. Analysis of an aerial census of ringed seals. J. Fish. Res. Bd. Canada 23(5):769-773.

__________. 1967. Seals and group selection. Ecology 48(1):104-110.

Mech, L. D. 1975. Disproportionate sex ratios of wolf pups. J. Wildl. Manage. 39(4):737-740.

Meyers, B. J. 1959. Lice on Phoca hispida Schreber. Can. J. Zool. 37:1123.

Milne, A. R. 1974. Use of artificial subice air pockets by wild ringed seals (Phoca hispida). Can. J. Zool. 52:1092-1093.

Rausch, R., B.B. Babero, R. V. Rausch, and E. L. Schiller. 1956. Studies on the helminth fauna of Alaska 27. The occurrence of larvae of Trichinella spiralis in Alaskan mammals. J. Parasit. 42:259-271.

Russell, R. H. 1975. The food habits of polar bears of James Bay and southwest Hudson Bay in summer and autumn. Arctic 28(3):117-129.

Smith, T. G. 1970. Computer programs used in the study of ringed seal population dynamics in the Canadian eastern Arctic. Fish. Res. Bd. Canada Tech. Rep. 224:45pp.

__________. 1973. Population dynamics of the ringed seal in the Canadian eastern Arctic. Fish. Res. Bd. Canada. Bull. 181:55pp.

__________. 1975. Ringed seals in James Bay and Hudson Bay: Population estimates and catch statistics. Arctic 28(3):170-182.

__________, B. Beck and G. A. Sleno. 1973. Capture, handling and branding of ringed seals. J. Wildl. Manage. 37(4):579-583.

__________ and I. Stirling. 1975. The breeding habitat of the ringed seal (Phoca hispida). The birth lair and associated structures. Can. J. Zool. 53(9):1297-1305.

Stirling, I. 1973. Vocalization in the ringed seal (Phoca hispida). J. Fish. Res. Bd. Canada. 30(10):1592-1594.

__________. 1969. Tooth wear as a mortality factor in the Weddell seal, Leptonychotes weddelli. J. Mammal. 50(3):559-565.

__________. 1974. Midsummer observations on the behavior of wild polar bears (Ursus maritimus). Can. J. Zool. 52(9):1191-1198.

__________ and E. H. McEwan. 1975. The caloric value of whole ringed seals (Phoca hispida) in relation to polar bear (Ursus maritimus) ecology and hunting behavior. Can. J. Zool. 53:1021-1027.

Terhune, J. M. and K. Ronald. 1975. Underwater hearing sensitivity of two ringed seals (Pusa hispida). Can. J. Zool. 53(3):227-231.

Usher, P. J. and M. Church. 1969. On the relationship of the weight, length and girth of the ringed seal (Phoca hispida) of the Canadian Arctic. Arctic 22:120-129.

Annual Report

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Number of Pages 7

An Aerial Census of Spotted Seals, *Phoca vitulina largha*

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1 March 1976

I. Summary of objectives, conclusions and implications with respect to OCS Oil and Gas Development

The major objectives of this project are to determine the distribution and density of spotted seals, *Phoca vitulina largha*, and to determine the size of the population. Field work involving both aircraft and shipboard censuses will be accomplished in April 1976. Efforts to date have been directed at coordination, program plans for ship and aircraft surveys, sampling procedures, data formats, etc.

Spotted seals, which are a major component of the Bering Sea marine mammal fauna, are mainly restricted to the ice front during late winter and spring. This distribution means that they are concentrated in three proposed lease areas: Bristol Bay, St. George Basin and Navarin Basin. A baseline assessment of distribution and total number of these seals constitutes part of the information required to evaluate the potential impact of OCS oil and gas development along the edge of the Bering Sea Continental Shelf.

II. Introduction

A. General nature and scope of study

This project involves an assessment of the size of the spotted seal population of the Bering Sea, exclusive of those which occur in the territorial waters of the U.S.S.R.

Assessment efforts, of necessity, must be based on many factors including knowledge of the natural history and behavior of the target species, its seasonal distribution, movements and ecological associations, population structure and peculiarities which may result in the acquisition of unacceptably biased results. Although this required information is not available for many pinniped species, it is for spotted seals.

Additionally, the simultaneous use of both aircraft and ship for the surveys will enable us to evaluate the accuracy of the proposed aerial survey.

References pertinent to this study are as follows:

Allen, 1880
Bee, 1956
Burns, 1970
Burns, 1971
Burns *et al.*, 1972
Bychkov, 1971
Fay, 1974
Fedoseev, 1966
Naumov and Smirnov, 1936
Scheffer, 1958
Shustov, 1965
Tikhomirov, 1961
Tikhomirov, 1964
True, 1889

B. Specific objectives

The specific objectives of this project are to:

1. Determine the geographical distribution and density of breeding adult spotted seals in eastern Bering Sea during the period of pupping and lactation, when they are most visible and concentrated.

2. Determine size of the spotted seal population in eastern Bering Sea based on survey results in conjunction with data on age structure, age at sexual maturity and incidence of pregnancy.

3. Compare the results of simultaneous surveys from ships and aircraft.

4. Obtain additional information about oceanographic and sea ice conditions which directly affect spotted seal distribution.

C. Relevance to problems of petroleum development

Spotted seals are ecologically tied to the ice front during the late winter and spring months. Therefore, a significant portion of the total population occurs in three proposed lease areas: Bristol Bay, the St. George Basin and the Navarin Basin. In addition to their physical presence, important biological events including birth, nurture of pups, mating and molting occur while spotted seals are present in the front.

A baseline assessment of total numbers, distribution, regional density and significant biological events of spotted seals is directly relevant to initial decisions concerning leasing and subsequent development of leases along the southern edge of the Bering Sea Continental Shelf.

III. Current state of knowledge

Previous and continuing investigations of spotted seals have resulted in a body of ecological and behavioral information about this species which is necessary in order to attempt meaningful assessment efforts. It is known that these seals are restricted to the ice front of the seasonal pack ice during late winter and spring. Birth of pups occurs mainly during the first half of April. Adults are monogamous and form pairs prior to birth of the pups and remain in pairs until the end of the lactation period in late April to early May. Ship expeditions in 1968, 1971 and 1972 indicate that adult pairs with pups spend a great deal of time on the ice where they are visible, and all pairs observed and closely checked invariably had a pup. From the standpoint of the presence of these seals on top of the ice, it appears that weather conditions have less influence than on seals not accompanied by pups (i.e. primarily sub-adults). Several pairs with pups may be found in the same vicinity, but they are rarely closer than 0.25 kilometer to each other.

Other studies conducted by the Alaska Department of Fish and Game and the Magadan Branch of TINRO provide information on age structure of the spotted seal population, age at sexual maturity and incidence of pregnancy. All of these parameters are important for determining the total number of spotted seals present in eastern Bering Sea.

IV. Study area

The study area includes the entire ice front extending from Bristol Bay to within 12 miles of the Siberian coast. The ice front is a distinct zone of the seasonal sea ice in Bering Sea which is continually subjected to the influence of the open ocean, its southern boundary. It is characterized by small floes mostly less than 20 meters across, separated by water or brash ice and subject to rapid dispersal or compaction by winds and ocean currents. Width of the front is variable, depending on direction and intensity of winds and currents. On the average, it is a recognizable band between 30 and 50 miles wide.

The front is a predictable, annually recurring ice habitat. Although it is always present during late winter and spring, its location varies according to the severity of winter conditions. In April the edge of the front usually coincides with the edge of the continental shelf.

V. Sources, methods and rationale of data collection

The rationale underlying this assessment effort is implicit in much of the foregoing discussion. Basically this project is both time and area specific. Surveys must be conducted during the brief period when adult spotted seals are with nursing pups, are highly visible and are restricted to a specific habitat. Aircraft and shipboard surveys must be conducted between 5 and 30 April, within the ice front.

Adult pairs with a pup are easily observed from either low flying aircraft or from ships. Extensive surveys will be conducted from a P2V aircraft at the same time that shipboard surveys are being conducted. Flights over the ship's survey tracks will be made in order to compare the results of both methods.

Survey tracks of the ship (R/V Surveyor) will be in those areas of the ice front in which the ship is capable of operation.

Aircraft surveys are statistically designed as stratified random samples. The sampling procedure will be based on consideration of sea ice conditions as determined by satellite imagery (available one day after the satellite photos are taken) and the results of the initial flight. The first flight will provide the required information on general distribution and geographical differences in seal density.

All sightings will be recorded in relation to time and position. Track width will be one mile.

Surveys will result in counts of breeding adults and pups. This information, in conjunction with information about age structure and reproductive status, will result in an estimate of the total population.

VI. Results

For a variety of reasons, this project was initiated too late to begin work during April 1975. The field work had to be delayed one year, until April 1976. Therefore, no actual survey results are available.

However, continuing efforts were devoted to the various details of coordination, program plans for both ship and aircraft, sampling procedures, data formats, etc. Several aspects of planning and coordination proved to be extremely time consuming.

VII. Discussion

None

VIII. Conclusions

None at present.

IX. Needs for further study

The subject of further study can be more adequately addressed after conclusion of the April 1976 surveys.

X. Summary of proposed 4th quarter activities (April-June 1976)

A. Ship activities

1. The NOAA research vessel Surveyor will be operating in the ice front from approximately 10 to 23 April. During this time approximately 8 hours on each of 10 days will be devoted to census of marine mammals.

2. The scientific party aboard the Surveyor will include:

Mr. Lloyd F. Lowry
Mr. Edward S. Muktoyuk
Ms. Kathryn J. Frost
Alaska Department of Fish and Game

Mr. John D. Hall
U. S. Fish and Wildlife Service

During the course of shipboard surveys the persons indicated above will conduct the actual surveys, record observations and other pertinent information and summarize results of the surveys.

3. Methods

Field sampling will consist of continuous observation during survey periods and the recording of animals observed in relation to time, location and habitat. Actual statistical analyses of survey results will be undertaken when both shipboard and aerial surveys are completed.

4. Sample localities

It is anticipated that sample localities for shipboard surveys will be in the ice front within an area bounded by lines between the following positions: 1) 58°25'N, 170°20'W; 2) 56°40'N, 170°20'W; 3) 58°25'N, 164°20'W; 4) 56°40'N, 164°20'W.

5. Data to be collected

Assuming that during marine mammal surveys the ship will be moving at 4 knots, for 8 hours on 10 survey days, the total length of track line will be 240 nautical miles. Since track width is 1 nautical mile, 240 square nautical miles will be surveyed for marine mammals.

B. Aircraft activities

1. A P2V survey aircraft, operated by the Office of Aircraft Services, USDI, will be employed for aerial surveys. Surveys will be undertaken between 7 and 25 April, as weather permits, for a total of 80 hours of flight time. The base of operations will be King Salmon, Alaska.

2. The scientific party aboard the aircraft will include but is not limited to:

   John J. Burns
   James B. Faro
   Karl B. Schneider
   Alaska Department of Fish and Game

   Samuel J. Harbo, Jr.
   University of Alaska

3. Methods

   Two types of survey flights will be undertaken. The first day of flying will be devoted to determining the general distribution of spotted seals and regional differences in density within the ice front. Subsequent flights will involve stratified random flight tracks in areas of low, moderate and high seal density. After 10 April, when the Surveyor arrives on station, survey flights will be made along the same tracks covered by the ship.

4. Sample localities

   Aerial surveys will be conducted throughout the entire ice front from Bristol Bay to within 12 miles of the Siberian Coast.

5. Data to be collected

   Approximately 70 hours of flight time will be spent in the survey areas. This will result in the survey of approximately 9,800 square miles of the ice front. The number of spotted seals and other marine mammals observed will be recorded and plotted.

C. Laboratory activities

Statistical analyses of both the shipboard and aerial surveys will be completed by John J. Burns and Samuel J. Harbo, Jr. using facilities at the University of Alaska. A final project report will be completed by 30 September 1976.

References

Allen, J. A. 1880. History of North American pinnipeds. U.S. Geol. and Geog. Surv. Terr., Washington. Misc. Publ. 12 xvi + 785pp.

Bee, J. W. and E. R. Hall. 1956. Mammals of northern Alaska. Univ. Kansas. Mus. Nat. Hist. Misc. Publ. No. 8. 309pp.

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

__________. 1971. Biology of the ribbon seal, _Phoca_ (_Histriophoca_) _fasciata_, in the Bering Sea. [Abstract]. Proc. 22nd Alaska Sci. Conf. p.135.

__________, G. C. Ray, F. H. Fay and P. D. Shaughnessy. 1972. Adoption of a strange pup by the ice-inhabiting harbor seal, _Phoca vitulina largha_. J. Mammal. 53:594-598.

Bychkov, V. A. 1971. A review of the conditions of the pinniped fauna of the USSR. Sci. Principles of the Conserv. of Nature, Moscow. pp.59-74. (Transl. Bureau Foreign Language Division, Canada, No. 0929).

Fay, F. H. 1974. The role of ice in the ecology of marine mammals of the Bering Sea. pp. 393-399 _in_ D. W. Wood and E. J. Kelley (ed.). Oceanography of the Bering Sea. Inst. of Mar. Sci., Univ. of Alaska, Fairbanks.

Fedoseev, G. A. 1966. Aerial observations of marine mammals in the Bering and Chukchi Seas. Izv. TINRO. 58:173-177.

Naumov, S. P. and N. A. Smirnov. 1936. Data on the systematics and geographical distribution of phocidae in the northern part of the Pacific Ocean. Izv. TINRO. 3:161-178 (Orig. not seen).

Scheffer, V. B. 1958. Seals, sea lions and walruses: A review of the pinnipedia. Stanford Univ. Press, Stanford, Calif. 179pp.

Shustov, A. P. 1965. Distribution of the ribbon seal (_Histriophoca fasciata_) in the Bering Sea. pp. 118-121 _in_ E. H. Pavlovskii, B. A. Zenkovich, S. E. Kleinenberg and K. K. Chapskii (eds.). Marine Mammals. Akad. Nauk SSSR, Ikhtiol, Comm. Moscow.

Tikhomirov, E. A. 1961. Distribution and migration of seals in waters of the Far East. pp. 199-210 _in_ E. H. Pavlovskii and S. K. Kleinenberg (eds.). Transactions of the Conference on Ecology and Hunting of Marine mammals. Akad. Nauk SSSR, Ikhtiol, Comm. Moscow.

__________. 1964. Distribition and biology of pinnipeds in the Bering Sea. Izv. TINRO 52:272-280.

True, F. W. 1899. The mammals of the Pribilof Islands. pp. 345-354 _in_ D. S. Jordan (ed.). The Fur Seals and Fur Seal Islands of the North Pacific Ocean. U.S. Government Printing Office, Washington, D. C. Part 3.

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Trophic relationships among ice inhabiting phocid seals

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1 March 1976

I. Summary

Ice inhabiting seals are highly visible, numerous and economically and sociologically important species in the Bering-Chukchi, and Beaufort marine ecosystems. A complete understanding of the role of these seals in the trophic structure of these ecosystems is crucial to the evaluation of potential impacts of OCS development. As a first step, the important items in the diet of each species in all areas at all times of year must be determined. Key areas and times of foraging must be determined and will have direct bearing on the suitability of various areas for leasing. When key prey species have been enumerated and data correlated with information on the distribution, abundance and natural history of these prey species (from other projects), an evaluation of effects of OCS development on the food base of the seals can be made. By understanding the trophic relationships among ice inhabiting seals and other consumers in the system, indirect effects of OCS development (e.g. those favoring population increase of potential food resource competitors) can be estimated.

Previous studies on food habits of ice inhabiting seals have all been geographically and temporally rather limited. From the literature surveyed it appears that ringed seals feed primarily on planktonic crustaceans and occasionally fishes, bearded seals eat a variety of benthic invertebrates and fishes, spotted seals eat pelagic and benthic fishes and planktonic crustaceans, and ribbon seals consume fishes (gadids and herring), cephalopods and shrimp.

To date in this study, the stomach contents of 48 ringed seals, 49 bearded seals and 2 spotted seals have been examined. The stomachs were collected at seven coastal hunting villages mostly during the summer months. While it is generally true that ringed seals feed on crustaceans and fishes, and bearded seals on benthic invertebrates, the actual prey species involved differed markedly at the different areas. For example, in the Chukchi Sea clams were the primary food source of bearded seals while in the Bering Sea decapod crustaceans were the most common prey items. Since it is conceivable that the impact of OCS development might be very different on clams than on shrimp or crabs, it is essential that specimen material be collected from several localities at all times of year.

The determination of prey items is only an initial step in this project. In order to attain the goal of ability to predict effects of OCS development, much information will be needed on the functioning of other components of the ecosystem. It is hoped that other OCSEAP projects will provide this information.

II. Introduction

The waters off the coast of Alaska support a tremendous abundance and diversity of marine mammals. Some species occur only during ice free months while others are more or less dependent on sea ice as a habitat in which to whelp, breed, molt and feed. The relationship between northern marine mammals and sea ice has been well summarized by Burns (1970) and Fay (1974).

In this project, four closely related species of pinnipeds have been chosen for study: the ringed seal, *Phoca (Pusa) hispida*; the bearded seal, *Erignathus barbatus*; the spotted seal, *Phoca vitulina largha*; and the ribbon seal, *Phoca (Histriophoca) fasciata*. Ringed seals and bearded seals are associated with ice throughout the year, with breeding ringed seals more common on shorefast ice and bearded seals occupying the drifting ice (Burns 1967, 1970; Burns and Harbo 1972). Ribbon seals and spotted seals utilize the ice front of the Bering Sea for whelping and molting in late winter and early spring, then ribbon seals appear to become pelagic while spotted seals move to the coast or north with the retreating ice (Burns 1970, in press, personal observations). An estimate of the combined numbers of these four species in the Bering, Chukchi and Beaufort Seas would be 1.5 to 2 million animals.

Marine mammals have a long history of subsistence and commercial utilization (Scammon 1874, Johnson *et al*. 1966, Reiger 1975). There is great public concern today for their continued well being. Some indications of this concern and interest are the Marine Mammal Protection Act of 1972, the increased interest in research and management at the international level and the present awareness of the non-consumptive recreational value of marine mammals (Reiger 1975). Subsistence utilization of certain species is still of considerable economic and cultural importance to coastal Eskimo communities (Johnson *et al*. 1966). These factors and others make it imperative that the potential effects of outer continental shelf development on ice inhabiting seals be anticipated and to whatever degree possible minimized. Such an evaluation requires a complete understanding of the biology of the species involved and how these species affect and are affected by their environment. This project will contribute to such an understanding by examining the trophic relationships of ice inhabiting phocid seals in the Bering, Chukchi and Beaufort Seas.

Specific objectives of this project are as follows:

1. Compilation of existing literature and unpublished data on food habits of ringed seals, bearded seals, spotted seals and ribbon seals. In addition, available information on distribution, abundance and natural history of potentially important prey species is being gathered.

2. Collection of sufficient specimen material (stomachs) for determination of the spectrum of prey items utilized by the species being studied throughout the geographic range involved and during all times of year that the species occurs in a particular area. The contents of these stomachs will be sorted, identified and quantified. This information will be analyzed for geographical and temporal variability in prey utilization patterns as well as for species, sex and age related dietary differences.

3. Analysis of feeding patterns in relation to distribution, abundance and other life history parameters of key prey species. This will involve determination of the degree of selectivity demonstrated by each species of seal as well as the availability and suitability of primary and alternative food sources. To whatever extent possible the effect of seal foraging activities on populations of prey species will be examined in light of observed rates of food consumption and foraging behavior. The accomplishment of this objective is largely dependent on information gathered by other OCSEAP projects involving benthic and planktonic organisms.

4. Analysis of trophic interactions among these species and other potential competitors such as walruses, whales, marine birds, fishes and humans. Input from other OCSEAP studies will be critical in this phase of the project.

5. With the understanding thus obtained of the trophic interrelationsips of ice inhabiting phocids in the Bering-Chukchi and Beaufort marine systems, evaluate the probable kinds and magnitude of effects of OCS development on these species of seals. This will involve both direct effects such as disruption of habitat in critical feeding areas or alterations of populations of key prey species and indirect effects such as influences on populations of competitors for food resources.

III. Current state of knowledge

The search for information on distribution, abundance, and natural history of potential prey items is not yet complete. However, it is evident that such information as is presently available (e.g. Stoker 1973, Crane 1974) is not sufficient to satisfy the needs of this study. This problem will be discussed in Section IX.

The earliest accounts of foods of marine mammals are to be found in the records of early polar expeditions, however such reports usually involve small samples and are lacking in taxonomic refinement. The discovery that seals are better collectors of some faunal elements, for example swimming crustaceans, than more traditional collecting gear resulted in the analysis of a fair number of ringed and bearded seal stomachs (e.g. VanWinkle and

Schmitt 1936, Dunbar 1954). Most of these studies were concerned with the nature of the contents rather than the feeding biology of the seals, a notable exception being the study of Dunbar (1941). The recognition of seals as potential competitors for commercially important fishes spurred a surge of research on pinniped feeding habits (e.g. Scheffer and Sperry 1931, Spaulding 1964, Briggs and Davis 1972, Rae 1973). However, although at least two species (ribbon seals and spotted seals) are known to feed somewhat extensively on commercially important pollack (Arseniev 1941, Burns in press, Wilke 1954), ice inhabiting seals have not been given systematic attention. Some limited information on the food of ice seals in Alaskan waters is available from the reports of interested persons who recorded the stomach contents of specimens they encountered (Kenyon 1962, Burns 1967, unpublished). The only systematic studies of feeding habits of ice inhabiting phocids were done by Johnson *et al*. (1966) as part of Project Chariot and the work of several Soviet investigators utilizing material made available by commercial sealing operations. A summary of the results of previous studies of food habits of each of the four species being considered in this project follows. Only reports dealing with animals taken in the Bering, Chukchi and western Beaufort Seas and adjacent waters are included.

Ringed seals

Barabash-Nikiforov (1936) reported that the contents of stomachs from two specimens from the Commander Islands contained fishes (Hexagrammidae), crabs and an octopus.

Pikharev (1946) examined the stomachs of 377 seals taken in the spring of 1939 in the Shantar Sea and the Sakhalin Gulf. Only 16 of the stomachs contained food remains, all of these being animals that were in the water or had only recently hauled out on the ice. From this Pikharev concluded that ringed seals do feed during the moult period, and digestion takes place quite rapidly. The most commonly encountered food items were the isopod *Saduria* (= *Mesidotea*) *entomon* and the euphausiid *Thysanoessa raschii*. Two species of gammarid amphipods and one species of hyperiid amphipod were found as well as shrimp (*Pandalus goniurus*), pollack (*Theragra chalcogramma*), smallmouth smelt (*Hypomesus olidus*) and herring (*Clupea harengus pallasi*), each found in one stomach.

Kenyon (1962) reported on the stomach contents of 14 seals taken at Little Diomede Island, May 11-June 14, 1958. Shrimp of the genus *Pandalus* accounted for 96 percent of the food items encountered with mysids, amphipods and fishes present in small amounts.

The intensive study of Johnson *et al*. (1966) at Point Hope and Kivalina resulted in the examination of 1923 stomachs from seals taken over the period November 1960 to June 1961. During the months of November, December, January and February, fishes (mostly sculpins, arctic cod (Boreogadus saida) and saffron cod (Eleginus gracilus)) made up 90 percent or more of the contents. During March, April, May and June, invertebrates, mostly shrimp and amphipods, were the predominant food making up more than half and occasionally more than 80 percent of the total contents.

Bearded seals

Kenyon (1962) reported on the stomach contents of 17 specimens taken at Little Diomede Island, May 11-June 6, 1958. Shrimps (Pandalus sp. and Sclerocrangon sp.), crabs (Hyas coarctatus alutaceus and Pagurus sp.) and clams (Serripes groenlandicus) comprised the bulk of the contents. Other benthic invertebrates (sponges, annelids and snails) and several species of fish were present in small amounts.

Johnson et al. (1966) examined the stomach contents of 164 bearded seals taken at Point Hope and Kivalina from November 1960 through June 1961. The only month in which a large sample (129) was obtained was June. Shrimp, crabs and clams were the most common food items with other benthic invertebrates in small quantities and fishes (sculpins and arctic cod) usually comprising less than 10 percent of the total volume.

In his summary of the biology of the bearded seal, Burns (1967) reported on his examination of stomachs from seals collected at Nome, Gambell and Wainwright. In May he found that crabs (Hyas coarctatus alutaceus and Pagurus sp.) accounted for 57 percent of the contents with shrimp, fishes (saffron cod, arctic cod and sculpins) and sponges comprising most of the remainder. In July and August, clams (Serripes groenlandicus, Spisula sp. and Clinocardium sp.) were the most abundant food item, with shrimp, crabs and isopods also quite commonly found.

Two works by Soviet investigators (Pikharev 1941, Kosygin 1966) have not yet been located and translated.

Spotted seals

Many studies have been done on the food of Phoca vitulina, however most of these have been on the land-breeding subspecies (P. v. richardi). Only three reports have been found dealing with the feeding habits of the ice-breeding form (P. v. largha).

Barabash-Nikiforov (1936) reported on the stomach contents of animals taken on the Commander Islands. He found that during the winter and early spring the principal foods were small octopus, crabs and sipunculids (Phascolosoma sp.). Amphipods (Gammarus sp.), algae and fishes were present but in small quantities. Later in the year benthic fishes (sculpins and greenlings) became important in the diet.

Wilke (1954) examined the stomach contents of 21 spotted seals killed on the pack ice of the Okhotsk Sea during April of 1949. In the 19 stomachs containing food, pollack made up 83 percent of the total volume, herring 10 percent, and traces of octopus, squid and other fishes the remainder.

Gol'tsev (1971) examined 319 stomachs from seals collected in the Bering Sea during the 1966-68 hunting seasons (April-June). From his collections he concluded that spotted seals feed in the morning and in the evening and digest their food quite rapidly. The food of newly weaned young (five weeks old) was entirely amphipods (*Nototropis* sp. and *Anonyx nugax*) and some algae. At seven to eight weeks old they begin to feed on shrimps (*Spirontocaris macarovi*, *Eualus fabricii* and *E. gaimardii*) and sand lance (*Ammodytes hexapterus*). At 12 weeks old, larger fish (flatfish and saffron cod) begin to be eaten. Juveniles (age one to four years) fed mostly on fish (arctic cod, sand lance, saffron cod) and shrimp (*Pandalus* sp.). Adults appear to feed more on benthic forms with octopus, crabs, flounders, sculpins and other bottom fishes prevalent.

Ribbon seals

Arseniev (1941) reported that near Sakhalin Island in the spring ribbon seals feed mainly on deepwater fishes (mostly pollack) and cephalopods. This was confirmed by Wilke (1954) who found 60 percent pollack and 40 percent squid in two stomachs he examined from animals taken in the Okhotsk Sea in April.

Shustov (1965) examined 1207 stomachs from seals taken at the ice front of the Bering Sea from March through July. Only 32 of these stomachs contained recognizable food. Shrimps (*Pandalopsis* sp., *Argis lar*, *Pandalus borealis*, *Eualus gaimardii* and others), amphipods (*Parathemisto* sp.), mysids and cephalopods were frequently found. Many types of fishes, especially arctic cod, saffron cod and herring were encountered but were not very common. In interesting contrast to the findings of Arseniev (1941) and Wilke (1954) in the Sea of Okhostsk, no pollack were found in the Bering Sea sample.

Burns (in press) reports on the food remains found in the stomachs of six specimens collected in the Bering Sea. Four animals were taken in April and May; one contained fish (*Pholis* sp.), two contained shrimp (*Pandalus* and *Sclerocrangon* sp.) and one contained only milk. The stomachs of two specimens collected in February contained large volumes of pollack and arctic cod.

IV. Study area

The study area involved includes the Beaufort, Chukchi and northern Bering Seas. Since some of the species being studied show extensive seasonal movement in relation to changes in ice conditions, the geographic focus of the study will also vary somewhat seasonally. To date our sampling has been done at the coastal hunting villages

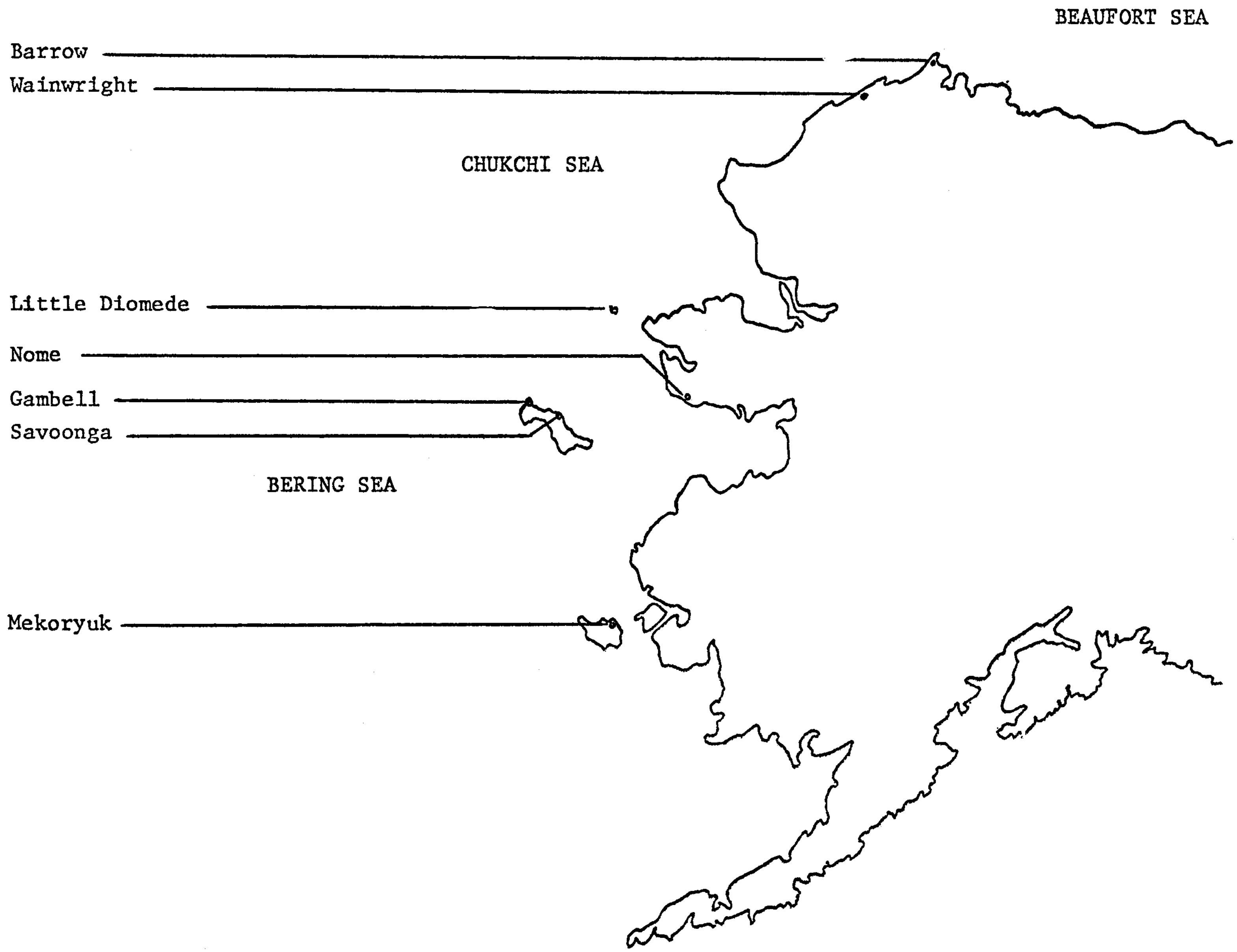

Figure 1. Villages from which seals were collected between April 1975 and January 1976.

shown in Figure 1. It is planned to make collections and observations from the R/V Surveyor in the Bering Sea in March and April and from the USCGC Glacier in the Beaufort Sea in August. Other shipboard work will be done pending availability of suitable vessels in the proper areas.

V. Sources, methods and rationale of data collection

Literature

Existing literature and unpublished data on the food habits and trophic interactions of ice inhabiting seals are being compiled and pertinent information abstracted for later reference. Available information on the distribution, abundance and natural history of potentially important prey species is also being accumulated. Literature and pertinent information has been compiled through an OASIS search on food habits of seals, discussion and consultation with personnel from the University of Alaska Marine Museum Sorting Center, use of various translation services (Israel Program for Scientific Translations and Fisheries Research Board of Canada) for access to Russian literature, search of Alaska Department of Fish and Game reprint files, library and other literature collections, the use of University of Alaska library facilities and inter-library loan services.

Field collection of specimen material

Collectors were sent to coastal hunting villages on the Bering and Chukchi Seas during predictably good hunting periods. Specimen material, including jaws and claws for aging, reproductive tracts, and stomachs were purchased directly from hunters. Sampling in the Bering and Chukchi Seas was done by John J. Burns, Glenn Seaman, and other ADF&G employees. Specimens from Point Barrow were provided by Harry Reynolds, ADF&G Area Biologist, who had access to intact seals purchased from local hunters by the Naval Arctic Research Lab as food for the animal colony.

Whenever possible seals from which specimen material was taken were weighed and sexed and a series of standard measurements made for use in this and other ongoing studies on ice inhabiting seals. Tissue and blood samples were collected in some cases and made available to other investigators for heavy metal, hydrocarbon, PCB and pathogen analysis. (See methods section in RU# 230, annual report, for detailed description of standard measurements and collection of additional specimen material.)

Only full or apparently full stomachs were collected. Stomachs were tied at the cardiac sphincter and pyloric sphincter and severed near these ties. They were then either injected with 10 percent formalin, labelled, and placed entire and unopened in plastic bags containing 10 percent formalin, or placed in bags and frozen, then shipped to the ADF&G Fairbanks office. Some stomach specimens collected at Diomede by cooperating investigators from the University of Alaska Institute of Marine Science were not intact. The stomachs had been opened in the field and only the contents retained in plastic bags, preserved in 10 percent formalin and delivered to ADF&G Fairbanks.

Laboratory procedures and identification

Laboratory analysis of stomach contents began October 15, 1975 and has been the major project activity since that date. Procedures for processing the stomachs, determining volumes of stomach contents items, rough sorting, fine sorting and identification of species were developed and refined. Necessary taxonomic keys and references were accumulated, a voucher specimen collection was established, personnel were trained for sorting activities, data sheets were designed.

Each stomach was trimmed of excess esophageal and small intestinal tissue and weighed intact (g). The stomach was then cut open and the contents transferred onto a standard Tyler screen where it was gently but thoroughly washed. Ringed seal stomach contents were washed onto a 1.0mm screen and bearded seal stomach contents were washed onto a 2.0mm screen due to the larger nature of bearded seal prey items. Empty stomachs were reweighed, returned to 10 percent formalin and stored for future reference and examination. The volume of the total stomach contents of each seal was then determined by water displacement method (ml). Those Diomede seal stomach contents that had been removed from the stomachs in the field were simply washed and a total volume determined as above.

The washed contents were either transferred to finger bowls and petri dishes for immediate rough sorting, or placed in jars and stored in 10 percent formalin until sorting could be done. Rough sorting entailed separation of parasites from food items, and separation of food items into major taxonomic groups. Parasites will be examined at a later date by other ADF&G personnel as part of the natural history studies on ringed and bearded seals.

Fine sorting and identification consisted of further refinement of the initial sorting procedure. Sorted fractions were broken down to the lowest possible taxonomic levels permitted by the condition of the material. All sorting and identification required recognition of small bits and pieces of organisms, as seldom were intact organisms present. Shrimp, crabs and amphipods were frequently identified with only claws, carapace or abdomen. Clams were recognized by feet, gastropods by opercula, fish by individual bones or otoliths, etc. Individuals of a group or species were counted, size range was measured (mm) and the volume of the fraction determined by water displacement (ml). Considerable time early in the project was devoted to developing an efficient means by which to measure volumes. Some fractions were also weighed (g) to provided volume to weight ratios for different groups or species.

The capability to do "in house" identification required initial familiarization with Alaskan invertebrate and vertebrate marine fauna. Necessary taxonomic keys and references were accumulated through library facilities, through contact with personnel at the University of Alaska Marine Museum Sorting Center, and correspondence with people presently working in pertinent fields. Much use was made of the Marine Museum Sorting Center reference collection and of the expertise of sorting center personnel. A reference and voucher specimen collection including bits and pieces of individuals, as well as intact specimens, has been established at ADF&G for use in future identifications and in training of personnel.

Data

Design of formats to handle data and design of compatible data sheets to facilitate key punching has been an ongoing and time consuming project. To date, preliminary data has been manually compiled and expressed as percent volume and percent frequency. Percent volume, for a given area, equals total volume of a prey item in all stomachs of one species divided by the total volume of all stomach contents for that species. Precent frequency reflects the number of stomachs, from any one area, in which a prey item occurred.

VI. Results

The search for background literature and unpublished data is nearly complete. Much material has been uncovered on feeding of pinnipeds, however, little of this is pertinent to the species being presently investigated. The most relevant articles are summarized under section III of this report. Most of the unpublished data on feeding of ice inhabiting phocids has been gathered by one of the Principal Investigators in this project (John J. Burns) and will be incorporated into this study as appropriate. As pointed out in section III, information on distribution, abundance and life history of potential prey items is quite scarce and will not be considered in this report.

Table 1 shows the results of sample collection efforts to date. A total of 114 stomachs containing food have been collected, of these, 45 were from the Bering Sea; 18 from the Bering Strait and 52 from the Chukchi Sea (includes Barrow sample). Bearded seals (49) and ringed seals (48) make up the majority of the collection with samples for both species from several localities. Spotted seals (17) were collected at only 3 locations with the great majority (15) coming from the Bering Sea. To date there have been no samples collected from ribbon seals nor are there samples from any species for the Beaufort Sea. Also, samples of all species from fall and winter periods are lacking. These problems will be discussed under Section IX of this report.

Table 1. Seal stomachs collected in a shore-based sampling program at six locations in Alaska from April 1975 to January 1976.

Location	Sampling Period	Phoca (Pusa) hispida M	Phoca (Pusa) hispida F	Erignathus barbatus M	Erignathus barbatus F	Phoca vitulina largha M	Phoca vitulina largha F	Unk.
Point Barrow	5/11/75-8/75	8	1	0	0	0	0	
Wainwright	7/24/75-8/11/75	9	10	9	13	0	2	
Diomede	5/28/75-6/10/75	8	4	3	3	0	0	
Gambell	5/12/75	1	0	1	1	0	0	
Savoonga	5/7/75-6/13/75	0	0	6	1	2	4	
Nome	1/23/76	0	1	0	0	0	0	
Mekoryuk	5/22/75-6/12/75	1	5	9	3	6	2	1
Total		27	21	28	21	8	8	1

The development of efficient laboratory techniques and procedures was a vital first step in the analysis of feeding habits. Details of the laboratory methodology now being used were given in the previous section. Procedures developed appear accurate and efficient and will likely be modified little throughout the remainder of the study.

The results of the analysis of stomach contents of ringed and bearded seals are given in Tables 2, 3 and 4. Most of the invertebrate material found has been identified at least to genus, however, due to lack of proper reference material and keys, fishes have not been dealt with as yet (see section IX). The total of the volumes for species listed under some of the large taxonomic groups is often less than the total given for that taxon due to material that could not be positively identified to species. A summary of the results for each species is given below. Figures given refer to percent of the total volume unless otherwise indicated.

Ringed seals - see Tables 2 and 4.

A sample of nine seals taken at Barrow in spring and summer showed euphausiids (*Thysanoessa inermis* and *T. raschii*) to be by far the most important food item (72.5%). Amphipods (mostly *Anonyx nugax*) were of secondary importance (24%). Fish occurred in only three of the stomachs examined accounting for only two percent of the total volume.

Twenty-five species of invertebrates were identified from 19 stomachs collected at Wainwright in the summer. Shrimp were the predominant food item found (45%) with Eualus gaimardii belcheri and Sclerocrangon boreas the most common species. At least 14 species of amphipods were found, but in total they comprised only 10 percent of the total volume. The isopod, Saduria entomon occurred in only two of the stomachs examined but accounted for 5.1 percent of the total volume. Fish (largely cottids) made up 24.9 percent of the contents.

In a sample of seals collected in the spring at Diomede, amphipods (mostly Anonyx nugax and Gammarus wilkitzkii) were the most common food (58.8%). Shrimp (mostly Pandalus goniurus, Argis lar and Eualus gaimardii belcheri) accounted for 17.5 percent of the contents. Fish amounted to 13.8 percent of the total volume.

Six stomachs were examined from Mekoryuk in spring. Fish (Eleginus gracilus and others) amounted to 58.5 percent of the total volume. The mysid Neomysis rayi (17.5%) and the hyperiid amphipod Parathemisto libellulua (13.2%) were both quite common and shrimp (mostly Sclerocrangon boreas) were present in small amounts (3.5%).

The stomach from a single animal collected at Nome on January 23, 1976 (not shown in Tables 2 and 4) contained only the remains of saffron cod (Eleginus gracilus).

The stomach of a single specimen collected at Gambell May 12, 1975 (not shown in Tables 2 and 4) contained 72.8 percent shrimp (Spirontocaris spp. and Argis crassa), several species of amphipods (20.7%) and small amounts of mysids and fish.

Bearded seals - see Tables 3 and 4.

In a sample of 22 stomachs collected at Wainwright during July and August, the clams Serripes sp. (37.5%) and Clinocardium sp. (15.2%) made up over half of the contents. Usually only the foot portions, sometimes with mantle and siphon attached, were found.

Sclerocrangon boreas accounted for 9.5 percent of the contents and the crab Hyas coarctatus alutaceus represented 4.2 percent. Thirty other species of invertebrates were identified but they were present only in small amounts. Fish accounted for 10.4 percent of the total volume.

In a sample of six stomachs from Diomede in June and July, the most common food item was Hyas coarctatus alutaceus (33.8%) followed by fish (30.8%), Serripes sp. (8.4%), octopus (6.5%) and snails (mostly Buccinum sp. (6%)).

Table 2. Food from 46 ringed seal stomachs taken at four locations, between April and August 1975.

Food Species	Barrow 5/75-8/75 N = 9		Wainwright 7/28/75-8/11/75 N = 19		Diomede 5/28/75-6/1/75 N = 12		Mekoryuk 4/22/75-6/12/75 N = 6	
	% Vol.	% Freq.[1]	% Vol.	% Freq.	% Vol.	% Freq.	% Vol.	% Freq.
Phylum Arthropoda, Class Crustacea								
Order Amphipoda	24.0	89	10.2	75	58.8	83	14.1	33
Suborder Gammaridea	22.0	89	8.1	65	58.3	58	*	
Anonyx nugax	11.1	89	1.8	40	33.7	50	*	
Gammarus wilkitzkii			3.6	30	24.0	8		
Gammaracanthus loricatus	*		*					
Acanthostepheia sp.			*					
Onisimus litoralis			*					
Apherusa sp.			*					
Stenothoides sp.			*					
Atylus sp.			*		*			
Weyprechtia pinguis			1.3	20				
Ischyrocerus sp.			*		*			
Ampelisca sp.			*		*			
Paramphithoe polyacantha			*					
Byblis gaimardi					*			
Westwoodilla caecula			*					
Suborder Hyperiidea	*		2.1	20	*		13.2	83
Parathemisto libellula	*		2.0	15	*		13.2	83
Order Euphausiacea	72.5	67	*				*	
Thysanoessa inermis	23.8	44	*					
T. raschii	18.6	22	*				*	
Order Mysidacea			1.5	60	*		17.5	83
Mysis litoralis			1.0	40	*			
Neomysis rayi			*				17.5	83
Acanthomysis sp.			*				*	

Table 2. Continued.

Food Species	Barrow % Vol.	Barrow % Freq.	Wainwright % Vol.	Wainwright % Freq.	Diomede % Vol.	Diomede % Freq.	Mekoryuk % Vol.	Mekoryuk % Freq.
Order Isopoda	*		5.1	20				
Saduria entomon			5.1	20				
Order Decapoda								
Section Caridea	1.0	22	45.1	47	17.5	83	3.5	50
Family Hippolytidae			27.4	47	4.0	50		
Eualus gaimardii belcheri			8.0[2]	37	1.0	33		
E. fabricii			*					
E. macilenta					*			
Spirontocaris spina					*			
Lebbeus polaris			*		*			
Family Crangonidae	*		12.2	30	2.8	17	3.5	50
Sclerocrangon boreas	*		10.8	30			2.2	17
Argis lar			1.4	5	2.8	17		
Crangon septemspinosa							*	
Family Pandalidae			*		6.3	33		
Pandalus goniurus			*		6.3	33		
Order Copepoda	*							
Invertebrates - Total	98.0	100	69.8	89	86.2	92	41.5	83
Total number of invertebrate species identified	6		26		13		7	
Number of invertebrate species making up more than 1% of total volume	3		9		5		3	
Number of invertebrate species making up more than 5% of total volume	3		3		3		2	

Table 2. Continued.

Food Species	Barrow		Wainwright		Diomede		Mekoryuk	
	% Vol.	% Freq.	% Vol.	% Freq.	% Vol.	% Freq.	% Vol.	% Freq.
Phylum Chordata								
Class Pisces	2.0	33	25.2	74	13.8	67	58.5	83
Mean volume of contents (ml)	19.2		24.9		54.9		67.0	

* Indicates food species which constitute less than 1% of the total volume.

1 Frequency of occurrence = $\frac{\text{number of times taxon found}}{\text{number of stomachs examined}} \times 100$

2 Much material identified only as *Eualus* sp. undoubtedly belonged to *E. gaimardii*. Including this material, this species probably accounted for over 20% of the total volume found in the Wainwright sample, making it the most important single food item at this locality.

Table 3. Food from 49 bearded seal stomachs taken at five locations, between May and August 1975.

Food Species	Wainwright 7/24/75-8/7/75 N = 22		Diomede 5/28/75-6/10/75 N = 6		Gambell 5/12/75 N = 2		Savoonga 5/7/75-6/13/75 N = 7		Mekoryuk 5/6/75-5/30/75 N = 12	
	% Vol.	% Freq.	% Vol.	% Freq.	% Vol.	% Freq.	% Vol.	% Freq.	% Vol.	% Freq.
Phylum Arthropoda, Class Crustacea										
Order Cumacea	*									
Diastylis sp.	*									
Order Isopoda	3.1	45	*						10.5	42
Saduria entomon	2.6	32							10.5	33
Synidotea bicuspida	*								*	
Tecticeps alaskensis	*									
Order Mysidacea	*						*		*	
Mysis litoralis	*									
Neomysis rayi							*		*	
Order Amphipoda	*		*		*		*		*	
Parathemisto libellula							*			
Acanthostepheia sp.	*						*			
Ampelisca macrocephala					*					
Anonyx nugax	*		*		*		*		*	
Atylus sp.	*				*				*	
Ericthonius sp.	*									
Eusirus sp.			*							
Ischyrocerus sp.					*					
Melitoides sp.	*									
Metopa sp.	*									
Paramphithoe polyacantha	*									
Pleustes sp.			*							
Stenothoides sp.					*					

Table 3. Continued.

Food Species	Wainwright % Vol.	Wainwright % Freq.	Diomede % Vol.	Diomede % Freq.	Gambell % Vol.	Gambell % Freq.	Savoonga % Vol.	Savoonga % Freq.	Mekoryuk % Vol.	Mekoryuk % Freq.
Order Decapoda	20.5	95	41.3	100	73.3	100	65.8	100	56.8	100
Section Anomura	*		1.6	50	9.7	100	3.1	43	*	
Hapalogaster grebnitzkii			*				2.9	29		
Pagurus pubescens					1.5	50				
P. rathbuni	*									
P. splendescens	*									
Paralithodes platypus					8.3	50				
Section Brachyura	4.2	82	34.0	100	42.1	100	*		17.7	50
Hyas coarctatus alutaceus	4.2	82	33.8	100	42.1	100	*		2.8	33
Hyas lyratus									14.9	50
Chionoecetes sp.			*						*	
Section Caridea	15.9	95	5.7	100	25.1	100	62.7	100	38.6	100
Family Pandalidae	*		1.4	67	*		17.5	43	*	
Pandalus goniurus	*		1.4	67	*		17.5	43	*	
Family Hippolytidae	*		1.1	67	*		5.2	86	*	
Eualus fabricii			*		*		*			
Eualus gaimardii belcheri	*		*		*		*			
Eualus pusiola			*							
Lebbeus groenlandicus			*				3.5	29		
Lebbeus polaris			*				*			
Spirontocaris phippsii	*									
Spirontocaris prionota									*	
Spriontocaris spina			*				*			
Family Crangonidae	11.4	91	2.9	83	14.9	100	32.5	57	34.0	100
Argis crassa			*		*		1.4	29	*	
Argis lar	1.1	50	*		14.2	100	18.4	14	*	
Crangon dalli									1.9	42
Crangon septemspinosa			*						4.1	83
Sclerocrangon boreas	9.5	86	1.5	67	*		1.1	43	23.0	69
Sabinea septemcarinata	*									

Table 3. Continued.

Food Species	Wainwright % Vol.	% Freq.	Diomede % Vol.	% Freq.	Gambell % Vol.	% Freq.	Savoonga % Vol.	% Freq.	Mekoryuk % Vol.	% Freq.
Phylum Annelida,										
Class Polychaeta	*		1.2	100	*		1.0	14	*	
Ampharete sp.	*									
Eunoe sp.			*		*				*	
Nephthys sp.	*		*							
Nereis sp.	*		*							
Phylum Echiuroidea	*		*		*		*		*	
Echiurus echiurus	*		*		*		*		*	
Phylum Mollusca	58.5	77	20.9	83	2.2	100	11.1	43	*	
Class Gastropoda	3.9	55	6.0	50	*		*		*	
Buccinum sp.	*		5.7	33	*		*			
Fusitriton sp.	*		*		*		*		*	
Natica sp.	*									
Neptunea sp.			*							
Polinices sp.	*									
Velutina sp.							*			
Class Bivalvia	54.2	68	8.5	83	1.8	50	10.7	14		
Clinocardium sp.	15.2	32								
Serripes sp.	37.5	64	8.4	67	1.8	50	10.7	14		
Siliqua sp.	*									
Class Cephalopoda	*		6.5	50						
Octopus sp.[1]	*		6.5	50						
Phylum Echinodermata, Class Holothuroidea										
Thyonidium commune	*									
Phylum Ectoprocta	*		*							
Phylum Porifera			1.5	17						

Table 3. Continued.

Food Species	Wainwright % Vol.	Wainwright % Freq.	Diomede % Vol.	Diomede % Freq.	Gambell % Vol.	Gambell % Freq.	Savoonga % Vol.	Savoonga % Freq.	Mekoryuk % Vol.	Mekoryuk % Freq.
Phylum Chordata, Class Ascidiacea	*								5.4	33
Invertebrates - total	88.1	100	68.7	100	78.3	100	80.1	100	76.2	100
Total number of invertebrate species identified	34		26		19		20		19	
Number of invertebrate species making up more than 1% of total volume	6		6		5		7		6	
Number of invertebrate species making up more than 5% of total volume	3		4		3		3		3	
Phylum Chordata, Class Pisces	10.4	73	30.8	100	20.6	100	12.8	57	19.2	67
Mean volume of contents (ml)	531.1		596.6		199.3		233.1		137.9	

[1] Identification uncertain

Table 4. Major food species (comprising more than 5% of the total volume of contents) of 49 bearded seals and 46 ringed seals taken at six locations in Alaska between April and August 1975.

	Barrow	Wainwright	Diomede	Gambell	Savoonga	Mekoryuk
Bearded Seals	No Sample	*Serripes* sp. *Clinocardium* sp. *Sclerocrangon boreas* Fish	*Hyas coarctatus* Fish *Serripes* sp. *Octopus* sp. *Buccinum* sp.	*Hyas coarctatus* Fish *Argis lar* *Paralithodes platypus*	*Argis lar* *Pandalus goniurus* Fish *Serripes* sp.	*Sclerocrangon boreas* Fish *Hyas lyratus* *Saduria entomon*
Ringed Seals	*Thysanoessa inermis* *Thysanoessa raschii* *Anonyx nugax*	Fish *Sclerocrangon boreas* *Eualus gaimardii* *Saduria entomon*	*Anonyx nugax* *Gammarus wilkitzkii* Fish *Pandalus goniurus*	No Sample	No Sample	Fish *Neomysis rayi* *Thysanoessa inermis*

Two stomachs from bearded seals taken at Gambell in June were examined. These contained largely crabs (Hyas arctatus alutaceus (42.1%), Paralithodes platypus (8.3%)) and shrimp (25.1%) mostly Argis lar. Fish accounted for 20.6 percent of the contents.

In a June-July sample of seven stomachs from Savoonga, the majority of contents (62.5%) was made up of several species of shrimp (mostly Argis lar and Pandalus goniurus). Fish amounted to 12.8 percent of the contents and Serripes sp. was 10.7 percent.

Twelve stomachs collected at Mekoryuk in June were examined. Shrimp (mostly Sclerocrangon boreas) were the most common food (38.6%) followed by crabs (Hyas spp. (17.7%)) and Saduria entomon (10.5%). Fish were 19.2 percent of the total volume.

Spotted seals

Stomachs of two seals collected at Wainwright during late July and early August were examined. The contents of these stomachs was almost entirely fish with small amounts of shrimp, amphipods, isopods and mysids. Specimen material has been collected from Savoonga and Mekoryuk but this material has not yet been examined.

Ribbon seals

To date, no specimen material from ribbon seals has been collected by this project.

VII and VIII. Discussion and Conclusions

From the limited number of samples examined to date, it would be premature to make generalized conclusions regarding important prey species over wide geographical ranges at various times of year. The information gathered does, however, point out some interesting things which will have bearing on future collecting and analysis.

Table 4 shows the major food items occurring for each species at each locality examined. It is interesting to note that although a total of 58 invertebrate species were identified from bearded seals and 31 species from ringed seals, in no case did more than 4 of these species (or perhaps species groups, e.g. Buccinum sp.) individually make up more than five percent of the total contents volume. It is quite likely that many of the species found were either ingested inadvertently (e.g. amphipods in bearded seals and copepods in ringed seals) or came from stomachs of prey items (e.g. Diastylis sp. was found in fish stomachs in bearded seal stomachs).

Even when only main food items are considered, a tremendous amount of variability is seen in importance of the various prey items at different localities (Table 4). At Point Barrow, ringed seal feeding was apparently almost entirely pelagic as indicated by the predominance of euphausiids. At both Diomede and Wainwright, more benthic feeding is indicated, although the major species eaten at the two areas are completely different. The sample of ringed seals at Mekoryuk was very interesting. The stomachs of two specimens taken on April 22 and June 12, 1975 contained almost entirely fish (Eleginus gracilus in the second specimen). The other four stomachs examined from specimens taken May 23-29, 1975 contained almost exclusively the pelagic amphipod Parathemisto libellula and the mysid Neomysis rayi. To date it appears that planktonic and benthic crustaceans are the primary food of ringed seals, although fishes may at times be very important.

The bearded seals we have examined have fed almost exclusively on benthic invertebrates with fish occurring in most of the stomachs examined but constituting a relatively small portion of the volume. At Wainwright, clams were by far the most important food item with shrimp commonly found, but in small volumes. At all other localities, decapod crustaceans are much more common than clams. Looking at all locations, Serripes sp., Hyas coarctatus alutaceus, Sclerocrangon boreas and Argis lar are frequently important food items (Table 4).

Sufficient samples have not yet been obtained and examined to separate temporal and geographical components of the observed variability. For now, it should be considered that all species listed in Table 4 are potentially important food items. Due partly to a delay in obtaining age determinations for the specimens and partly to small sample sizes, potential age and sex related differences cannot yet be determined, although it is quite likely that such factors may be responsible for some of the observed variability (e.g. ringed seals at Mekoryuk).

Trophic interaction between ringed and bearded seals appears to be minimal. Only at Wainwright did one of the primary food items (Sclerocrangon boreas) appear in both species. It would be premature to evaluate trophic interactions between other combinations of marine mammals, but information is being compiled and this facet of the study will be fully evaluated at a future date.

An evaluation of degree of selectivity and food utilization in relation to abundance is crucial to this study. Again, it is too early to make such an evaluation, and unless extensive studies are done of organisms at the lower trophic levels, an adequate understanding will never be obtained.

IX. Needs for further study

As this project involves the study of trophic relationships of high level consumers, its success is to a significant degree dependent on information being gathered by other OCSEAP projects. Therefore it seems appropriate to discuss needs for futher study both within this project and from other projects.

Needs for futher study - this project

In light of the variation in key food items observed to date, it is imperative that temporal series of samples be obtained at several geographical localities throughout the study area. Field sampling done in the spring of 1975 constituted a substantial first step in this direction. Unfortunately, due to the necessity to hire and train personnel and attend to administrative duties (e.g. data management, reports and proposals), samples for the fall and winter seasons were not collected. We plan to try and fill this gap in the fall and winter of 1976. As geographical variability appears so great, and temporal variability may also be significant (see Johnson et al. 1966), it will be necessary to obtain large samples from single localities over restricted time periods in order to test for age and sex related dietary differences. We hope to accomplish this objective during the upcoming summer.

The only source of specimen material collected so far has been coastal native hunters. Although it has been a convenient and relatively inexpensive method, it has presented some problems. The major advantage of obtaining specimen material from the natives is that it obviates the necessity for killing large numbers of animals solely for collection of specimen material. A major disadvantage with this system is that specimen material is only available when and where the villagers are hunting. Frequently, the only information obtained about the specimen is the date on which it was killed and sometimes its sex and age. The success experienced by people collecting material in villages varies with the resource base of the village at the time and the prevailing philosophical and political attitudes.

There are presently no coastal villages on the Beaufort Sea which depend primarily on marine mammals for subsistence (for our purposes we do not consider Barrow representative of the Beaufort Sea system). We therefore plan, at considerable expense and effort, to conduct a collection operation there in May utilizing ADF&G personnel. Also, we plan to utilize the USCGC Glacier in August to obtain more samples from the Beaufort Sea.

Ribbon seals pose a rather special problem. They are almost never taken at coastal villages, and their distribution during ice-free months is largely unknown. It is hoped that some specimen material can be collected utilizing the R/V Surveyor this spring, and subsequent vessels as available.

In all instances when actual collection of animals is done by ADF&G employees, we will have an opportunity to gather more detailed information (e.g. time of collection, exact location of collection, water depth, relationship to ice, water and other animals, behavior prior to collection, etc.) than is obtained in village collections

We plan in future phases of this study to initiate behavioral, physiological and additional ecological studies as necessary to obtain a complete understanding of the trophic relationships of ice inhabiting seals. These studies will be dealt with in future proposals.

Needs for future study - other projects

We envision the following types of information will be needed in order to carry out our project and properly evaluate the results:

1. Development of a key to otoliths and skeletal parts of fishes as proposed by RU#s 285 and 318. Also keys to several groups of macro-invertebrates for Arctic waters would be helpful. Provisions for translation of pertinent Soviet faunal works could perhaps substitute for development of keys for some groups.

2. A compilation of existing literature on distribution and abundance of benthic and pelagic invertebrates and fishes in the Bering, Beaufort and Chukchi Seas. Such compilations are task objectives in several projects, and we do not intend in this project to duplicate the efforts of others. We do, however, need access to these compilations so that we can examine pertinent literature, incorporate it into evaluation of our results, and determine what gaps in existing knowledge need immediate filling.

3. Fill in gaps in knowledge of distribution and abundance of key species. Contracts have already been awarded for some of this work, however it would be most helpful if some special attention could be given to key types of organisms (macro-benthic decapods and molluscs, and pelagic crustacea) as pointed out in this report and listed below. Whenever possible, this project will collect such material in conjunction with collection of seal specimens, however we do not have the time, personnel, facilities or expertise to carry out extensive studies of the benthos and plankton.

4. Intensive studies on life history and ecological sensitivity of key prey items. From our studies so far, the following species of invertebrates should be considered:

   Phylum Mollusca, Class Bivalvia - Serripes groenlandicus
   Phylum Arthropoda, Class Crustacea
   Order Decapoda - Sclerocrangon boreas, Pandalus goniurus, Eualus gaimardii belcheri, Hyas coarctatus alutaceus
   Order Amphipoda - Anonyx nugax
   Order Euphausiacea - Thysanoessa inermis, T. inermis
   Order Isopoda - Saduria entomon
   Order Mysidacea - Neomysis rayi

Sufficient work has not yet been done on identification of fish material to state with confidence which species are potentially important prey items.

5. Consideration should be given to determination of baseline levels of pesticides, heavy metals and hydrocarbons in the above listed species, since they appear to be important organisms in the arctic marine food web.

6. Information is needed on prey utilization, both quantitative and qualitative, of other major consumers, fishes, birds and crustaceans, which share the food resources of the Bering-Chukchi and Beaufort systems. Much of this work is being presently done under other OCS contracts.

Due to the involved nature of this study, it is imperative that the principal investigators be given copies of the annual reports of all other projects as soon as they are compiled.

X. Summary of 4th quarter operations

Fourth quarter activities were devoted primarily to laboratory processing of specimen material, development of and modifications to data formats, field work in Nome and on St. Lawrence Island, preparation of an annual report, and preparation for the upcoming R/V Surveyor cruise to occur in March and April. See Table 5 for a more complete schedule of activities, dates and personnel involved.

Six ringed seal and twenty-six bearded seal stomachs were opened, rough sorted (by Glenn Seaman, ADF&G), fine sorted and invertebrate species identified (by Kathryn Frost and Lloyd Lowry, ADF&G) as described in Section V of this report. Assembly of invertebrate taxonomic reference material and keys was almost completed. Virtually all identifications were made "in house" by project personnel. Identifications of problematic species were confirmed at the University of Alaska Marine Museum Sorting Center by George Mueller and Ken Coyle.

Fish remnants were not identified more specifically than "unidentified fish". No keys exist at present for skeletal parts or otoliths of arctic and subarctic fishes. Work was begun, however, on building a reference collection of fish parts and otoliths from an existing, albeit incomplete, ADF&G collection of intact identified specimens. Contact was made with J. E. Morrow, principal investigator for OCSEAP projects, RU#s 285 and 318. Arrangements were made to share available fish material and to provide the fish project with further specimen material collected on the upcoming Surveyor cruise. Fish material will also be provided to Ron Smith, RU# 284.

An OCS Littoral Zone Workshop was attended in Seattle in mid-January by Lloyd Lowry. The purpose of the workshop was to discuss definitions and terminology to be used by OCS investigators involved in littoral zone studies and to provide for integration of related projects. Contacts were made with other OCS investigators who might have potential input into this project.

A field trip to Nome and St. Lawrence Island was made in mid-February by L. Lowry and T. Eley (RU# 230) for the collection of specimen material. Seal data records from previous ADF&G studies were obtained, and about 800 sets of ringed seal claws used for determining ages were either "read" in Nome or returned to the Fairbanks office for determination of seal ages. No seal stomachs were obtained on this trip, contrary to expectations, as hunting of seals had ceased in favor of polar bear hunting.

Preliminary data analysis was begun during the fourth quarter. Data from stomach contents processed to date were compiled and percent of total volume and percent frequency of occurence for each prey item calculated (see sections V and VI of this report). Several meetings were held with OCS data management personnel concerning data formatting. Final OCS format requirements have not yet been received from project headquarters. Therefore, keypunching and computer processing of data have not yet begun. A person has been hired to assume future data management responsibilities for Fairbanks ADF&G personnel involved in OCS marine mammals projects. Training of this person will be ongoing during March.

Preparations were made for the 13 March - 26 April Bering Sea ice edge cruise on the NOAA R/V Surveyor. John Burns, Lloyd Lowry and Ed Muktoyuk (ADF&G) will participate in the first leg of the cruise. L. Lowry, K. Frost and E. Muktoyuk will be aboard for the second leg. A partial list of cruise objectives includes collection of stomach specimen material, benthic trawls for collecting invertebrates and fish, and observation of natural history and behavior of ice inhabiting seals.

Considerable time was spent in preparation of this annual report. Progress reported and data submitted only include work completed by 25 February 1976 due to the necessity for project investigators to complete reports before beginning field work in early March.

Table 5. Schedule of 4th quarter activities, 1 January - 1 April 1976.

Activity	Dates	Personnel
Laboratory processing of seal stomachs, invertebrate identifications	Continuous	K. Frost, L Lowry, G. Seaman, other ADF&G personnel
Compilation of literature from OASIS search, other library work.	Intermittent	L. Lowry, K. Frost
Data management - development of data forms, hiring and training of person to coordinate data management activities	Intermittent	J. Burns, L. Lowry, K. Frost
OCS Littoral Zone Workshop	Jan. 12-14	L. Lowry
Field trip to Nome and St. Lawrence Island for collection of specimen material	Feb. 17-24	L. Lowry, T. Eley
Compilation of Data and preparation of OCS annual report	Feb. 25 - Mar. 10	L. Lowry, K. Frost, J. Burns
Cruise on NOAA R/V Surveyor to Bering Sea ice edge for collection of data and specimen material on seals, fishes and invertebrates	Upcoming Mar. 13 - Apr. 26	L. Lowry, J. Burns, E. Muktoyuk, K. Frost

References

Arseniev, V. A. 1941. Food of the ribbon seal (Histriophoca fasciata) [in Russian]. Izv. TINRO 20:121-127.

Barabash-Nikiforov, I. I. 1936. Pinnipeds of the Commander Islands, pp. 223-237 in S. V. Dorofeev and S. J. Frieman (ed.). The marine mammalia of the USSR Far East [in Russian]. Trudy VNIRO, Vol. III, Moscow.

Briggs, K. T. and C. W. Davis. 1972. A study of predation by sea lions on salmon in Monterey Bay. Bull. Calif. Fish and Game 58:37-43.

Burns, J. J. 1967. The Pacific bearded seal. Alaska Dept. Fish and Game, Juneau. 66pp.

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

__________. in press. The ribbon seal.

__________ and S. Harbo, Jr. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25:279-290.

Crane, J. J. 1974. Ecological studies of the benthic fauna in an arctic estuary. M.S. Thesis. Univ. of Alaska, Fairbanks. 104pp.

Dunbar, M. J. 1941. On the food of seals in the Canadian eastern arctic. Can. J. Res. D. 19:150-155.

__________. 1954. The amphipod crustacea of Ungava Bay, Canadian eastern Arctic. J. Fish. Res. Bd. Can. 11:709-798.

Fay, F. H. 1974. The role of ice in the ecology of marine mammals of the Bering Sea, pp. 383-399 in D. W. Wood and E. J. Kelley (ed.). Oceanography of the Bering Sea. Inst. of Mar. Sci., Univ. of Alaska, Fairbanks.

Gol'tsev, V. N. 1971. Feeding of the common seal [in Russian]. Ekologiya 2:62-70.

Johnson, M. L., C. H. Fiscus, B. T. Ostenson and M. L. Barbour. 1966. Marine mammals, pp. 897-924 in N. J. Wilimovsky and J. N. Wolfe (ed.). Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Kenyon, K. W. 1962. Notes on the phocid seals at Little Diomede Island, Alaska. J. Wildl. Manage. 26:380-387.

Kosygin, G. M. 1966. Some data on food and food habits of lakhtak (bearded seal) during spring and summer in the Bering Sea. [in Russian]. Izv. TINRO 58:153-157.

Pikharev, G. A. 1941. Some data on the food of Far Eastern bearded seals (Erignathus barbatus Pall.) [in Russian]. Izv. TINRO 20:101-120.

__________. 1946. The food of the seal Phoca hispida [in Russian]. Izv. TINRO 22:259-261. (Transl. Fish. Res. Bd. Can. No. 150).

Rae, B. B. 1973. Further observations on the food of seals. J. Zool. 169:287-297.

Reiger, G. 1975. Song of the seal. Audubon 77:6-27.

Scammon, C. M. 1874. The marine mammals of the northwestern coast of North America. John H. Carmany and Company, San Francisco. 319 pp.

Shustov, A. P. 1965. The food of ribbon seals in the Bering Sea [in Russian]. Izv TINRO 59:178-183.

Spaulding, D. J. 1964. Comparative feeding habits of the fur seal, sea lion and harbour seal on the British Columbia coast. Fish. Res. Bd. Can. Bull. 146. 52pp.

Scheffer, T. H. and C. C. Sperry. 1931. Food habits of the Pacific harbor seal, Phoca richardii. J. Mammal. 12:214-226.

Stoker, S. W. 1973. Under-ice studies of the winter benthos on the continental shelf of the Northeastern Bering Sea. M.S. Thesis, Univ. of Alaska.

Van Winkle, M. E. and W. L. Schmitt. 1936. Notes on the Crustacea, chiefly Natantia, collected by Captain Robert A. Bartlett in Arctic Seas. J. Wash. Acad. Sci. 26:324-331.

Wilke, F. 1954. Seals of northern Hokkaido. J. Mammal. 35:218-224.

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Assessment of the Distribution and Abundance of Sea Otters Along the Kenai Peninsula, Kamishak Bay and the Kodiak Archipelago

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April 1, 1976

I. Summary

Aerial and boat surveys were conducted around the Kenai Peninsula and the Kodiak Archipelago to determine the present distribution and relative abundance of sea otters. Sea otter populations in these areas are relatively small but are expanding their range. The potential for adverse impacts of OCS activities on sea otters appears high. Sea otters are more vulnerable to direct oiling than any other species of marine mammal and they may be indirectly affected by chronic low levels of pollution through the food chain. Where populations are expanding their range, a localized influence could retard repopulation of large areas. Sea otters exert a significant impact on nearshore marine communities. It is necessary to consider the history of sea otter occupation of an area when studies of these communities are conducted. Information being gathered under this project will be used to trace the patterns of range expansion, predict future trends, identify those areas where OCS activities would have greatest impact on the population and provide a basis for evaluating the sea otter's role in changes in marine communities.

Data collected on a helicopter survey in October 1975 and a boat survey in February 1976 indicate that sea otters have reoccupied all of the available habitat from Port Graham to Cape Puget on the Kenai Peninsula and are now expanding into Kachemak Bay and lower Cook Inlet. The area from Gore Point to Port Graham currently supports high sea otter densities and is probably the major source of animals repopulating Kachemak Bay. This area appears critical to the process of repopulation as are Kachemak Bay and offshore areas between Homer and Anchor Point. The area east of Gore Point appears to contain less suitable habitat. The sea otters there are probably contributing little to range expansion and may be relatively protected from oil spills by the topography of the area.

The population around the north end of the Kodiak Archipelago has grown and expanded its range rapidly in recent years. Its primary range presently extends southward to Ban Island on the west side and Marmot Strait on the east side of the Archipelago. Small numbers extend to Uyak Bay and Spruce Cape. Rapid range expansion into Marmot and Chiniak Bays is expected in the next few years. The entire northern portion of the Archipelago appears critical to the process of repopulation of former sea otter habitat.

Other sea otter populations which will be surveyed in the future are known to exist in Kamishak Bay, the Barren Islands and around the south end of the Kodiak Archipelago.

II. Introduction

Sea otters were reduced to very low numbers by commercial hunting between 1742 and 1911. A number of small nucleus populations did survive, however, and many have steadily grown and expanded their ranges. For the past 20 years the pattern of repopulation of former sea otter habitat has been monitored by the U. S. Fish and Wildlife Service and the Alaska Department of Fish and Game through a series of surveys (Lensink 1960, Kenyon 1969, Schneider unpublished data). In recent years survey techniques have been refined to permit more realistic estimates of abundance, although we are still unable to census sea otters with a high degree of confidence over large areas (Schneider 1971, Estes and Smith 1973).

Most of these efforts were directed at populations in the Aleutian Islands where rapid range expansion was taking place. Through a combination of extensive aerial surveys and intensive boat and shore counts it was possible to assess the status and trends of sea otter populations, identify critical areas, predict patterns of range expansion and evaluate the impacts of both natural and unnatural catastrophic events.

Sea otter populations in the Gulf of Alaska have generally been smaller and attracted less attention from scientists. The status of these populations has been monitored through a haphazard series of fragmentary surveys and reported sightings. Calkins et al. (1975) summarized most of the pertinent available data. While the basic distribution of sea otters was known and some rough estimates of abundance had been made (A.D.F.& G. 1973) it was clear that the basis for assessment of changes in distribution and abundance was poor.

Concern for the potential effects of the Trans-Alaska oil pipeline terminal, the proposed Trans-Alaska gas pipeline terminal and associated tanker traffic on marine mammals in general and sea otters in particular caused scientists to turn their attention to the Prince William Sound area. The Alaska Department of Fish and Game conducted two helicopter surveys (Pitcher 1975) and cooperated with the U. S. Fish and Wildlife Service in a supportive boat survey. The U. S. Fish and Wildlife Service then initiated more intensive studies adjacent to tanker routes and terminal sites.

Sea otters are probably the most vulnerable of all marine mammals to the direct effects of oil. Unlike most marine mammals they have no thick blubber layer. They rely on air trapped in their dense fur for conservation of body heat and buoyancy. When clean this mat of fur is waterproof and the skin over most of the body remains dry. If the fur is soiled it loses its water repellency and its insulative quality. If this is not corrected quickly the animal will die of hypothermia. While little information is available on the quantities and types of petroleum products necessary to kill a sea otter, it appears that exposure to relatively small amounts of both refined fuels and crude oil will cause death (Kenyon no date, Schnieder unpublished data). Kenyon (1969) cited cases where massive kills may have occurred near shipwrecks.

Long-term chronic pollution may have serious detrimental impacts on all high trophic level species if one or more of the links in the food chain are affected. Sea otters require very large quantities of food (20 to 25 percent of their own body weight per day) to support their high metabolic rate. The main factor limiting most sea otter populations appears to be food availability.

Sea otters in most areas appear to be relatively sedentary and feed on relatively sessile organisms. Therefore they may be exceptionally sensitive to changes in the food chain and any such effects would tend to be site specific.

All of the populations of sea otters bordering the Gulf of Alaska are still recovering from the period of commercial exploitation, and are expanding their range into unpopulated or sparsely populated habitat. The range of some of these populations is extremely limited. Very localized effects of human activity could endanger some of these populations and seriously retard the process of repopulation of former sea otter habitat.

Sea otters exert a profound influence on nearshore plant and animal communities (Faro 1969, Estes and Palmisano 1974, and others). Knowledge of the history of sea otter occupancy of an area is necessary for understanding changes in those communities.

The purpose of this project is to extend the work started in Prince William Sound (Pitcher 1975) to the Kenai Peninsula, Kamishak Bay and the Kodiak Archipelago. The primary technique is a helicopter survey of known concentrations of sea otters supplemented by fixed wing aerial surveys, boat counts and compilation of miscellaneous sightings.

The information being collected will allow us to map out the present distribution and relative abundance of sea otters in those areas. With existing data this will allow us to determine trends in population growth and range expansion. It should be possible to document the history of each population for purposes of assessing the sea otter's impact on each area and to predict the patterns of future range expansion and within some limits the timing of this expansion. We will be able to identify areas critical to the survival and continued growth of the population. With information from other studies on other components of the marine community, current and wind patterns, etc. it should be possible for decision makers to regulate OCS activities to minimize adverse impacts on sea otters.

III. Current State of Knowledge.

Calkins et al. (1975) provided the most current summary of available information on sea otter distribution and abundance in the study areas prior to the initiation of this project. The following discussion is extracted from that report.

Kenai Peninsula

Prior to 1967, only scattered observations of otters had been reported from Cape Puget to Port Graham on the Kenai Peninsula. In 1967 large numbers of otters began to be sighted regularly on the southern tip of the Kenai Peninsula in the area from Koyoktaluk Bay to Chugach Bay. In a 1968 survey of this area 400 otters were seen. Lensink (1960) reported sighting 15 animals near Elizabeth Island in 1953, while Kenyon (1969) felt that no significant population of otters occupied the area. The apparent movement of large numbers of otters to the southern tip of the Kenai Peninsula, probably from the Barren Islands, and subsequent expansion up the southeast side of the Kenai Peninsula, probably occurred in the years 1966 to 1968. At the same time otters from Prince William Sound probably moved into the eastern portion of the area.

Our most recent information from surveys conducted in 1970 confirms existence of otter concentrations on the tip of the Kenai Peninsula with scattered groups found along the coast up to Cape Puget (Table 1). It is important to realize that data presented in Table 1 originated from a series of surveys conducted by different observers under varying conditions from various fixed-wing aircraft. The large variation between surveys renders them useless for comparative purposes. The Kenai Peninsula information should only be used to indicate the presence of animals and can in no way be extrapolated to give total numbers. More work is required in this area to delineate the population. Reports from the public since 1970 indicate that up to 200 otters are regularly seen in Port Graham and that small numbers are straying into Kachemak Bay. Sightings from as far north of Kachemak Bay as Ninilchik are increasing.

Barren Islands

Sea otter sightings in the Barren Islands date back to 1931, when two otters were seen near Sud Island. Otters have been observed regularly in the Barren Islands since then. The highest count prior to 1970 was 325 animals seen in 1957 (Lensink 1960). Kenyon (1969) reported seeing 272 otters in the Barren Islands during a 1959 survey and estimated a population of 363 animals.

In June 1970 Schneider flew as the only observer in a Grumman Goose during a survey of the Barren Islands. Offshore coverage was poor although conditions and visibility were good and a complete count of the Barren Islands was made with a total count of 307.

Kamishak Bay

The Kamishak Bay area including Augustine Island, Shaw Island and Cape Douglas has been partially surveyed on numerous occasions. Lensink (1962) reported that approximately 50 otters were seen near Augustine Island in 1948 and that Spencer counted 40 at Augustine Island and one at Shaw Island in 1957. Lensink counted 52 at Augustine in 1959, but he considered it a poor count. In 1965 Kenyon counted 18 at Augustine Island and 101 in the Shaw Island-Cape Douglas area. In 1969 Alaska Department of Fish and Game biologists tallied 62 and 130 animals in the Augustine Island area on different counts. In 1971 Alaska Department of Fish and Game biologists counted 150 otters between Augustine Island and Tignagvik Point. Also in 1971 Prasil (1971) counted 60 otters between Augustine and Shaw Islands.

Kodiak Archipelago

Portions of the Kodiak-Shuyak-Afognak area, including the Trinity Islands and Chirikof Island, have good sea otter habitat. Some of the

Table 1. SEA OTTERS COUNTED ON AERIAL SURVEYS OF KENAI PENINSULA
June, 1970 - January, 1971

AREA	JUNE 5 & 9	JULY 15-20	AUG. 14	OCT. 12	NOV. 12	JAN. 12
C. Junken-C. Resurrection	5	30	42	27	10	30
Resurrection Bay	2	2	0	4	2	NS
Aialik Bay	1	20	5	8	0	21
Harris Bay	8	18	7	5	3	25
Nuka Bay	106	16	NS	31	28	27
Port Dick	0	11	NS	NS	3	23
Rocky Bay-Port Chatham	121	115	NS	NS	9	26
Koyuktolik Bay-Port Graham	0	0	NS	NS	0	NS
Total	243	212	54	75	55	152

* 38 Sea otters counted from shore and skiff 11/20/70.

area is undoubtedly of poor quality. Kodiak was an important hunting area during the period of Russian exploration, but the population was never completely extirpated.

Reports from the Kodiak area are fragmentary and incomplete; no thorough surveys have been attempted. We know that a relatively large population exists at the north end of the group and a population of unknown size occurs at the south end.

In 1948 Refuge Manager Beals reported three otters off Shuyak Island and in 1951 Chapados and Spencer saw 15 on Sea Otter Island and 67 at Latax Rocks (Lensink 1960). In 1957 Lensink saw 14 in the Trinity Islands and 281 around the Shuyak area. In 1964 Ed Klinkhart counted 63 sea otters at Latax rocks, 13 at Seal Island and one at Marmot Island. Most recently (July 1975) 15 were sighted off the south end of Marmot Strait.

Sightings at areas other than the north and south ends include five sighted by James Faro at Uyak Bay, three near the south end of Chirikof sighted by the crew of the "Teal" and, most recently, 10 otters sighted by Ben Ballenger in April 1975 just off Outlet Cape south of Raspberry Island.

The most recent survey information came from Schneider (1970, unpub. report) who saw 18 at Ban Island-Shuyak Strait, six in Perenosa Bay, three at Marmot Island, 121 in the area of Sea Otter Island, 33 on the west side of Shuyak Island and 26 in the area of Latax Rocks and Dark Island for a total of 207. A separate group of unknown size inhabits the shallow waters around the Trinity Islands and Chirikof Island. Lensink (1962) reported several sightings of up to 15 animals in the 1950's. Reports of small numbers and occurrenceof beach-dead animals on Tugidak Island indicate that at least moderate numbers occur there.

Lensink (1960) estimated the total sea otter population of the Kodiak Archipelago including the Barren Islands at 800-1,500, while Kenyon (1969) indicated that the Kodiak area had not been repopulated to a significant degree with a total estimate of 1,118 otters. Our most recent information suggests that this population should now be well over 2,000 animals and is probably slowly expanding to Kodiak Island.

IV. Study Area.

The study area includes the shoreline and adjacent waters of less than 40 fathoms in depth including all offshore rocks and islets and floating glacial and sea ice pans in the following areas.

1. The Kenai Peninsula from Cape Puget to the mouth of the Kenai River including the Chugach Islands.

2. The west side of lower Cook Inlet from Tuxedni Bay to Cape Douglas including Augustine Island.

3. The Barren Islands.

4. The entire Kodiak Archipelago including Shuyak Island, Afognak Island, Marmot Island, Kodiak Island, the Trinity Islands and Chirikof Island.

V. Methods of Data Collection.

Between 1 October and 7 October 1975 a helicopter survey was made of the Kenai Peninsula and the northern part of the Kodiak Archipelago. A Bell 206B "Jet Ranger II" helicopter (N90217) was flown along the survey trackline at altitudes of 50 to 70 m and an average airspeed of 70 knots. Altitude and airspeed were varied according to counting conditions. A forward observer sat in the left front seat and counted animals directly in front and to the left of the helicopter, an offshore observer sat in the right rear seat and counted on the right side, and a recorder sat in the left rear seat and recorded all observations and photographed concentrations of marine mammals. Both the pilot and recorder assisted the observers by pointing out animals. Personnel were Vernon Lofstedt - pilot, Karl Schneider - forward observer, Donald Calkins - recorder, Warren Ballard - right observer on the Kenai Peninsula, and Kenneth Pitcher -right observer on Afognak Island. This survey required a total of 38.4 hours of flying time including 25.1 hours of actual survey time.

Sea otters were counted visually. Large pods of sea otters were photographed and the number of individuals was determined from projected 35mm slides.

Survey conditions which influenced the observability of sea otters were classified according to the following system.

Code

1 Excellent - surface of water calm, usually a high overcast sky with no sun glare. Sea otters appear dark against a uniformly light gray background of the water's surface. Individuals easily distinguished at a distance.

2 Very good - may be light ripple on water's surface or slightly uneven lighting but still relatively easy to distinguish individuals at a distance.

3 Good - may be light chop, some sun glare or shadows. Individuals at a distance may be difficult to distinguish but individuals nearby and small groups at a distance are readily identified.

4 Fair - usually choppy waves and strong sun glare or dark shadows in part of the survey track. Individuals in kelp beds, in the lee of rocks, or near the observer and most pods readily identified but most individuals and some pods in areas of poor lighting or at a distance difficult to distinguish.

5 Poor - individuals difficult to distinguish unless very close and some pods at a distance may be missed, however conditions still good enough to give a very rough impression of the distribution of animals.

6 Unacceptable - heavy chop with many whitecaps, lighting poor or large waves breaking on rocks. No surveys should be conducted under these conditions but occasionally a sighting of significance may be made in the course of other activities.

Conditions may vary within a single count area. Therefore the classification may represent the average conditions encountered.

Between 3 February and 11 February 1976 counts of sea otters were made from skiffs along portions of the Kodiak Archipelago. Three observers jointly counted numbers of pups and numbers of adults as the skiff paralleled the shoreline and circled offshore rocks. Binoculars were used to aid counts offshore and to identify pups.

Sightings of significance, primarily around the fringes of the present populations, were collected by biologists and technicians of the Alaska Department of Fish and Game.

Considerable time was spent in designing an ADP format for storage and retrieval of this type of information. The study areas are being divided into standardized subunits that will permit presentation of data in a manner that will graphically show past and future population shifts. Data in hand have been partially converted to conform to this format but final compilation is pending final adoption of the format.

VI. Results.

Results of the 1 October - 7 October helicopter survey are presented in Table 2 and displayed graphically in Figs. 1 - 6. The survey tracks are also shown in Figs. 1 - 6. Skiff counts and other sightings made between 3 February and 11 February are presented in Table 3 and Figs. 7 - 8. Significant sightings not previously reported are summarized in Table 4. It should be noted that these data are not presented in the standardized format that is being developed. Presentation of all data in the final report will conform to that format.

VII. Discussion

The effectiveness of surveys of the type being used in this project can be highly variable. Results should be interpreted carefully with consideration of the survey conditions and the thoroughness of coverage. The probability of sighting a sea otter is influenced by the speed and altitude of the platform, distance from the trackline, lighting conditions, sea state, activity of the animal, group size and presence of birds, other marine mammals, kelp etc. Experience indicates that many otters are missed even under ideal conditions and ideal conditions rarely occur along Alaska's coast. Some success has been achieved in attempts to census sea otters through intensive use of combinations of air and ground counts over small areas and at considerable cost. These indicate that there may be 1.5 to 4 times as many sea otters as are seen from a helicopter, but it has never been possible to measure all variables. Therefore the counts presented in this report should not be considered total counts. They do represent distribution and relative abundance.

Kenai Peninsula

Survey conditions around the Kenai Peninsula in October were less than ideal. The percentage of sea otters recorded was probably near the lower part of the range for helicopter surveys. There may be three or

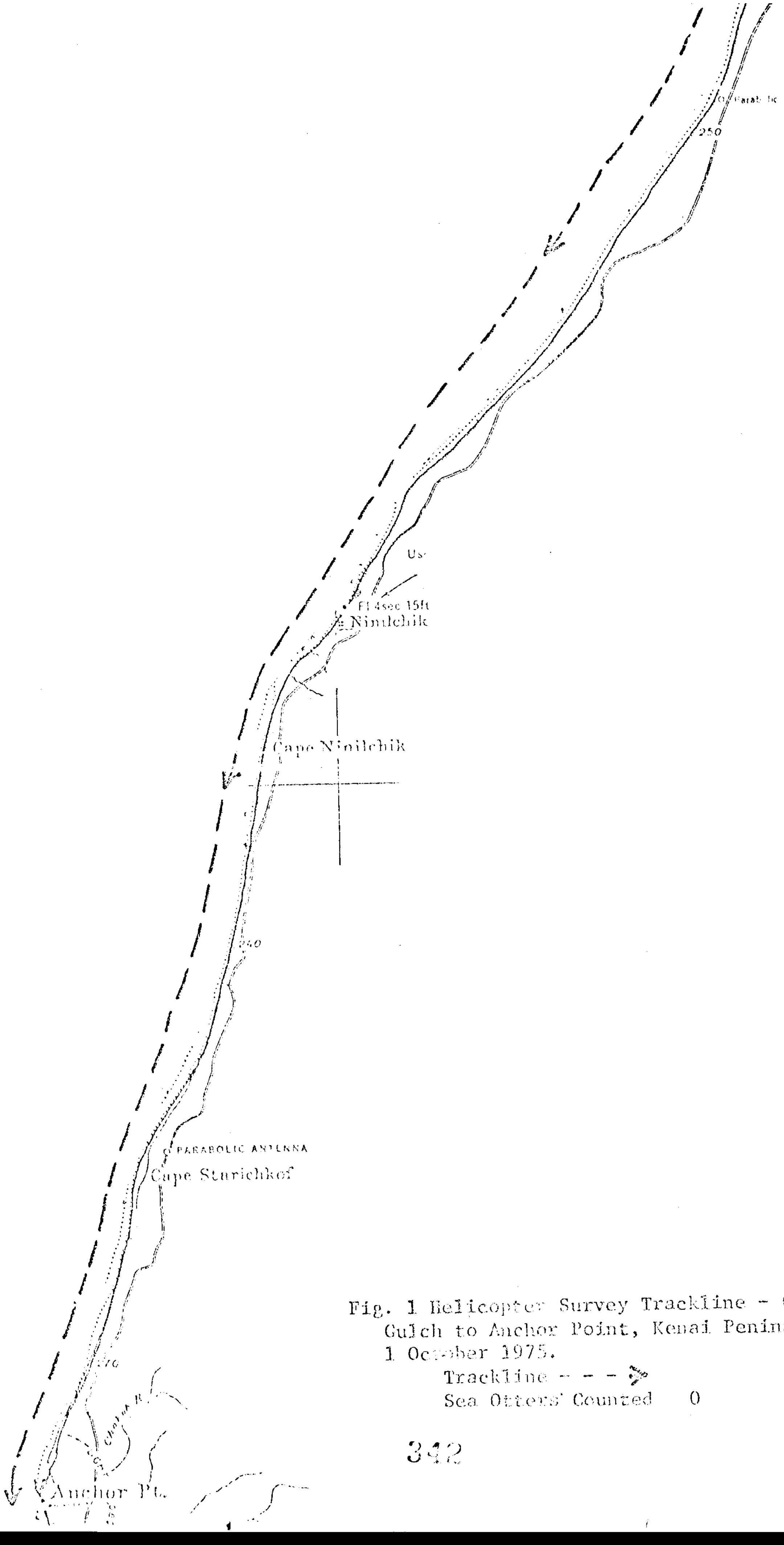


Fig. 1 Helicopter Survey Trackline - Clam Gulch to Anchor Point, Kenai Peninsula - 1 October 1975.
Trackline - - - >
Sea Otters Counted 0

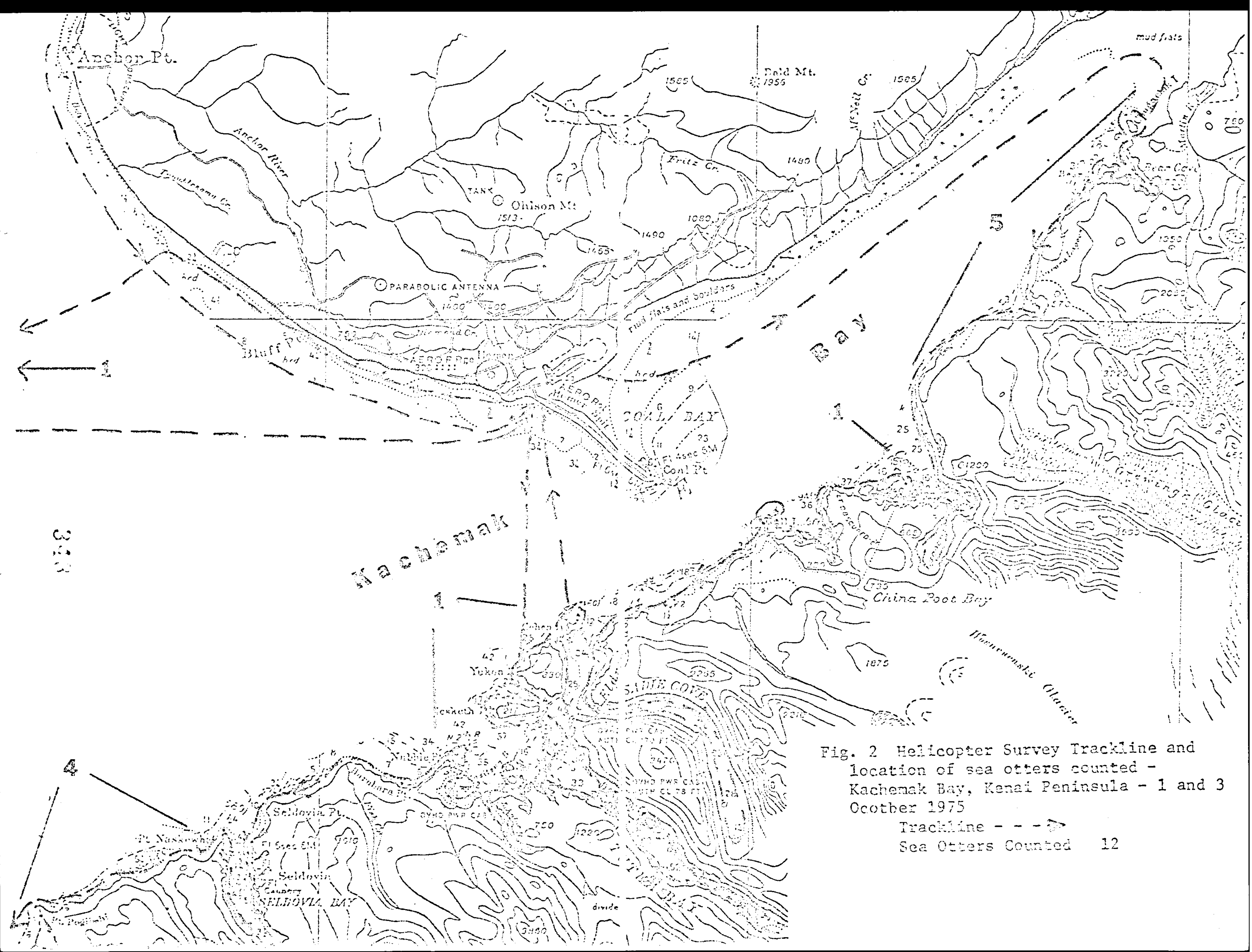


Fig. 2 Helicopter Survey Trackline and location of sea otters counted - Kachemak Bay, Kenai Peninsula - 1 and 3 Ocotber 1975

Trackline - - -▷

Sea Otters Counted 12

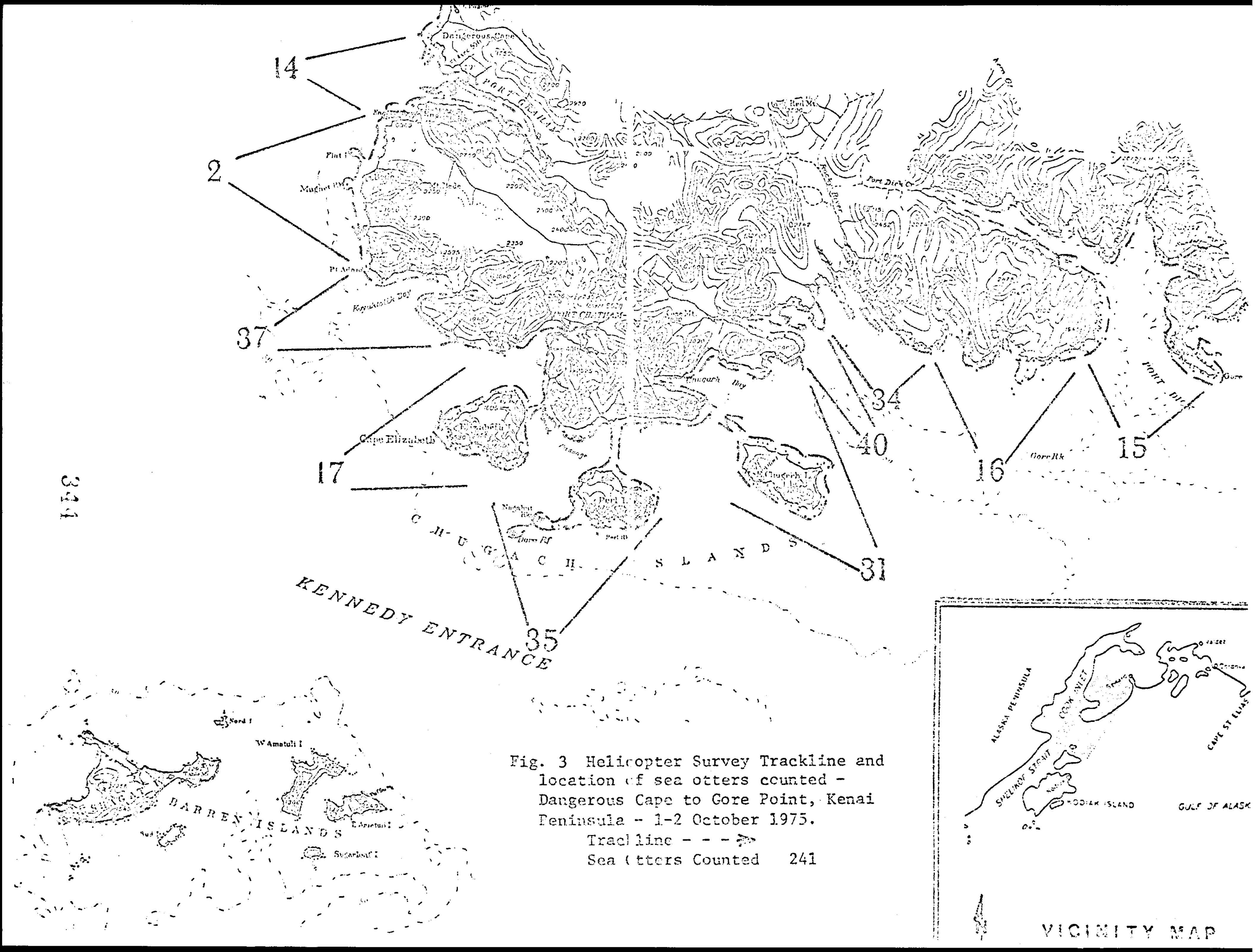
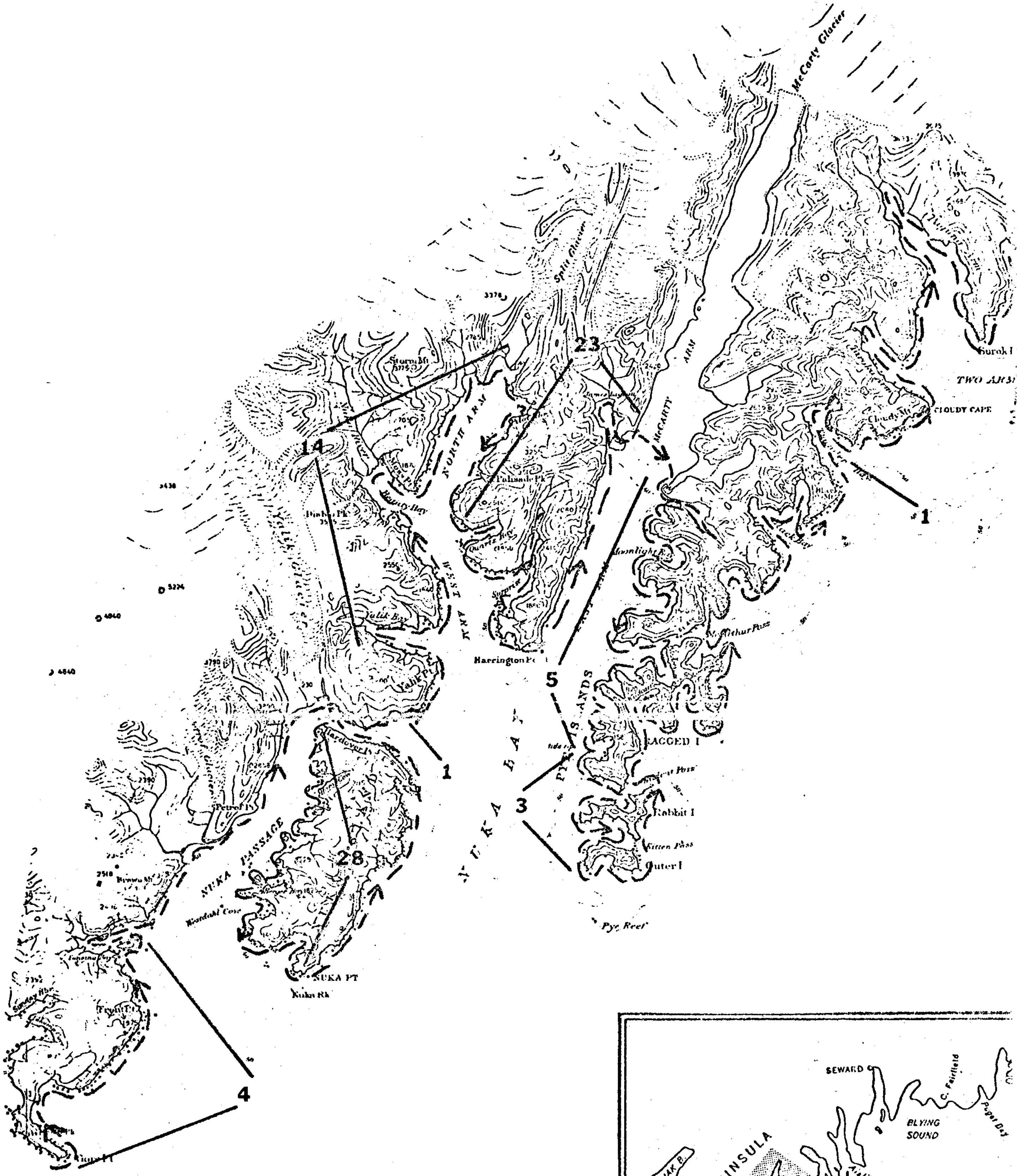


Fig. 3 Helicopter Survey Trackline and location of sea otters counted - Dangerous Cape to Gore Point, Kenai Peninsula - 1-2 October 1975.

Trackline - - - ➳

Sea Otters Counted 241



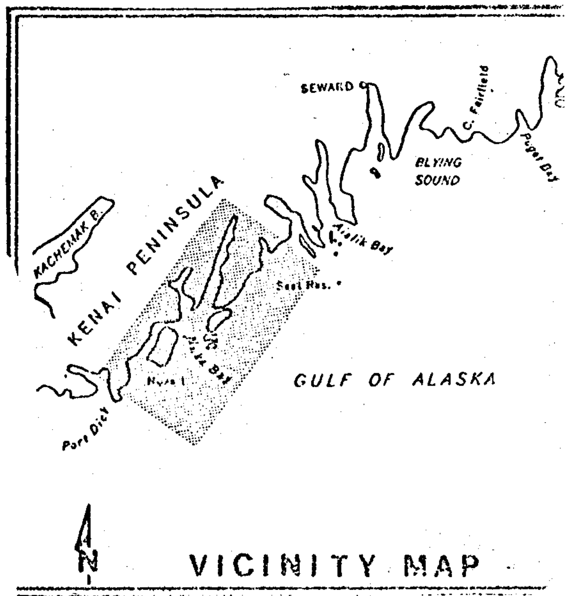


Fig. 4 Helicopter survey trackline and location of sea otters counted - Gore Pt. to Harris Pt., Kenai Peninsula - 2, 3, 4 October 1975.

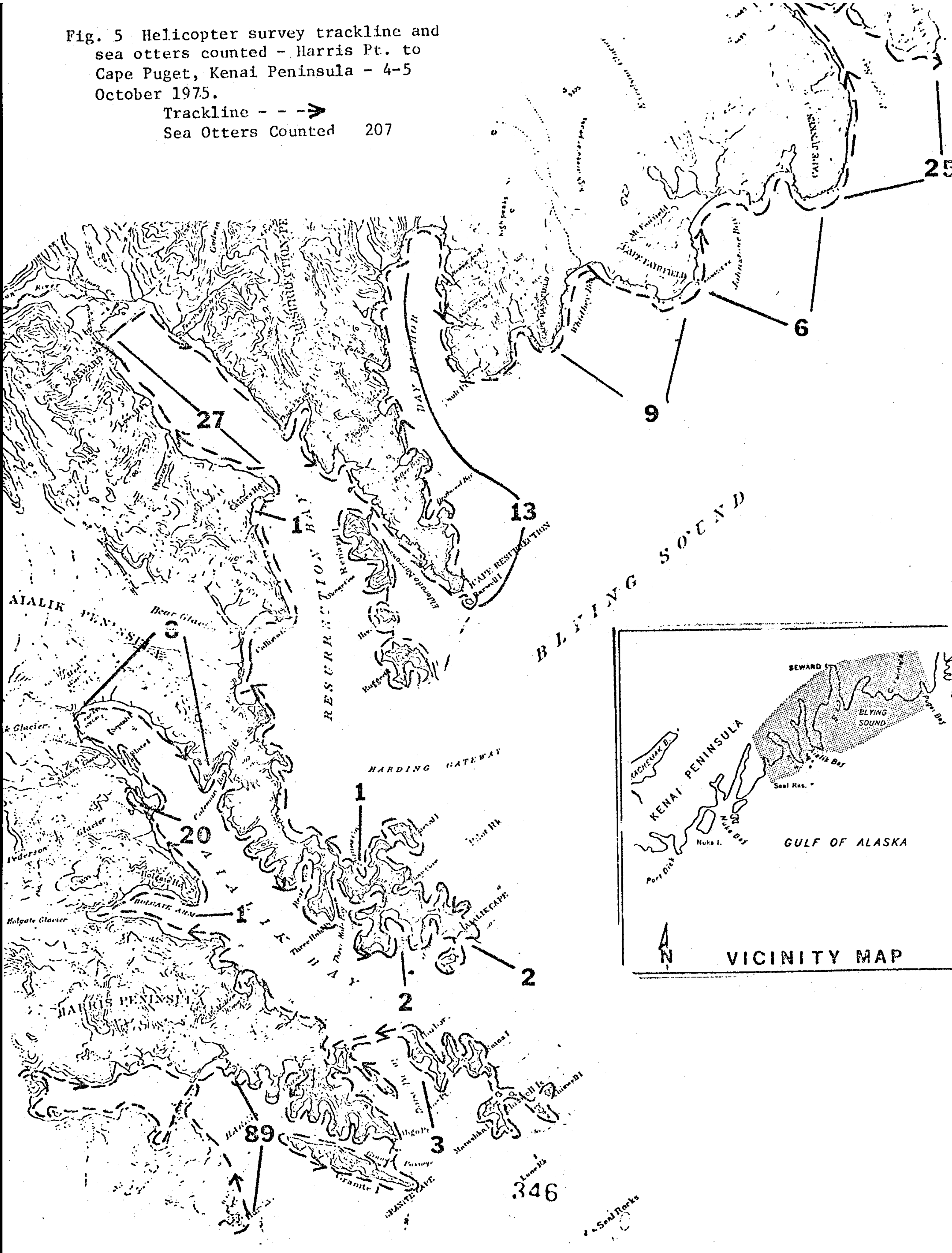
Trackline - - ->

Sea Otters Counted 82

Fig. 5 Helicopter survey trackline and sea otters counted - Harris Pt. to Cape Puget, Kenai Peninsula - 4-5 October 1975.

Trackline - - - ➔

Sea Otters Counted 207



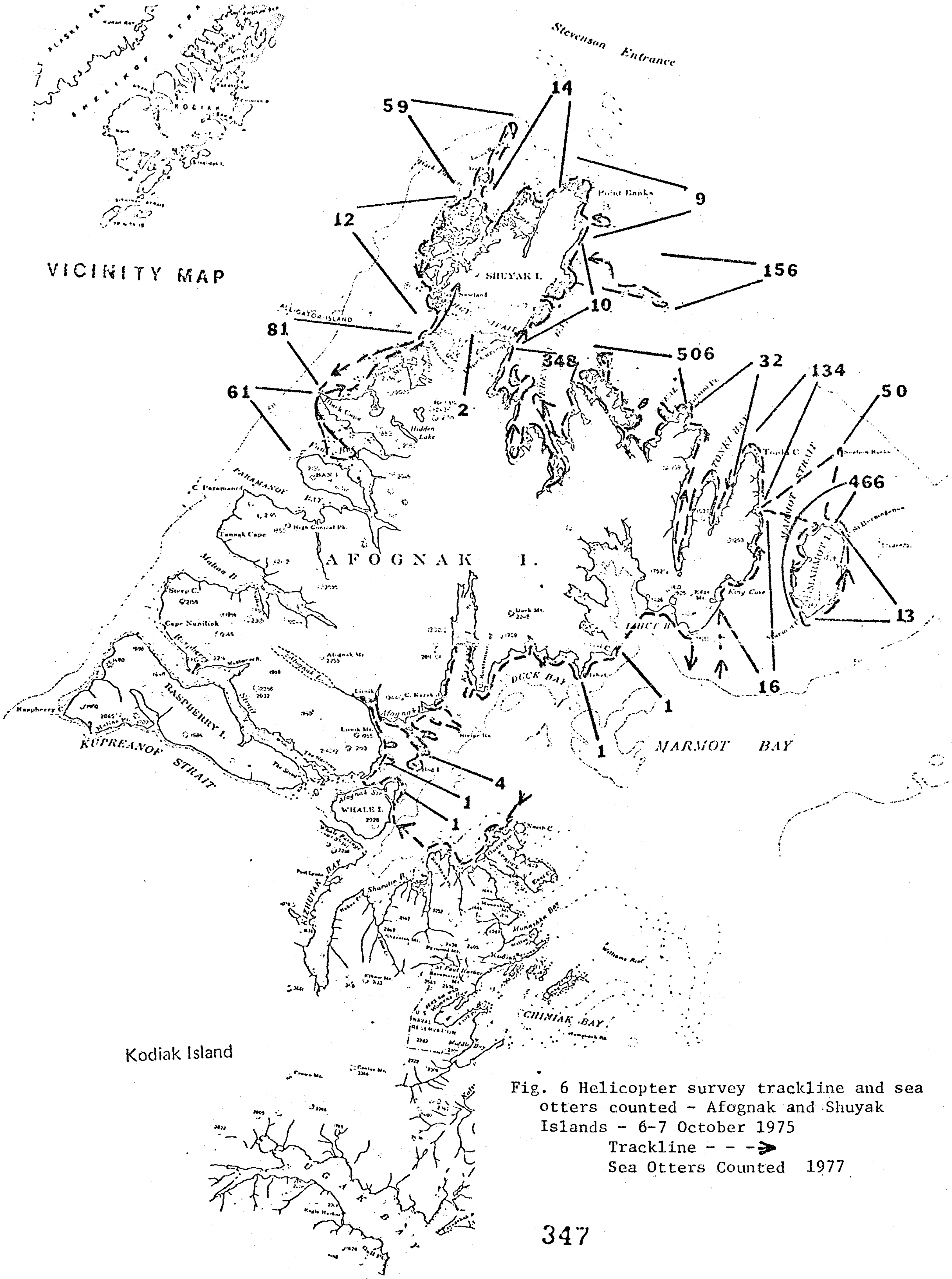


Fig. 6 Helicopter survey trackline and sea otters counted - Afognak and Shuyak Islands - 6-7 October 1975

Trackline - - -➔

Sea Otters Counted 1977

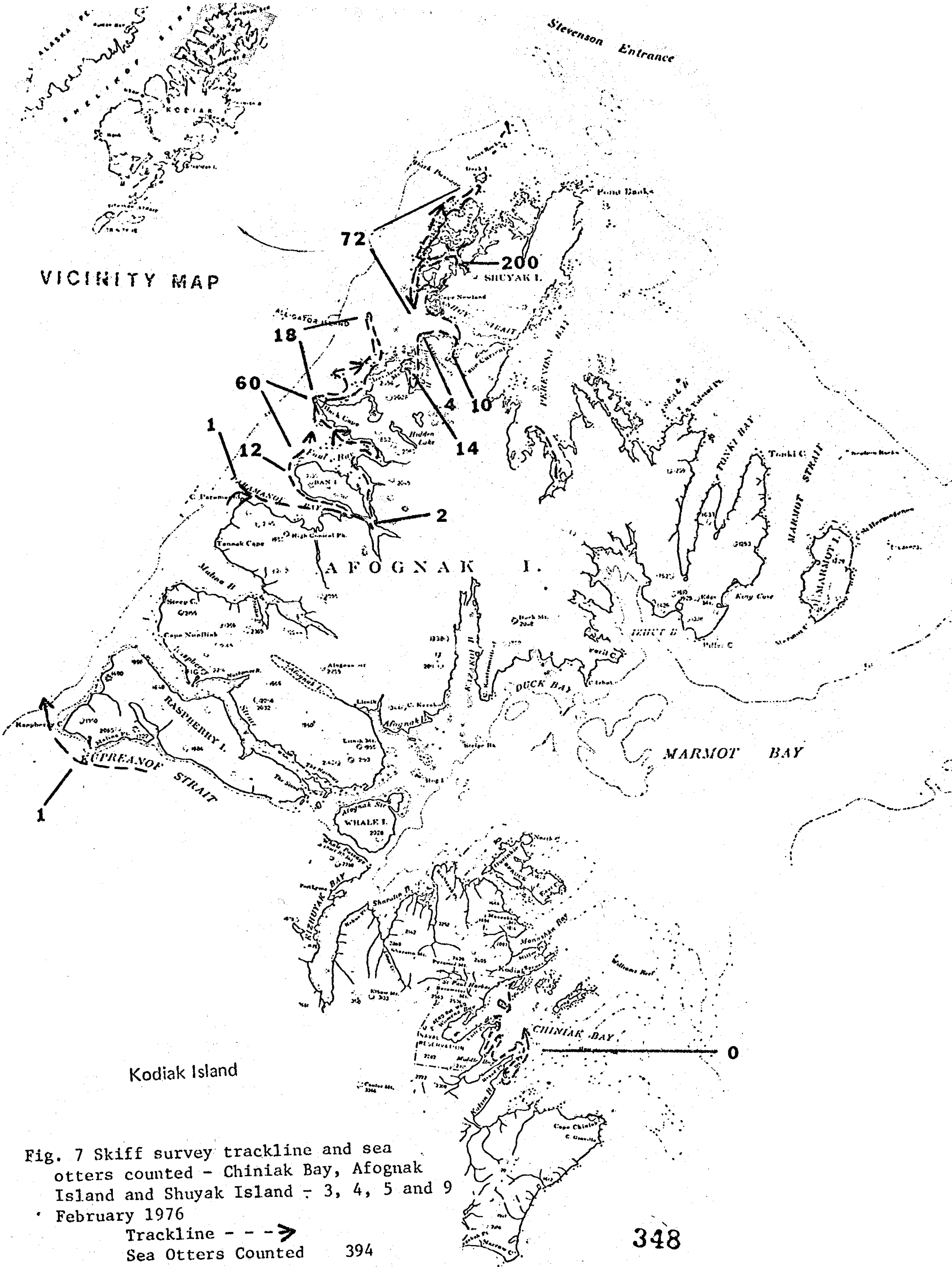


Fig. 7 Skiff survey trackline and sea otters counted - Chiniak Bay, Afognak Island and Shuyak Island - 3, 4, 5 and 9 February 1976

Trackline - - ->

Sea Otters Counted

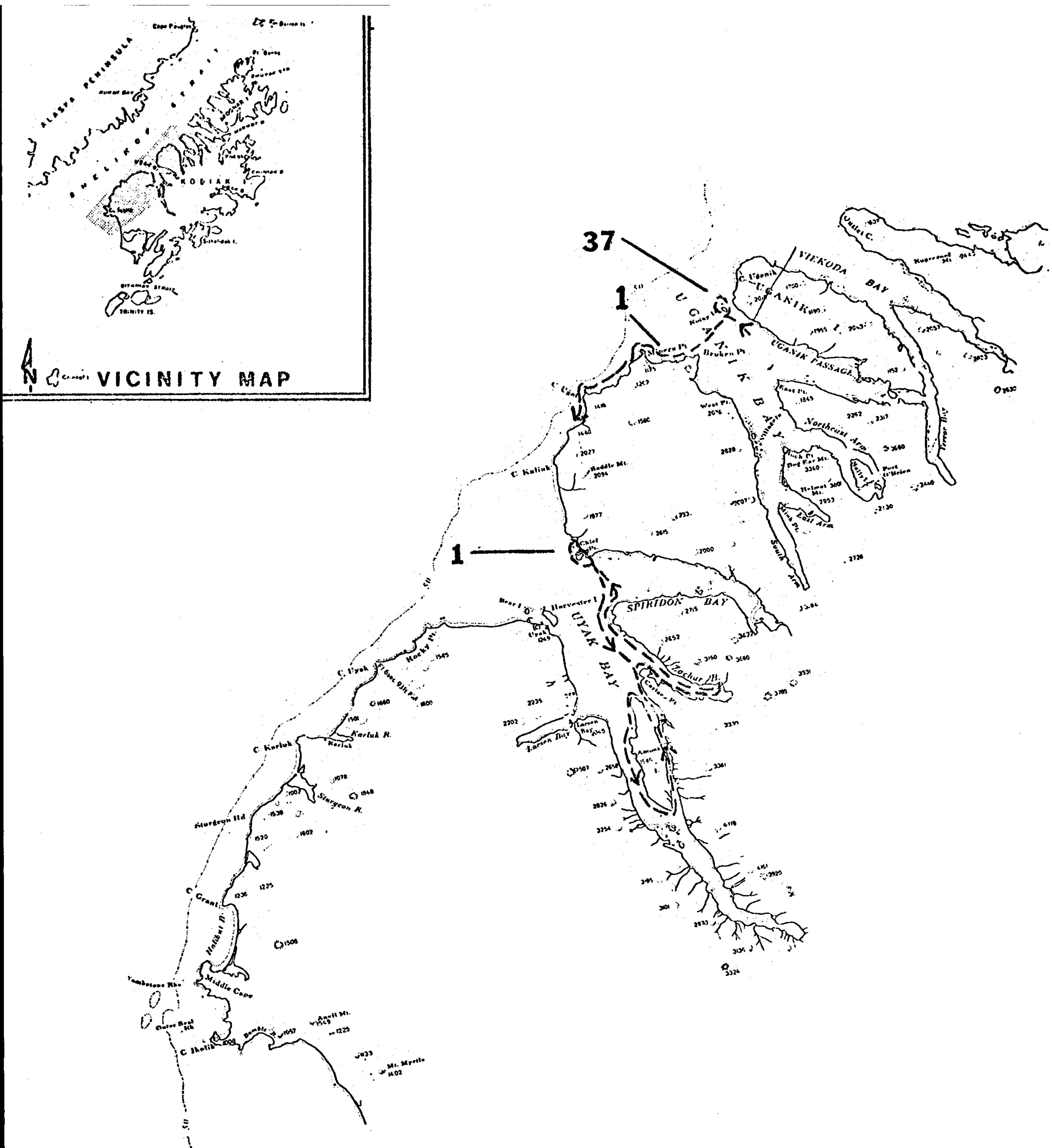


Fig. 8 Skiff survey trackline and sea otters counted - Uganik Island to Uyak Bay, Kodiak Island - 10-11 February 1976

Trackline - - - ->

Sea Otters Counted 39

Table 2. Helicopter counts of sea otters around the Kenai Peninsula and the Kodiak Archipelago 1 Oct. - 7 Oct. 1975 (See figs. 1-6 for survey tracklines).

Kenai Peninsula

Area	Date Surveyed	Sea Otters Counted	Survey Conditions
Kenai River - Anchor Pt.	10/1/75	0	Fair
Anchor Pt. - Homer Spit	10/1/75	0	Fair
Anchor Pt. - Homer Spit	10/3/75	1	Very Good
Homer Spit - Fox River	10/1/75	0	Very Good - Excellent
Fox River - Gull I.	10/1/75	6	Fair - Good
Gull I. - Seldovia Pt.	10/1/75	1	Good
Seldovia Pt. - Dangerous Cape	10/1/75	4	Fair - Good
Dangerous Cape - Pt. Adam	10/1/75	16	Fair
Pt. Adam - Elizabeth I.	10/1/75	54	Fair - Poor
Perl I. - Chugach Bay	10/2/75	66	Fair - Poor
Windy Bay - Rocky Bay	10/2/75	90	Fair
Port Dick	10/2/75	15	Fair
Gore Pt. - Nuka Pt.	10/2/75	32	Fair
Nuka Pt. - Pye Reef	10/2,3,4/75	46	Poor - Incomplete
Pye Reef - Surok Pt.	10/4/75	1	Poor
Surok Pt. - Aligo Pt.	10/4/75	92	Very Good
Aligo Pt. - Aialik Cape	10/4/75	36	Very Good
Aialik Cape - C. Resurrection	10/4,5/75	29	West side-Good,East side-Poor
C. Resurrection - C. Mansfield	10/5/75	13	Fair - Good
C. Mansfield - C. Junken	10/5/75	15	Fair
C. Junken - C. Puget	10/5/75	25	Good
Kenai Peninsula Total		542	

Kodiak Archipelago

Area	Date Surveyed	Sea Otters Counted	Survey Conditions
Ouzinki	10/6/75	0	Poor
Afognak Bay	10/6/75	6	Fair
Kazakof Bay	10/6/75	0	Poor
Duck Bay	10/6/75	1	Poor
Izhut Bay (west)	10/6/75	1	Poor
Izhut Bay (east)	10/6/75	0	Poor
King Cove	10/7/75	16	Fair
Marmot I.	10/7/75	529	Fair
Tonki Cape	10/7/75	134	Good
Tonki Bay	10/7/75	32	Good
Seal Bay (east)	10/7/75	164	Good
Seal Bay (west)	10/7/75	342	Good
Perenosa Bay (south)	10/7/75	290	Excellent
Perenosa Bay (north)	10/7/75	58	Excellent
Shuyak (east)	10/7/75	10	Good
Sea Otter Island	10/7/75	156	Fair
Point Banks	10/7/75	9	Very Good
Shuyak (north)	10/7/75	14	Very Good
Latax Rocks	10/7/75	59	Very Good
Shuyak (west)	10/7/75	12	Very Good - Incomplete
Shuyak Strait	10/7/75	2	Very Good - Incomplete
Bluefox Bay	10/7/75	81	Very Good - Incomplete
Foul Bay	10/7/75	61	Very Good - Incomplete
Afognak-Shuyak Total		1977	

Table 3. Skiff Counts of Sea Otters in The Kodiak Archipelago 3 February - 11 February 1976 (See figs. 7-8 for Survey Tracklines).

Area	Date Surveyed	Sea Otters Counted Adults	Pups	Total	Survey Conditions
Kupreanof Strait	2/3/76			1	Poor
Paramanof Bay	2/3/76			1	Fair
Paramanof Bay	2/4/76			14	Fair
Foul Bay	2/4/76	56	4	60	Poor
Black Cape - Aligator I.	2/4/76	18	0	18	Fair
Bluefox Bay	2/4/76	13	1	14	Fair
Lighthouse Pt.	2/4/76	4	0	4	Poor
Redfox Bay	2/4/76	10	0	10	Fair
West Shuyak (outside)	2/5/76	65	7	72	Fair
West Shuyak (Big Bay)	2/5/76			200*	Fair
Noisy Islands	2/10/76	37	0	37	Excellent
Broken Pt. - C. Ugat	2/10/76	1	0	1	Fair
Ugak Bay	2/11/76	1	0	1	Very Good
Chiniak Bay	2/9/76			0	Fair

* Many Pups

Table 4. Recent significant sightings of sea otters reported to the Alaska Department of Fish and Game.

Location	Date	Number of Sea Otters	Observer
Kachemak Bay			
Bear Cove	Spring 1973	1	M. McBride
Peterson Bay	Spring 1973	1	M. McBride
8 mi. S. of Anchor Pt. & 12 mi. W. of Homer	3 June 1975	2	Dave V. ?
3-5 mi. offshore between Anchor Pt. and Homer	June 1975	6	Dave V. ?
5 mi. offshore - Bluff Pt.	15 June 1975	3	Wes. ?
3 mi. S. Anchor Pt.	1 June 1975	2	Lance Trasky
4-5 mi. offshore Diamond Gulch	Aug.-Dec. 1975	4	Paul Foster
Glacier Spit	1 June 1975	1	Bill McDermitt
Sadie Cove	4 May 1975	2	Merl Wolford
Tutka Bay	April-May 1975 (daily)	1	T. Kronin
Outer Kenai Coast			
Quartz Bay (Nuka Bay)	2 May 1975	50	S. Linderman
Chugach Passage	1 April 1975	"Hundreds"	T. Edwards
Port Graham	13 June 1975	40-50	K. Kyle
Kodiak			
Malina Pt. Raspberry I.	Spring 1975	20	"A Pilot"(B. Ballenger)
South of Marmot Strait	July 1975	25	B. Ballenger
Raspberry Strait	1975	1	B. Ballenger
Spruce Cape	"frequently" 1975	1-2	G. Hadju
Outlet Cape	22 April 1975	10	B. Ballenger

more times as many as counted. Occasional reports of up to 200 in Port Graham and "hundreds" in Chugach Passage tend to support this view. The survey did delineate the distribution of the population and provide good information on the relative abundance of sea otters occupying various parts of the area. These were the primary objectives of the survey.

Following is a discussion of the pattern of population changes that have occurred in the last 20 years, the present status of the population and probable future trends.

Sea otters were probably eliminated from the Kenai Peninsula by the early 1900's. It appears that remnant populations may have survived in southeastern Prince William Sound, the Barren Islands and Kamishak Bay. Small numbers were occasionally reported between the Chugach Islands and Cape Puget in the 1950's and early 1960's but Kenyon (1969) concluded that no significant population occurred in the area. Reports increased steadily through the mid 1960's and in 1967 several hundred abruptly appeared in the vicinity of Port Graham and Chugach Bay.

By 1970 sea otters were distributed in small numbers along the entire peninsula from Cape Puget to Port Graham. Rare sightings occurred in Kachemak Bay. It appeared that repopulation was the result of range expansion by the Prince William Sound population and large scale immigration from another area, perhaps the Barren Islands. Since 1970 no major changes have been reported although sightings in Kachemak Bay have increased and sea otters have become a common sight near Seward.

The October helicopter survey and recent sightings indicate that the distribution of sea otters is essentially the same as in 1970 except that some expansion into Kachemak Bay has occurred. The distribution and relative densities of sea otters between Port Graham and Cape Puget generally seem to conform to the distribution of suitable habitat.

This indicates that no major range expansion is occurring in that area and it is unlikely that significant changes will occur in the future, although densities may increase. Kachemak Bay and lower Cook Inlet appear to contain large areas of potential sea otter habitat. Repopulation of this habitat is occurring and the rate of immigration should accelerate. Kenyon (1969) described a common pattern of range expansion for sea otters. Concentrations often build up at the fringes of a population then abruptly disperse into adjacent habitat when competition for food occurs. These concentrations appear to be extremely important. Animals toward the center of the population probably contribute less to repopulation than those near the fringes. From this standpoint the area from Port Graham to Rocky Bay may be critical. A reduction in sea otter densities in that area could seriously retard repopulation of Kachemak Bay. Kachemak Bay should also be considered critical because of its potential as sea otter habitat.

Opportunities for the general public to view sea otters are extremely limited. Kachemak Bay will probably eventually be the most accessible sea otter viewing area in Alaska. Therefore the importance of the bay and its potential sea otter population is increased.

It is difficult to predict how far into Cook Inlet this population will expand. Some sea otters are capable of foraging in waters up the 40 fathoms deep. Vast areas of shallow water exist in Cook Inlet. The main limiting factor will probably be the distribution of food species and perhaps the distribution of seasonal sea ice. We have not adequately surveyed the area north of Homer, however the frequency of sightings 3 to 5 miles off Bluff Point in the past year (Fig. 9) suggests a recent population shift. These sea otters appear to have bypassed Kachemak Bay. Such leapfrogging usually indicates the presence of high quality habitat that will eventually support high densities of sea otters. It may be more than a coincidence that the same area has been identified as critical habitat for dungeness crab and other potential sea otter food items and was the focus of considerable concern during the recent Kachemak Bay lease sale. Sea otter distribution and abundance should be closely monitored in this area over the next few years.

Densities of sea otters between Gore Point and Cap Puget are low. The area consists of deep, steepsided fiords. Water of suitable depths for sea otter foraging is limited to a narrow band along the shores and a few scattered submerged glacial morains and shallow lagoons. The distribution of sea otters seems generally to coincide with the distribution of shallow water. Many concentrations were in or near lagoons. Most of these areas are inside the major bays. Very few sea otters were seen near exposed capes. Areas with a direct southeast exposure to the Gulf of Alaska are generally precipitous, wave scoured and offer little habitat for sea otters.

The combination of topography of the area and sparse distribution of sea otters would probably limit the impact of offshore oil spills in this area. Sea otters east of Gore Point are probably contributing less to repopulation of new areas than those west of Gore Point. If a short term impact such as an oil spill reduced sea otter numbers east of Gore Point, recovery could be rapid if the relatively dense populations in Prince William Sound and west of Gore Point remained unaffected. Perhaps the greatest loss in human terms would be a loss of opportunity to view sea otters should a reduction occur in Resurrection Bay.

Kodiak

Survey conditions were generally good around the north side of Afognak and Shuyak Islands in October. Many sea otters were resting in pods increasing their observability. The percentage of sea otters seen was probably much higher than that seen around the Kenai Peninsula. We were forced to terminate the helicopter survey before we could clearly delineate the southwestern fringe of the population. The February skiff survey and reported sightings corrected this one flaw and provided some information on shifts in distribution and sex segregation. The following is a discussion of the status of the Afognak-Shuyak population and recent range expansion trends.

A remnant population of sea otters survived in the Latax Rocks and Sea Otter Island areas. This population appeared to expand very slowly through the 1950's and early 1960's, although surveys were not adequate to determine changes in numbers. By 1970 it was evident that the population had expanded its range to Black Cape on the southwest and scattered otters were known to occur as far to the southeast as Marmot Bay. Large numbers probably were moving into Seal Bay but no data were available to

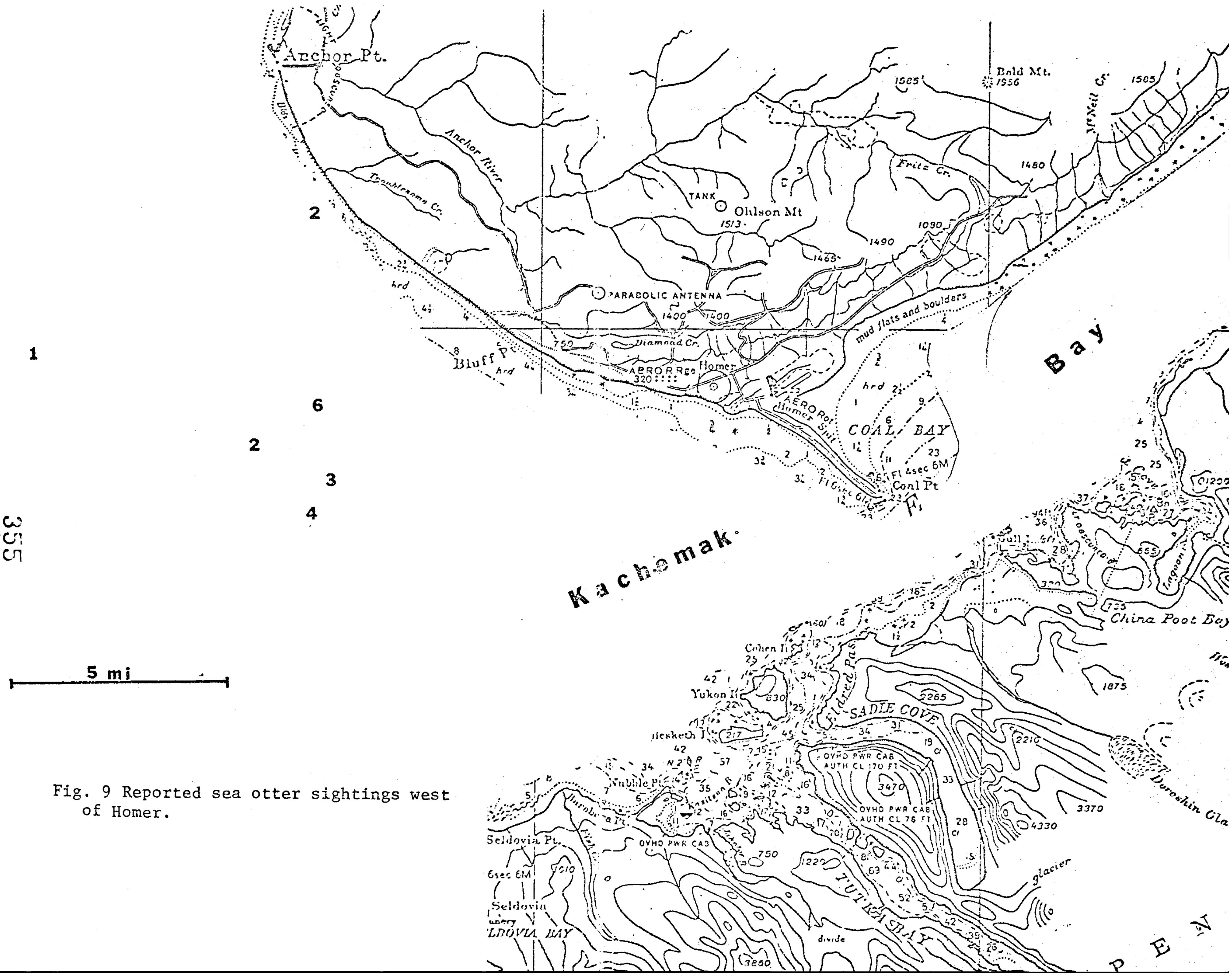


Fig. 9 Reported sea otter sightings west of Homer.

substantiate this. In the past 5 years sightings in Marmot Bay and around Marmot Island have increased steadily indicating that the rate of range expansion was accelerating. The full scope of this expansion was not evident until the October survey was conducted.

The area from Marmot Island to Ban Island presently supports sea otter densities comparable to anywhere in the world. While historical data are poor, the population appears to be expanding its range rapidly down both sides of the Kodiak Archipelago. High densities and high proportions of females with pups occur at both fringes of the population. Increasing numbers of animals without pups, probably mostly males, are being seen as far south as Spruce Cape and Uyak Bay. Based on range expansion patterns observed in other areas, we can expect massive immigration into Marmot and Chiniak Bays over the next few years.

This population has been vulnerable to oil spills for many years and the possibility that its growth has been retarded by periodic accumulation of oil from tanker ballast pumping has been considered.

The population is now sufficiently large and dispersed that it could survive even a massive oil spill. However repopulation of the remainder of the Archipelago could be retarded by either oil spills or the indirect effects of chronic pollution. The entire northern portion of the Kodiak Archipelago should be considered critical sea otter habitat at this time. Significant changes in nearshore marine communities can be expected as high densities of sea otters enter the system. It will be important for investigators studying these communities to consider the sea otters impact.

Sea otters tend to segregate according to sex and age and in some cases reproductive condition. It is often important to know what animals are using a particular area when assessing localized impacts. The effects of a particular event in a female area may be quite different than the effects of the same event in a male area. The only mechanism available for classifying areas, without actually handling animals, is to map the distribution of females with pups. Areas with numerous pups usually contain females of all ages and reproductively active males. These areas are where most reproductive activities occur. Areas where few or no pups are found tend to contain reproductively inactive animals, primarily surplus males.

Areas where pup densities were judged to be high are Foul Bay to Party Cape, Perenosa Bay, Tonki Bay, Tonki Cape and the west side of Marmot Island. Pups appeared to be absent in Uganik Bay and Marmot Bay. We do not have adequate information on other areas.

VIII. Conclusions

The outer Kenai Peninsula was repopulated by sea otters immigrating from Prince William Sound and perhaps the Barren Islands. The present population is contiguous with that in Prince William Sound. All of the habitat south and east of Port Graham is presently occupied and the only significant range expansion is occurring in Kachemak Bay and lower Cook Inlet. The potential for significant impacts of oil and gas development on sea otters appears greatest in the area west of Gore Point and into lower Cook Inlet.

The Afognak - Shuyak population of sea otters is currently rapidly expanding its range southward on both sides of the Kodiak Archipelago. While the current size and distribution of this population have reduced its vulnerability to the effects of oil and gas development, impacts on any portion of the northern third of the Archipelago could retard repopulation of Kodiak Island.

IX. Needs for further study

Three other populations of sea otters are known to exist in the area covered by this study: Kamishak Bay, the Barren Islands and the Trinity Islands. Present plans are to delineate these populations through fixed-wing aircraft surveys to be conducted in conjunction with Research Unit 243 between March and June, 1976.

There are several other areas in the Gulf of Alaska where the status of the sea otter is uncertain. There are indications that sea otters are expanding east of Cape St. Elias at least as far as the Italio River. This is one of the largest areas of previously unoccupied sea otter habitat in Alaska. It is also immediately adjacent to tracts recently selected for leasing. The area has never been surveyed in its entirety, however enough sightings have been reported to suggest that several small concentrations exist. Other areas that warrant limited further study are Middleton Island, the Semidi Islands and portions of the Alaska Peninsula. There does not appear to be a need for intensive work in any of these areas. Fixed-wing aerial surveys coordinated with other activities should be adequate.

X. Summary of 4th Quarter Operations

1. Field Trip Schedule

   Skiff counts of pup and adult sea otters were made around portions of the Kodiak Archipelago between 3 February and 11 February 1976 in conjunction with activities conducted under RU 229 and 243. The ADF&G vessel MV "Resolution" was used as a support platform.

   An aerial survey being made in conjunction with RU 243 was in progress at the time this report was prepared.

2. Scientific Party

   Karl Schneider - ADF&G - Principal Investigator
   Kenneth Pitcher - ADF&G - Observer
   Donald Calkins - ADF&G - Observer
   Roger Aulabaugh - ADF&G - Observer

3. Methods

   Visual counts of sea otters were made from a skiff. Pups and adults were counted separately.

   Data from the October 1975 helicopter survey were compiled.

Formats for data management were developed and a system of standardized count areas was being developed.

Sightings were collected from other scientists and members of the public.

Visual counts of sea otters were being made throughout the study area in conjunction with a fixed-wing aerial survey conducted under RU 243 at the time this report was prepared.

4. Tracklines and data collected

Figs. 1 - 9 in the accompanying annual report show all tracklines and counts of sea otters.

LITERATURE CITED

Alaska Department of Fish and Game. 1973. Alaska's wildlife and habitat. Anchorage, Alaska. 144 pp. +563 maps.

Calkins, D., K. Pitcher and K. Schneider, 1975. Distribution and abundance of marine mammals in the Gulf of Alaska. Alaska Dept. of Fish and Game, Anchorage. 67 pp. +31 maps. (typewritten).

Estes, J. and J. Palmisano. 1974. Sea otters: Their role in structuring nearshore communities. Science. 185:1058-1060.

Estes, J. and N. Smith. 1973. Amchitka bioenvironmental program: Research on the sea otter, Amchitka Island, Alaska. USAEC Res. Dev. Rep. NVO 520-1.

Faro, J. 1969. A survey of subtidal sea otter habitat off Point Pinos, Calif. Unpubl. MS Thesis Humbolt State College.

Kenyon, K. 1969. The sea otter in the eastern Pacific Ocean. U. S. Fish Wildl. Serv. N. A. Fauna No.68. 352pp.

Kenyon, K. No date. The effect of oil pollution on marine mammals. U. S. Dept. Interior. 102 Statement Task Force B, Task Force on Alaska Oil Devel. 9pp. (typewritten).

Lensink, C. 1960. Status and distribution of sea otters in Alaska. J. Mammal. 41(2):172-182.

________. 1962. The history and status of sea otters in Alaska. Unpubl. PhD. Thesis Purdue Univ. 188pp.

Pitcher, K. 1975. Distribution and abundance of sea otters, sea lions and harbor seals in Prince William Sound. Alaska Dept. of Fish and Game. Anchorage.

Schneider, K. 1971. An evaluation of sea otter survey techniques. Alaska Dept. of Fish & Game, Anchorage. 18pp. (typewritten)

ANNUAL REPORT

Contract # 03-5-022-69
Research Unit # 241
Reporting Period 1 July 1975-
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Number of Pages: 10

Distribution and Abundance of Sea Otters in Southwestern Bristol Bay

Karl Schneider
Alaska Department of Fish and Game

April 1, 1976

I. Summary

A large population of sea otters occupies approximately 3000 square miles of habitat north of Unimak Island and the Alaska Peninsula. At present the approximate distribution of the population is known but no reliable estimates of its size are available. Sea otters are particularly vulnerable to the direct effects of oiling and may be indirectly affected through the food chain by chronic low levels of pollution. This population inhabits waters in and around proposed OCS lease areas. The objective of this project is to systematically survey the range of population to determine the distribution of sea otters and estimate their numbers. The survey should provide a basis for designating critical areas and for monitoring changes in distribution and numbers.

The survey will be conducted in spring or summer 1976. Efforts to date have been directed at designing the survey. The results of two surveys conducted under RU 67 indicate that the population is currently concentrated north of Unimak Island and Izembek Lagoon. Numbers northeast of that area were reduced by the effects of sea ice formation in 1971, 1972 and 1974.

II. Introduction

A large, and in many respects unique, population of sea otters occupies the shallow waters north of the Alaska Peninsula and Unimak Island. In most areas sea otters reside close to shore, concentrating in areas with offshore rocks and kelp beds. In contrast, otters in this population range widely in offshore waters. Although they concentrate within a mile of the adjacent sandy beaches at times, they frequently scatter to the vicinity of the 40 fathom curve, 30 or more miles from shore.

Sea otters are probably the most vulnerable of all marine mammals to the direct effects of oil. Unlike most marine mammals they have no thick blubber layer. They rely on air trapped in their dense fur for buoyancy and conservation of body heat. When clean, this mat of fur is waterproof and the skin over most of the body remains dry. If the fur is soiled it loses its water repellency and its insulative quality. If this is not corrected quickly the animal will die of hypothermia. While little information is available on the quantities and types of petroleum products necessary to kill a sea otter it appears that relatively small amounts of both refined fuels and crude oil will cause death (Kenyon no date, Schneider unpublished data). Kenyon (1969) cited cases where massive kills may have occurred near shipwrecks.

Long-term, chronic pollution may have serious detrimental impacts on all high trophic level species if one or more of the links in the food chain are affected. Sea otters require very large quantities of food (20 to 25 percent of their own body weight per day) to support a high metabolic rate. The main factor limiting most sea otter populations appears to be food availability. Sea otters in most areas appear to be relatively sedentary and feed on relatively sessile organisms. Therefore they may be exceptionally sensitive to changes in the food chain and any effects would tend to be site specific.

This population appears to be vulnerable to oil spills. It is bounded by the proposed Bristol Bay OCS lease area and by Unimak Pass, a potential hazard area for tankers. The population periodically concentrates making it possible for a small spill to directly kill large numbers of otters. This population appears to be the most likely source of otters that will repopulate the Fox and Krenitzin Islands, the largest area of unpopulated sea otter habitat remaining in Alaska. A severe reduction of the Unimak-Alaska Peninsula population could delay repopulation of these islands for many years.

The range and distribution of this population have fluctuated in recent years partly as a result of periodic formation of sea ice (Schneider and Faro 1975). There appear to have been some fluctuations in numbers but no reliable estimates have been made.

The objective of this project is to estimate the size of the population and to quantitatively demonstrate its current distribution to provide a basis for determining future changes and for identifying critical areas.

III. Current State of Knowledge

A number of fixed-wing aerial surveys of the study area have been flown since 1957 by U. S. Fish and Wildlife Service and Alaska Department of

Fish and Game personnel. The most significant counts are summarized in Table 1. None of these surveys systematically covered the entire area and the numbers of sea otters counted varied greatly. A general pattern of changes in distribution is evident however.

A remnant population probably survived the period of commercial exploitation prior to 1911. This population was concentrated north of Unimak Island and Izembek Lagoon. During the early 1960's it expanded its range to the vicinity of Port Moller although the largest numbers remained north of Izembek Lagoon (Kenyon 1969). By 1970 sea otters were common as far northeastward as Port Heiden and occasional individuals were seen near Ugashik and Egegik Bays. In 1971, 1972 and 1974 sea ice, which normally forms only to the vicinity of Port Heiden, advanced to Unimak Island. Many sea otters were killed and others were forced southwestward (Schneider and Faro 1975). The cummulative effects of the three years of ice formation appeared to severely restrict the range of this population although the potential for expansion northeastward during mild years exists.

Because potential range of the population covers over 3000 square miles of open water, traditional survey methods have not been adequate to estimate the size of the population. Kenyon (1969) estimated that the population was over 3,800 in 1965 but more recent information indicates that his survey did not cover the entire range of the population and there has been considerable expansion of the range since that time. In 1970 a total of 2157 sea otters were counted in photographs of several pods clustered southeast of Amak Island. One of these pods was the largest ever recorded, containing over 1000 sea otters. No pups were visible in the photographs, indicating that all segments of the population were not represented. Crude estimates made from aerial surveys indicate that this population may contain on the order of 8,000 to 10,000 sea otters (Alaska Department of Fish and Game 1973).

IV. Study Area

At one time or another parts of this population have been observed in the waters north of Unimak Island and the Alaska Peninsula from Scotch Cap to Egegik Bay (Fig. 1). They have occupied Bechevin Bay, Izembek Lagoon and Port Moller frequently and probably at least small numbers have used all of the bays and lagoons in the area. Surveys indicate that large numbers may occasionally move offshore to the vicinity of the 40 fathom curve north of Unimak Island and Izembek Lagoon. Some otters have been sighted 30 miles from shore and one moribund animal was found 65 miles from shore (T. Newby, personal communication). The potential study area delineated by these observations is over 3000 square miles in extent. It is anticipated that most of the effort will be directed at the area from Cape Sarichef to Port Moller, however.

V. Methods

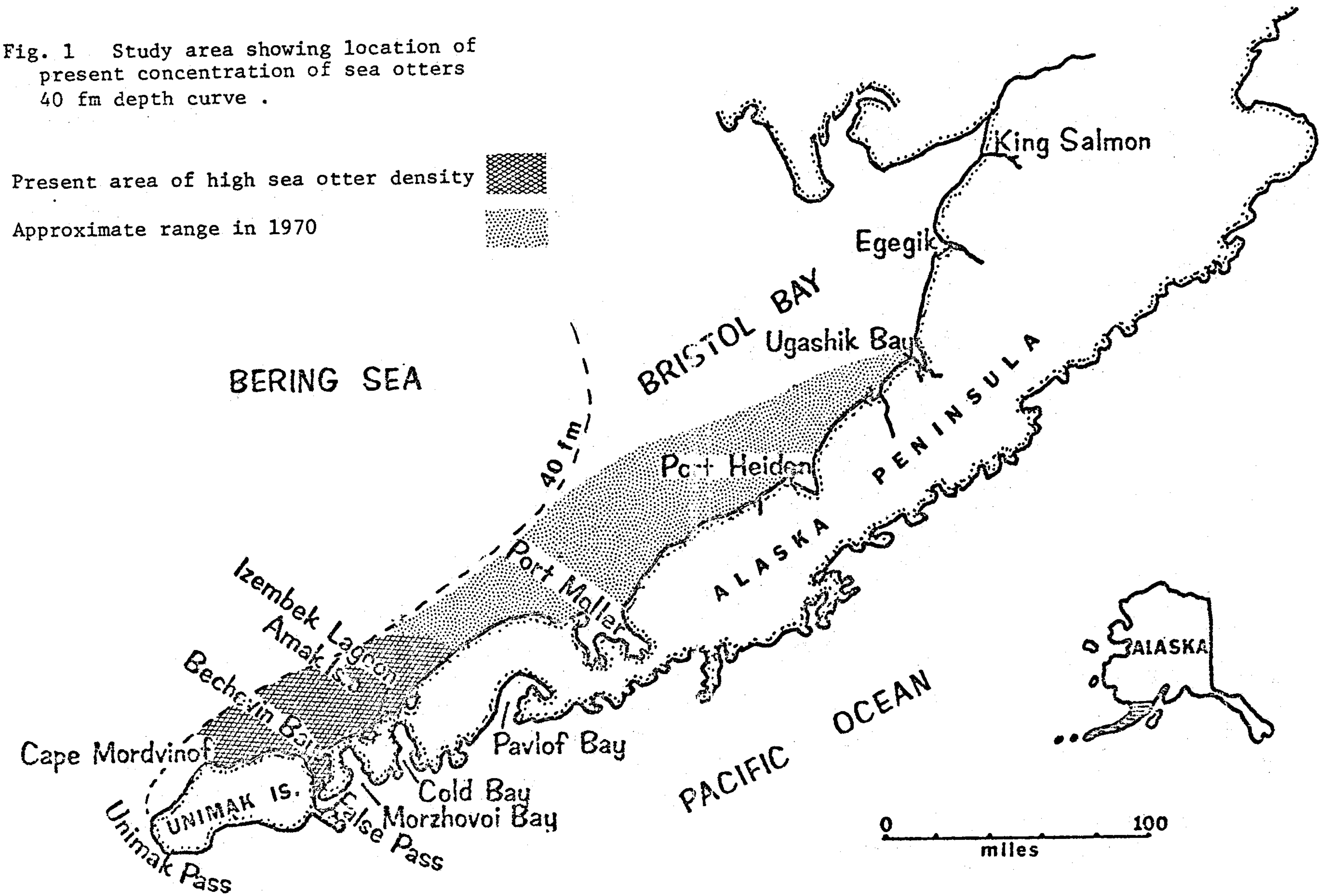
A single aerial survey will be conducted during spring or summer 1976. All activities to date have been directed at planning and design of the survey.

Table 1. Significant sightings of sea otters along the north side of the Alaska Peninsula and Unimak Island.

	1957	1958	1962	1965	1969	1970	March 1971	Oct. 1971	March 1972	May 1972	Oct. 1972 to June 1973	June 1975	Aug. 1975
Cape Chichagof to Cape Greig										0	4	0	0
Cape Greig to Reindeer Creek				0				4		0		0	0
Reindeer Creek to Cape Kutuzof				0			5	40		0	3	0	0
Cape Kutuzof to Cape Lieskof				39			74	60	18	1		0	0
Cape Lieskof to Moffet Point				20			38	24	1	2		24	0
Moffet Point to Otter Point	786 (Moffet Point to Cape Mordvinof)		811 (Moffet Point to Cape Sarichef)	2765	330	2157	20	273	400-600	79		198	2325
Otter Point to Cape Mordvinof				58	152							1	19
Cape Mordvinof to Cape Sarichef				10	0							0	1
Cape Sarichef to Scotch Cap		75										0	0
Total	786	75	811	2892	482	2157	137	401	-	82	7	223	2345

1957-1965 from USFWS reports by Kenyon and Lensink.
None of these surveys covered the entire area. The primary purpose of this table is to demonstrate changes in distribution and relative abundance in some area.

Fig. 1 Study area showing location of present concentration of sea otters 40 fm depth curve .



The principal investigator participated in two aerial surveys of marine mammals conducted under RU 67 that provided information useful in designing the planned survey. Since these surveys were conducted under another research unit and by another principal investigator I will discuss them only to the extent that they bear on this project.

VI. Results

The counts of sea otters made during the two surveys conducted under RU 67 are summarized in Table 1 along with other pertinent counts.

These surveys were primarily designed to locate other species of marine mammals. Coverage of sea otter habitat was incomplete, survey conditions were frequently poor and no attempt was made to delineate concentrations of sea otters unless they were encountered on the regular trackline. A minimum of 225 sea otters were seen in June and 2,345 were seen in August. The numbers seen are not particularly important but the distribution of the population is of considerable interest. On both surveys the majority of the sea otters seen were between Cape Lieskof and Cape Mordvinof (Fig. 1). Only a few stray otters were seen northeast of Cape Lieskof even though four tracklines were flown through the area. Bechevin Bay contained concentrations of sea otters both times it was surveyed.

VII. Discussion

The results of the June and August surveys indicate that the distribution of the population has been altered significantly in recent years, probably as a result of severe sea ice conditions in 1971, 1972 and 1974. At present most of the otters are confined to a relatively small area. If the distribution of the sea otter population remains restricted, it may be beneficial to concentrate the census between Cape Lieskof and Cape Mordvinof with only superficial coverage of other areas. This would permit a more accurate estimate of the portion of the population inhabiting that area. Since only a small percentage of the population lives outside of this area, it should be possible to make a more accurate estimate of the population as a whole than previously expected.

Because this population leads an almost pelagic existence traditional shoreline survey techniques are inadequate. Similarly a total count is impossible because of the size of the area and potential for duplication. Therefore some system for sampling the area is required.

Attempts have been made to conduct such surveys of a number of other species of marine mammals over both sea ice and open water. Many problems have been encountered. The following is a list of some of the major problems expected in designing this survey.

<u>Visibility</u>

Many factors influence the visibility of sea otters in the water. These factors often influence each other providing a wide array of conditions. Often these conditions change rapidly. Among the more common factors are:

1. Sea state - any type of wave will reduce visibility. Sharp, choppy waves are worse than large swells so wind velocity and direction at the time of the survey are major factors. Lighting conditions often magnify the effect of sea state.

2 Lighting conditions - sun glare on the water's surface, reflection on the windshield of an aircraft, low light intensity because of clouds or time of day and the wave lengths of light reflected from the water's surface strongly influence visibility. Since the angle of incidence is important, visibility on one side of the observer may be significantly different from that on the other side.

3. Presence of confusing objects - the presence of other species of marine mammals or birds, certain types of kelp, drift or any object similar to the target species will distract the observer and reduce his ability to identify the target species.

4. Behavior - normally behavior and distribution of the target species are considered to be a factor separate from surface visibility, however the way animals react to the survey platform, their activity and posture in the water, and their distribution in relation to each other and in relation to geographical features have a strong influence on observability and may be subconsciously considered in the classification of visibility conditions. Distribution of individuals has an effect that often overrides the effects of all other factors. When most animals are resting on the surface of the water in large groups, counts are almost always high. When they are widely scattered, counts will be low unless other conditions are ideal.

It would be impossible to quantitatively measure all factors influencing visibility, therefore classification of visibility conditions must be a subjective assessment of all factors.

Several classification systems have been developed. The following system differs somewhat from that used by Estes and Smith (1973), but is similar to that used by Kenyon (1969).

Code

1 Excellent - surface of water calm, usually a high overcast sky with no sun glare. Sea otters appear dark against a uniformly light gray background of the water's surface. Individuals easily distinguished at a distance.

2 Very good - May be light ripple on water's surface or slightly uneven lighting but still relatively easy to distinguish individuals at a distance.

3 Good - may be light chop, some sun glare or shadows. Individuals at a distance may be difficult to distinguish but individuals nearby and small groups at a distance are readily identified.

4 Fair - usually choppy waves and strong sun glare or dark shadows in part of the survey track. Individuals in kelp beds, in the lee of rocks, or near the observer and most pods readily identified, but most individuals and some pods in areas of poor lighting or at a distance difficult to distinguish.

5 Poor - individuals difficult to distinguish unless very close and some pods at a distance may be missed, however conditions still good enough to give a very rough impression of the distribution of animals.

6 Unacceptable - heavy chop with many whitecaps, lighting poor or large waves breaking on rocks. No surveys should be conducted under these conditions but occasionally a sighting of significance may be made in the course of other activities.

Distribution

Group size always influences observability of sea otters and may be the most significant cause of variability in counts. This problem has been particularly acute in this area where pods of over 1000 animals have been seen but often the animals appear widely scattered.

Sea otter distribution in the area is by no means random but it does appear highly variable. It appears that time of day and weather conditions influence distribution but our ability to predict this is poor. Logistics and visibility conditions will tend to dictate timing of the survey limiting the option of selecting a time when sea otters are concentrated.

Behavior

Behavior influences the observability of the animal. Resting animals are probably more visible than those upright in the water. A percentage of the animals are under water at all times. Some studies of diving times and activity patterns have been made, however none have been conducted in habitat similar to the study area.

Limitations of the Platform

The speed, altitude and range of the survey platform limit the design of the survey track. The only safe platform capable of covering the area before significant animal movements occur and at a reasonable cost is a multi-engine, fixed-wing aircraft. Sampling from an aircraft is usually limited to relatively continuous, non-random tracklines. Observability of sea otters declines with distance from the survey track. The rate of decline will vary with visibility conditions. Although this can be corrected to a degree if the distance of each animal from the trackline is known, the rate of sea otter sightings is expected to be too high to permit such measurement.

Many of the above problems as well as others such as observer variability could be corrected if there were a method of gathering ground truth data at the time of the survey. This has been possible in some nearshore areas where sea otters concentrate near suitable shore observation points. Unfortunately there does not appear to be any way to gather reliable gound truth information in the study area.

It is eveident that certain assumptions will have to be made and that while some sources of variability may be measured others can not.

At the present time it appears that the best approach will be to lay out a systematic series of transects of predetermined width. The possibility of using two sets of observers simultaneously counting transects of two widths is being examined. We will probably use parallel, north-south flightlines extending from shore to the 40 fathom curve. Each transect will be broken into segments. It will probably be necessary to assume that the observers see all the otters on the surface in the transect. Some will not be seen but the percentage missed should be reduced if the transect is narrow. Bays and lagoons and perhaps the shoreline of Amak Island will be treated separately.

It will probably not be possible to quantify the effects of behavior and group size but if group size and behavior of animals seen are recorded it may be possible to make some estimate of the effects of these factors on the counts.

The estimate of numbers will probably be conservative but it will be far more accurate than those made previously. An attempt will be made to collect data in a manner that may permit refinement of the estimate at a later date. The systematic layout of tracklines should provide much better information on the distribution of sea otters in the area than is presently available. The standardized approach will provide a basis for comparison with future surveys.

VIII. Conclusions

The southwestern Bristol Bay population of sea otters is presently concentrated north of Unimak Island and Izembek Lagoon. Numbers northeast of Moffet Point are far lower than in the past.

IX. Needs for further study

Studies of activity patterns and movements of sea otters in the study area would greatly enhance our ability to design and evaluate the census. The cost of such studies probably exceeds their value to the OCSEAP program, however. Little is known about the food habits of this population, and the relationship between concentrations of sea otters and the distribution of potential food species has not been examined.

X. Summary of 4th quarter operations

No field work was conducted during the fourth quarter. The principal investigator discussed the design of the survey with a number of individuals and a number of tentative decision were made on design. No charges have been made to this project to date.

LITERATURE CITED

Alaska Dept. of Fish & Game. 1973. Alaska's wildlife and habitat. Anchorage, Alaska, 144 pp. + 563 maps.

Estes, J. and N. Smith. 1973. Amchitka bioenvironmental program. Research on the sea otter, Amchitka Island, Alaska. USAEC Res. Dev. Rep. NVO 520-1.

Kenyon, K. 1969. The sea otter in the eastern Pacific Ocean. U. S. Fish and Wildl. Serv. N.A. Fauna No. 68. 352 pp.

________. No date. The effects of oil pollution on marine mammals. U. S. Dept. Interior, 102 Statement Task Force B of Task Force on Alaska Oil Devel. 9 pp. (Typewritten).

Schnieder, K. and J. Faro. 1975. Effects of sea ice on sea otters J. Mammal 56(1):91-101.

ANNUAL REPORT

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Research Unit #243
1 July 1975 - 1 April 197(
Pages: 15

Population assessment, ecology and trophic relationships of Steller Sea Lions in the Gulf of Alaska

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I. Summary

This project is a broadly based investigation into the population status and biology of the Steller sea lion in the Gulf of Alaska. Basic objectives are to provide information on population status, seasonal distribution, movement patterns, population composition and segregation and use of critical habitat. We are also examining food habits and basic trophic relationships. Reproductive biology is being examined in order to provide the parameters necessary for population productivity calculations. Other objectives include collection of data on growth, pathology and environmental contaminant levels.

The project is designed to closely examine the potential impact of development associated with exploration for and development and transport of crude oil and natural gas reserves in the Gulf of Alaska. Delineation of rookeries, hauling grounds, feeding areas and their seasonal use patterns are very necessary as it has been shown that disturbance can modify use and even cause abandonment (Thorsteinson and Lensink 1962, Pike and Maxwell 1958). Population level and productivity should be determined before development in order to evaluate possible effects. Knowledge of the degree of segregation is important so that localized kills or disturbances can be evaluated in terms of importance to the total population. The importance in establishing trophic relations in the Gulf is evident. Activities which reduce basic productivity would eventually reduce the carrying capacity for high level consumers such as sea lions.

Branding activities on Sugarloaf and Marmot Islands were successful in marking 1319 sea lions. Observations made 3 months later indicated that at least some pups remained near the pupping rookeries for that length of time. Distribution surveys were conducted along the Kenai coast and around northern Afognak and Shuyak Islands in October. Six previously unrecorded hauling areas have been identified. To date gadids, particularly _Theragra_, have been the dominant prey species. Collecting activities have provided further evidence that segregration of sex and age classes probably does occur.

II. Introduction

A. This investigation of Steller sea lions (*Eumetopias jubatus*) in the Gulf of Alaska is a broadly based undertaking designed to provide basic information about population status, distribution, movement patterns, segregation, use of critical habitat, population composition and dynamics, growth, pathology, food habits and trophic relationships. Achievement of these goals is being accomplished through concurrent subprojects involving: (1) aerial photographic census and distribution surveys; (2) autecological investigations; and (3) a study of food habits and trophic relationships. The project will require four years, however much of the population census work is being completed the first year.

B. Basic objectives of the project are as follows:

To determine numbers and biomass of Steller sea lions in the Gulf of Alaska. To establish sex and age composition of groups of sea lions utilizing the various rookeries and hauling grounds. To determine patterns of animal movement, population identity and population discreteness of sea lions in the Gulf. To determine changes in seasonal distribution.

To investigate population productivity and growth rates of Steller sea lions in the Gulf of Alaska with emphasis on determining; age of sexual maturity, overall reproductive rates, age specific birth rates and duration of reproductive activity.

To determine food habits of Steller sea lions in the Gulf of Alaska with emphasis on variation with season, area and habitat type. An effort will be made to relate food habits with prey abundance and distribution.

To collect information on pathology, environmental contaminant loads and use of critical habitat.

C. Population numbers and seasonal distribution of sea lions should be determined before exploration and development begin. It has been demonstrated that disturbance can cause changes in sea lion distribution and even cause abandonment of an area (Thorsteinson and Lensink 1962, Pike and Maxwell 1958). Information on movement patterns and the composition of groups of animals occupying various locations is important in order to evaluate possible effects should disturbance or kills occur in localized areas.

Baseline data on reproduction and population dynamics should be collected before development begins. These data are necessary so that post development changes can be evaluated.

The sea lion is a dominant high level carnivore in the marine system of the Gulf of Alaska. Oil and gas exploration and development have the potential of greatly affecting basic productivity and the abundance of prey species. Therefore the importance of establishing trophic relationships is evident.

Oil and gas exploration and development could possibly increase levels of various environmental contaminants which are concentrated in top-level consumers such as the sea lion. Baseline levels should be established.

III. Current State of Knowledge

A reservoir of general knowledge exists on pinnipeds but specific information on sea lions in the Gulf of Alaska is lacking. With the exception of the Prince William Sound area, population assessment studies have not been carried out in the Gulf since 1956-1958 (Mathisen and Lopp 1963). Changes in seasonal distribution are only partially known. In general, it appears there is considerable movement from exposed summer rookeries to more sheltered wintering areas. There is no information about the proportions or composition of animals involved in such movements, nor the direction, rate or extent of movement. Large scale movements of Steller sea lions in Oregon have been noted by Mate (1973). Bartholomew and Boolootian (1960) suggested that seasonal migratory movements were correlated with age and sex in California. Seasonal movements are known to occur in British Columbia although they are not fully understood (Spalding 1964 and Smith 1972).

Composition of animals using the various rookeries and hauling grounds in the Gulf of Alaska is unknown although some degree of sex and age segregation obviously takes place. Data collected from various sea lion rookeries in Prince William Sound suggested they were not a discrete population but that there might be considerable interchange with other areas, possibly from the large rookeries of the Kenai Peninsula and Kodiak area (Pitcher and Vania 1973).

Adequate information is lacking on reproduction and growth in the Steller sea lion. Data from other species of marine mammals (Sergeant 1966, 1973) suggest that population productivity may be a good indicator of relationship to carrying capacity. Laws (1959) showed that seals with plentiful food supplies grew faster and became sexually mature earlier, thus increasing population productivity There are some indications that reproductive rates of sea lions in Alaska are lower than in other portions of their range (Brooks 1957, Pike and Maxwell 1958 and Thorsteinson and Lensink 1962).

Previous studies of food habits have been incidental in nature and all were done during summer months. Fiscus and Baines (1966) reported on the stomach contents of four animals taken in the Gulf. Species encountered included: *Ammodytes*, *Mallotus*, *Sebastes*, cottids and cyclopteridae. Imler and Sarber (1947) found *Theragra*, *Oncorhynchus*, *Platicthys*, *Microgadus*, *Hippoglossus atheresthes*, *Raja* and *Octopus* in seven sea lions collected from the Barren Islands, Chiswell Island and Kodiak. Thorsteinson and Lensink (1962) reported on nine animals which contained food items from Marmot Island. They identified rockfishes, greenlings, sandlances and cephalopods.

IV. Study area

Population assessment activities are being conducted at rookeries and hauling grounds in the Gulf of Alaska from Cape Spencer to Scotch Cap on Unimak Island. Specific sampling areas from which we have collected or plan to collect sea lions include Kayak Island, Middleton Island, Prince William Sound, the Kenai Coast, Barre- Islands and the Kodiak area.

V. Sources. Methods and Rationale of Data Collection

Sea lion population data have been collected by three major methods. The first is aerial surveys of sea lion rookeries and hauling areas along the coast of the Gulf of Alaska. Recent procedures for aerial surveys of sea lions have proven quite effective because of the considerable body of information available about sea lion behavior and seasonal and diurnal activities (Orr and Poulter 1967, Sandegren 1970, Mate 1973, Bigg 1973, Fiscus 1969 and Fiscus and Baines 1966). Aerial surveys of hauling areas consist of flying by in either fixed-wing aircraft or helicopters and photographing all hauled out animals with hand held, motor driven 35 mm cameras. The rookeries are approached to within 50 meters at an altitude of approximately 200 meters and overlaping photos are taken. From the developed photos a mosaic is constructed and numbers of animals are counted.

The second method of data collection on sea lion populations consists of visiting selected rookeries for sex and age composition counts and marking pups. The marking system presently in use is that of highly visible hot brands (Smith et al. 1973, Rand 1950, Scheffer 1950, Chittleborough and Ealey 1951). These brands are standard cattle type brands applied to the front shoulder of the sea lion pup. The iron, heated by propane gas, measures approximatel 4 cm by 8 cm. Seven rookeries have been selected for branding on the basis of numbers of pups produced. The rookeries where pups are to be branded are Marmot Island which is off the east side of Afognak Island, Sugarloaf Island in the Barren Islands, Outer Island one of the Pye Islands off the eastern Kenai coast, the Chiswell Islands off the eastern Kenai coast, Fish Island in the Wooded Islands off Monague Island in Prince William Sound, Seal Rocks between Montague Island and Hinchinbrook Island in the entrance to Prince William Sound and Pinnacle Rock at Cape St. Elias.

Branding takes place in late June and early July shortly after the pups are born. Gothic style letters are used and are coded to the specific rookeries. Through the use of letter brands applied to different areas on the animal, it is possible to mark pups for several years and still distinguish between age classes and location of birth. Recovery of branded animals is through the collection of individuals and during sex and age compostion counts on specific rookeries and hauling areas.

The third method of collecting information on sea lion populations has been through observations made while aboard vessels engaged in collecting sea lions and harbor seals. Crews of these vessels generally have contributed local knowledge about sea lion populations.

Data on growth, development, condition, reproduction, food habits, pathology and environmental contaminant loads are being obtained from the analysis of specimen materials from collected sea lions. These animals are being collected systematically from different areas throughout the year. This is being done to detect variations in food habits and body condition with season, area and habitat type.

Weights and standard measurements are taken from each collected animal including: total weight, blubber weight, standard length, curvilinear length, axillary girth, and blubber thickness (Scheffer 1967). These data are being collected to establish growth rates and assist in making calculations of biomass.

The ovaries and uterus are taken from each female and preserved in formalin. Standard laboratory techniques for reproductive analysis are used through which the presence or absence of a conceptus in the uterus is determined and a partial reproductive history is reconstructed by examination of ovarian structures. These data are necessary for determination of ages of sexual maturity and age specific birth rates which are basic parameters required for population productivity calculations.

Testes and epididymides from each male sea lion are collected and preserved. A microscopic examination is made of epididymal fluid to determine whether sperm are present or not. This is necessary for determination of age of sexual maturity and periods of seasonal potency in males.

Age determinations are being made for each animal. This is done by decalcifying a tooth from each animal, using a microtome to produce thin sections, staining the thin sections with hematoxylin and counting the annual growth rings with the aid of a microscope (Johnson and Lucier 1975). Age determinations are necessary for assessment of growth rates and to determine population structure and productivity.

Stomach contents from each animal were preserved in formalin, weights and volumes were determined for all contents. Identifications of prey species were made by examination of recognizable individuals and skeletal materials of diagnostic value. Frequency of occurrence of prey species was then determined.

Intestinal contents from each sea lion were strained through mesh sieves to recover fish otoliths. Otoliths, which are diagnositic to species, were compared to a reference collection and identified (Fitch and Brownell 1968). Tissue samples are being collected and frozen so that baseline levels of heavy metals, pesticide residues and hydrocarbons eventually can be determined.

VI. Results

One survey was completed in October 1975 in conjunction with RU 240. This survey covered the sea lion rookeries along the Kenai Peninsula and Kodiak Island (Figs. 1 and 2). The rookeries surveyed and visual estimates of sea lions are shown in Table 1.

Table 1. Sea lion rookeries surveyed October 1975.

Rookery	Visual est.	Rookery	Visual est.
Cape Puget	0	Nuka Point	0
Cape Junken	0	Gore Point	2
Barwell Island	0	East Chugach Island	0
Hive Island	0	Perl Island	70
Rugged Island	0	Sugarloaf Island	4588
Chat Island	0	Nagahut Rocks	1
Chiswell Island	3251	Cape Elizabeth	69
Seal Rocks (Kenai)	155	Flat Island	0
Outer Island	6300	Latax Rocks	625
Tonki Cape	0		
Sealion Rocks	625		
Marmot Island	7995		
Sea Otter Island	290*		

* Not previously identified as a sea lion hauling area.

The next scheduled survey is in progress at this time and will be reported on at a later date. This survey is designed to cover all the sea lion haul outs in the entire study area and will provide information on winter distribution and haul out use.

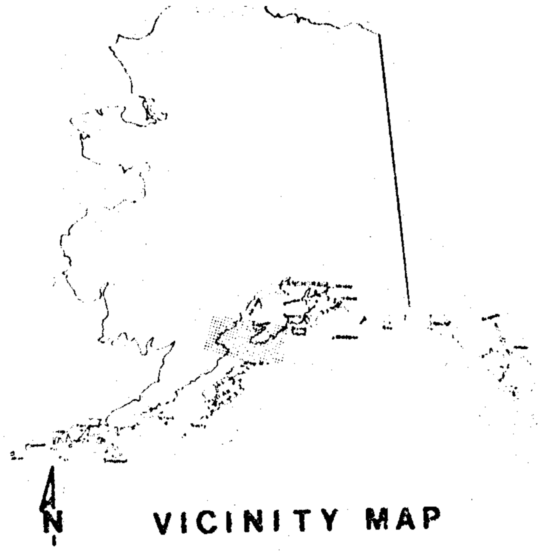
Through our surveys, collecting activities and interviews with vessel crews, the following previously unreported haul-outs have been located:

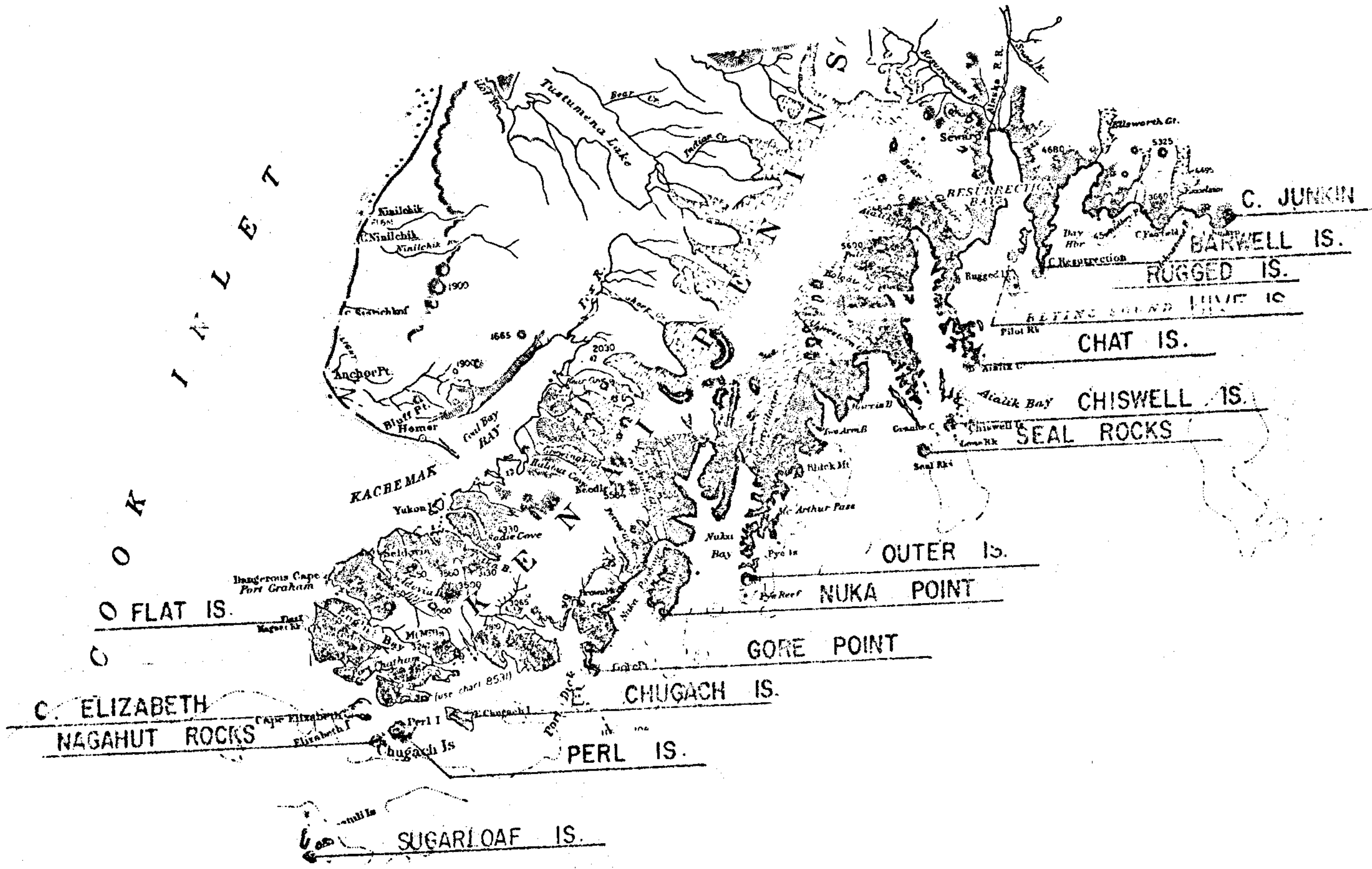
1. Sea Otter Island (off Afognak I.)
2. Steep Cape (S.W. side of Afognak I.)
3. Raspberry Island (Shelikof Strait)
4. Raspberry Island (Kupreanof Strait)
5. Noisy Island (on S.W. side of Uganik I.)
6. Uganik Island (on N.W. side)

Sea lion branding was accomplished at Sugarloaf Island and Marmot Island in July 1975. The pups were branded with an X at Sugarloaf and an O at Marmot. A total of 1319 pups were branded; 373 males and 346 females at Sugarloaf and 320 males and 280 females at Marmot

To date 8 sea lions have been collected; 18 from Prince William Sound, five from Kodiak and 3from the Kenai Coast. Preliminary food habit analyses have been completed from the Prince William Sound animals (Table 2). Gadids were the dominant food items composing 72 percent of the total occurrences. <u>Theragra</u> was the major species making 48 percent

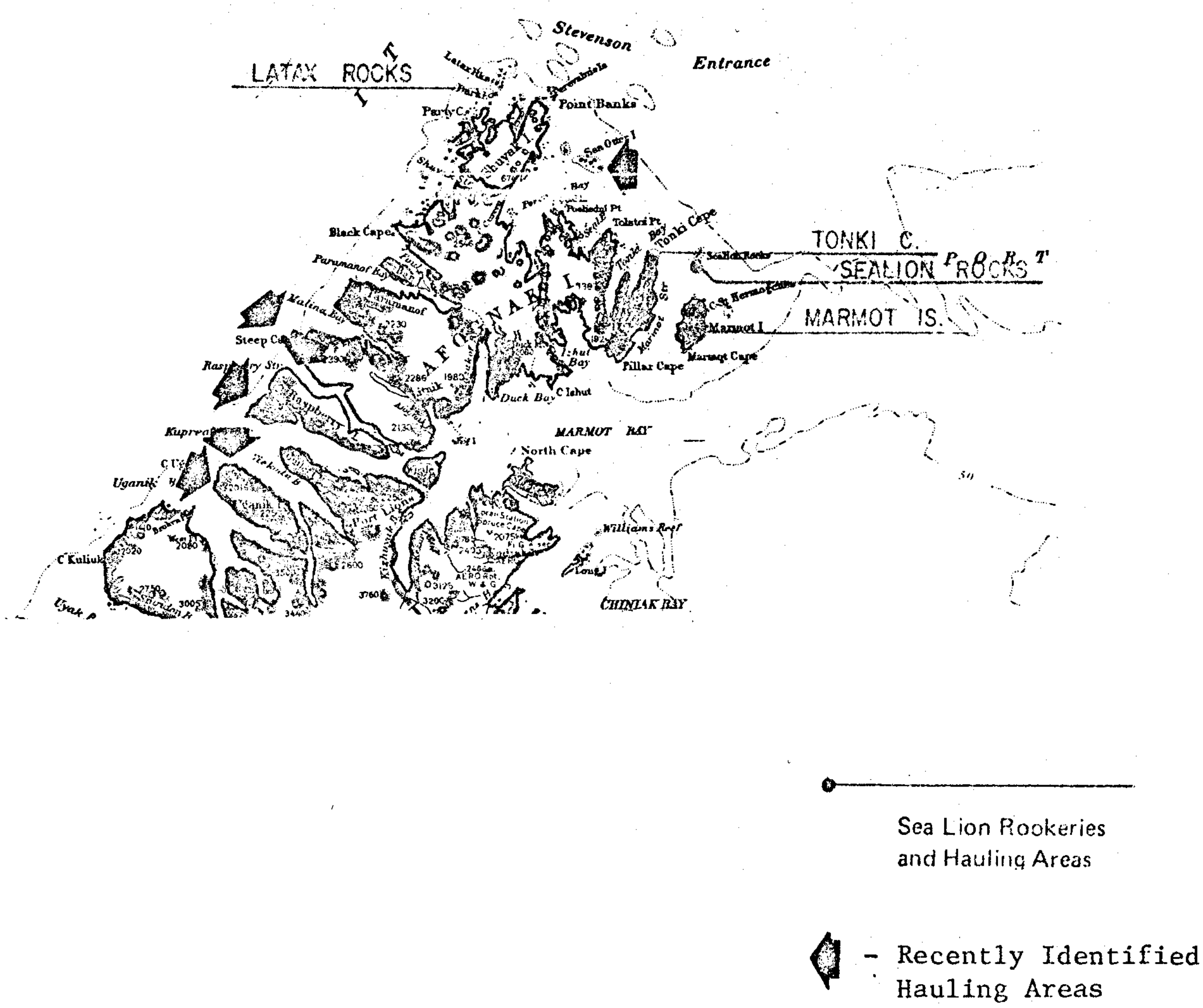
Figure 1. Sea lion rookeries and hauling areas along the Kenai Coast.





Sea Lion Rookeries and Hauling Areas

Figure 2. Sea lion rookeries and hauling areas - Northern Kodiak and Afognak Area.



of the total. In this report we will only look at frequency of occurrence, however, data are being collected on weights, volumes and number of individuals and will be presented in the final report. Of particular interest is one animal which had stomach contents (exclusively Theragra) totaling 7.9 percent of its body weight.

Table 2. Frequency of occurrence of sea lion food items.

Food Items	Number of Occurrences	Percentage of Occurences
Gadidae (Total)	18	72%
Theragra	12	48%
Gadus	4	16%
Eleginus	2	8%
Clupeidae (Total)	2	8%
Clupea	2	8%
Pleuronectidae (Total)	2	8%
Platicthys	1	4%
unid. pleuronectid	1	4%
Cephalopoda (Total)	3	12%

Work is still underway to develop a satisfactory technique for age determination of Steller sea lions, however tentative ages have been assigned to 15 of the sea lions collected in Prince William Sound. Weights and measurements are also presented in Table 3. Not enough data are available to construct growth curves or develop seasonal condition patterns.

Reproductive analyses have been completed on the four females from Prince William Sound (Table 4). SL-1-75, tentatively aged at 3-4 years, was pregnant apparently for the first time. No evidence of a previous pregnacy or ovulation were found. SL-2-75, tentative age 9 years, was pregnant and lactating. SL-3-75, aged at 7 years, was pregnant but not lactating. Each appeared to have produced a minimum of one previous pup. Cord-1-75 has not been aged but is either an 8-month-old pup or a yearling. It was nulliparous, and showed no follicular activity.

Table 3. Age, growth and condition data from collected sea lions.

Number	Sex	Age	Weight	Standard Length	Blubber Thickness
SL-5-76	MM	-	70.0 Kg	168.5 cm	1.4 cm
PWS-5-75	MM	-	77.3 Kg	164.0 cm	1.3 cm
PWS-6-75	MM	-	69.5 Kg	172.0 cm	1.5 cm
SL-4-76	MM	-	160.0 Kg	187.0 cm	3.0 cm
SL-4-75	MM	2-3	175.0 Kg	197.0 cm	2.4 cm
SL-12-75	MM	2-3	200.0 Kg	202.0 cm	2.5 cm
SL-7-75	MM	3-4	205.0 Kg	195.0 cm	2.8 cm
SL-14-75	MM	3-4	230.0 Kg	205.0 cm	5.0 cm
SL-13-75	MM	3-4	240.0 Kg	218.0 cm	3.0 cm
SL-5-75	MM	4+	255.0 Kg	207.0 cm	3.0 cm
SL-10-75	MM	3-4	260.0 Kg	222.0 cm	2.6 cm
SL-9-75	MM	3-4	305.0 Kg	227.0 cm	2.9 cm
SL-8-75	MM	2-4	320.0 Kg	-	3.2 cm
SL-6-75	MM	3	334.0 Kg	226.0 cm	4.0 cm
SL-11-75	MM	3-4	370.0 Kg	-	3.5 cm
SL-15-75	MM	5	375.0 Kg	249.0 cm	3.0 cm
SL-1-75	FF	3-4	210.0 Kg	-	2.4 cm
SL-3-76	FF	-	215.0 Kg	217.5 cm	3.0 cm
SL-2-75	FF	9+	255.0 Kg	-	3.5 cm
SL-1-76	FF	-	258.0 Kg	228.0 cm	3.0 cm
SL-3-75	FF	7+	280.0 Kg	229.5 cm	4.9 cm
SL-2-76	FF	-	315.0 Kg	227.0 cm	4.5 cm

Table 4. Reproductive status of four female sea lions collected from April 1975 to December 1975.

Number	Tentative Age	Pregnant Yes-No	Status	Comments
Cord-1-75	8 mos.-or 20 mos.	No	Nulliparous	No follicular activity
SL-1-75	3-4 yrs.	Yes	Primiparous	No corpus albicans, or placental scars, 2.2g fetus
SL-2-75	9 yrs.	Yes	Multiparous	Lactating, 23.g fetus
SL-3-75	7 yrs.	Yes	Multiparous	Not lactating, 14.4 g fetus, possible corpus albicans

C. Tissue samples

Various tissue samples have been taken from each sea lion collected under this program. Liver, muscle, blubber and kidney samples have been taken for heavy metals, hydrocarbon and pesticide analyses, liver, kidney and whole blood have been taken for blood chemistry studies and sera have been preserved for pathology studies.

VII. & VIII. Discussion and Conclusions

It is important to recognize that although this report is written to meet the annual report requirements, the project has not been in progress for the full year. Funding of this project did not begin until July 1, 1975 for a total working period of seven months. Much has been accomplished in this short period although the bulk of the work is yet to come. As has already been mentioned, the winter survey is now in progress and is expected to be completed by mid-March. A summer survey of all the rookeries and hauling areas in the Gulf is planned for mid-June. In late June and early July extensive branding is planned for the seven rookeries. Collecting trips are scheduled for March, April and May.

It is difficult to draw any conclusions from the data collected at this time. No complete surveys have been flown and the recovery phase of the branding program has not yet started. Some interesting points have been noted and will be discussed here.

On the October collecting trip, 14 sea lions were collected in Prince William Sound. Of these 14, eight were collected in the area of Port Bainbridge in one day; these 8 were all subadult males and were taken from several large groups of sea lions, all of which appeared to be males. This brings up some interesting questions about sexual segregation in sea lions. We have known for some time that sexual segregation does occur, particularly at some of the haul out areas, but in most cases it is not known to what degree this occurs. It is also unknown how age specific this segregation is. Large oil spills or disturbances could have far reaching effects on sea lion populations if they were concentrated on specific sex and age classes of the population.

Several hauling areas have been located which were previously unreported in the literature. All of these are on the north end of the Kodiak Archipeligo. Inclusion of these areas in the literature is essential if consideration is to be given to protecting them from oil and gas development related disturbance.

Of the tissue and blood samples collected to date, analysis has only begun on those taken for blood chemistry studies. These studies are directed towards population identity and discreteness.

The most important finding to date in the food habits studies is the dominance of gadids, Theragra in particular. None of the previous workers in the Gulf (Fiscus and Baines 1966, Imler and Sarber 1947 and Thorsteinson and Lensink 1962) reported gadids as common food items. It is important to continue sampling to see if the present pattern continues in other areas and seasons of the year.

Not enough progress has been made in the reproductive work to draw any firm conclusions. One finding of particular interest is a 3-4 year old primiparous female which provides some insight into age of sexual maturity. Virtually no information is presented in the literature on age of sexual maturity, frequency of breeding, pregnacy rates or duration of reproductive activity. Mathisen et al. (1962) reported females between the ages of 9 and 22 years were breeding in the Shumagin Islands. Thorsteinson and Lensink (1962) working on Marmot Island found that 160 harem bulls between 6 and 17 years were potent. These animals were collected between 27 May and 15 July. They felt that all males were sexually mature by 6 or 7 years of age.

IX. Needs for further study

In addition to the activities planned for the remainder of the contract period it is essential that we gather more information on the specifics of sex and age classes using the different rookeries and hauling areas and the extent of segregation. In the future it will be necessary to execute activities primarily designed to locate branded animals away from the rookeries where they were branded.

Collecting of sea lions should continue until a sample sufficiently large to determine foods habits by season, area and habitat type is obtained. This same sample should provide enough reproductive material to establish the basic parameters necessary for population productivity calculations.

Consideration should be given to developing a radio-tracking techniqu for sea lions. Once developed the technique would rapidly provide badly needed information on movements, seasonal distributio feeding areas and habitat utilization.

Investigations into the life histories of important prey species should be undertaken. Particular emphasis should be given to potential effects of oil and gas exploration and development on these species.

Studies should be initiated to determine what makes a particular haul out or rookery more desirable than other similar locations. It is important that we better understand the extent and limitations of areas critical to sea lions.

X. Summary of fourth quarter activities

A. Field and laboratory activities

1. Field Activities

a. 28 Oct.-4 Nov. 1975. M.V. "Montague" (ADF&G) Prince William Sound

b. 3 - 13 Feb. 1976, M.V. "Resolution" (ADF&G) Kodiak, Afognak, Shuyak

c. 1 - 15 March 1975 - Winter distribution surveys charter aircraft.

d. 16 - 23 March 1976 - M.V. "Big Valley" (charter) Kenai Coast.

2. Scientific party

a. Karl Schneider - ADF&G - PI #243
b. Don Calkins - ADF&G - PI #243, Co PI #229
c. Kenneth Pitcher - ADF&G - PI #229, Co. PI #243
d. Various employees - ADF&G - Field and laboratory assistants.

3. Methods - see section V. Annual report.

4. Sample Localities

a. Prince William Sound
b. Kenai Peninsula - outside coast
c. Northern Kodiak, Afognak and Shuyak Islands

5. Data collected and analyzed

a. During the Oct. - Nov. 1975 cruise, 14 sea lions were collected in southwestern Prince William Sound The Feb. 1976 cruise in the Kodiak area produced five additional animals. The March trip along the Kenai coast produced 8 sea lions.

b. Preliminary identifications were made of the food items from the animals collected in Prince William Sound.

c. Reproductive analyses were completed for the female sea lions collected in Prince William Sound.

d. Preliminary ages were assigned to 15 of the sea lions.

LITERATURE CITED

Bartholomew, G. A. and R. A. Boolootian. 1960. Numbers and population structure of the pinnipeds of the California Channel Islands. J. Mamm. 41(3)366-375.

Bigg, M. A. 1973. Census of California sea lions on southern Vancouver Island, British Columbia. J. Mamm. 54(1):285-287.

Brooks, J. W. 1957. Annual report No. 9. Alaska Dept. of Fish and Game.

Chittleborough, R. G. and E. H. M. Ealey. 1951. Seal marking at Heard Island, 1949. Interim Reports of Australian Natl. Antarctic Res. Expeditions. Issued by the Antarctic Division, Dept. of External Affairs, Melbourne, Oct. 1951.

Fiscus, C. H. 1969. Steller sea lions at Ugamak Island, Aleutian Islands Alaska. Dept. of Interior, Marine Mammal Laboratory. Unpublished report.

__________. and G. A. Baines. 1966. Food and feeding behavior of Steller and California sea lions. J. Mamm. 47(2):195-200.

Fitch, J. and R. Brownell. 1968. Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. J. Fish. Res. Bd. Canada. 25(12)

Imler, R. H. and H. R. Sarber. 1947. Harbor seals and sea lions in Alaska. USFW Serv. Spec. Rep. 28, 22p.

Johnson, A. and C. Lucier, 1975. Hematoxylin hot bath staining technique for aging by counts of tooth cementum annuli. Alaska Dept. of Fish and Game. Unpubl. report. 29pp.

Laws, R. M. 1959. Accelerated growth in seals with special reference to the Phocidae. Norweigian Whaling Gaz. 9:425-452.

Mate, B. R. 1973. Population kinetics and related ecology of the northern sea lion, <u>Eumetopias jubatus</u>, and the California sea lion, <u>Zalophus Californianus</u>, along the Oregon coast. PhD. thesis. Univ. Oregon. Dept. Bio. 93pp.

Mathisen, O. A., R. J. Bade and R. J. Lopp. 1962. Breeding habits, growth and stomach contents of the Steller sea lion in Alaska. J. Mamm. 43(4):469-477.

__________. and R. J. Lopp. 1963. Photographic census of the Steller sea lion herds in Alaska, 1956-58. USFW Serv. Sp. Scientific Rep. Fisheries No. 424.

Orr, R. T. and T. G. Poulter. 1967. Some observations on reproduction, growth and social behavior in the Steller sea lion. Proc. Calif Acad. of Sciences 35(10):193-226.

Pike, G. C., and B. E. Maxwell. 1958. The abundance and distribution of the northern sea lion (Eumetopias jubata) on the coast of British Columbia. J. Fish. Res. Bd. Canada. 15:5-17.

Pitcher, K. W. and J. S. Vania. 1973. Distribution and abundance of sea otters, sea lions and harbor seals in Prince William Sound, Alaska. Summer 1973, a preliminary report. Alaska Dept. Fish and Game. Anchorage, Alaska. mimeo.

Rand, R. W. 1950. Branding in field-work on seals. J. Wild. Man. 14(2).

Sandegren, F. E. 1970. Breeding and maternal behavior of the Steller sea lion (Eumetopias jubata) in Alaska. MSc. Thesis. Univ. Alaska, College, Alaska 138pp.

Scheffer, V. B. 1950. Experiments in the marking of seals and sea lions. U. S. Dept. of Interior. Fish and Wildlife Service. Spec. Sci. Report No.4.

________. 1967. Standard measurements of seals. J. Mamm. 48(3).

Sergeant, D. E. 1966. Reproductive rates of harp seals (Pagophilus groenlandicus). J. Fish Res. Brd. Canada. 23(5).

________. 1973. Feeding, growth and productivity of northwest Atlantic harp seals (Pagophilus groenlandicus). J. Fish. Res. Brd. Canada. 30(1):17 29.

Smith, I. D. 1972. Sea lions wintering along the outer coast of Vancouver Island. J. Fish. Res. Brd. Canada 29(12):1764-1766.

Smith, T. G., B. Beck and G. A. Sleno. 1973. Capture, handling and branding of ringed seals. J. Wildl. Mgmt. 37(4):579-583.

Spalding, D. J. 1964. Comparative feeding habits of the fur seal, sea lion and harbor seal. Fish. Res. Brd. Canada, Bull. 146 52pp.

Thorsteinson, F. V. and C. J. Lensink. 1962. Biological observation of Steller sea lions taken during an experimental harvest. J. Mamm. 26(4):353-359.

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THE RELATIONSHIPS OF MARINE MAMMAL DISTRIBUTIONS, DENSITIES AND ACTIVITIES TO SEA ICE CONDITIONS

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I. SUMMARY

The general objectives of this project are to determine the distribution and aerial extent of the different ice habitats utilized by marine mammals of the Bering, Chukchi and Beaufort seas, to investigate the relationships of the various marine mammals to these ice habitats, and to determine how the seasonal changes in sea ice cover regulate the distribution and activities of marine mammals.

Field work for this project has just begun which limits the data available upon which to base conclusions. An exception is provided by a comparison of the results of two previous studies (Burns, 1970; Shapiro and Burns, 1975a), which permit a correlation to be made between the distribution of breeding adults of the pagophilic pinnipeds and average ice conditions in the Bering and Chukchi seas in March and April. This suggests that those areas most heavily used by marine mammals at various times of year, and the associated ice conditions, can be identified and described. This in turn provides the basis for estimating the effect that various types of development may have on these populations.

II. INTRODUCTION

A. General Nature and Scope of Study

The relationships of ice inhabiting marine mammals to the variety of ice-dominated habitats which exist in the Bering, Chukchi and Beaufort seas are not well understood. It is generally known that the distribution and activities of mammals in these areas are related to, and broadly synchronous with, the seasonal dynamics of the sea ice; that each species occupies a different ecological niche within the ice-dominated system; that a variety of ice 'habitats' are present; and that the various species 'utilize' sea ice in different ways (Burns, 1970; Fay, 1974).

As pointed out by Fay (1974), ice of these and other sub-polar and polar seas is important to marine mammals in several ways. It serves as a substrate on which some pinniped species haul out to sleep and bear their young. It also forms a rigid barrier through which pinnipeds and cetaceaus alike must find or make holes in order to have access to the air that they breathe and the sea that holds their food. For some species of marine mammals, the nature of the ice may be as important in habitat selection as are terrain, soil type and vegetation to terrestrial mammals. For other species, the presence of ice may be disadvantageous, requiring them to carry on extensive migrations in order to avoid it.

Almost all investigations to date of the relationships of marine mammals to sea ice have focused on the species and its adaptations to the ice. This approach is understandable because more is known about the form, function and distribution of the animals than about the dynamic processes of ice formation, movement and deformation. The latter have been difficult to study in broad perspective from land, ships, or aircraft, but the recent introduction of repetative high-resolution satellite imagery has provided that greater perspective. Broad views of sea ice distribution are now available from which these processes can be observed, so that the chronological and spatial distribution of marine mammals may now be related to sea ice characteristics, conceivably to the degree that a predictive model can be developed.

Our general objectives are to determine the distribution and aerial extent of the different ice habitats utilized by marine mammals of the Bering, Chukchi and Beaufort seas, to investigate the relationships of the various marine mammals to these ice habitats, and to determine how the seasonal changes in sea ice cover regulate the distribution and activities of marine mammals. A continuing program for obtaining various kinds of 'ground truth' is an integral part of this project.

Of necessity, this project requires, and is designed around, the involvement of both physical and biological scientists.

B. Specific Objectives

The specific project objectives are:

(1) To determine the extent and distribution of regularly occurring ice-dominated marine mammal habitats in the Bering, Chukchi and Beaufort seas;

(2) to describe and delineate these habitats;

(3) to determine the physical environmental factors which produce these habitats;

(4) to determine the distribution and densities of the various marine mammal species in different ice habitats; and

(5) to determine how the dynamic changes in quality, quantity and distribution of sea ice relates to major biological events in the lives of marine mammals (e.g., birth, nurture of young, mating, molt and migrations).

C. Relevance to Problems of Petroleum Development

Petroleum development in the Bering, Chukchi and Beaufort seas will, without exception, take place in regions of seasonal sea ice cover in which ice-associated marine mammals occur abundantly and are involved in major annual biological events. As examples, proposed lease areas in Bristol Bay, St. George Basin and Havarin Basin are in areas seasonally covered by the ice front in which spotted and ribbon seals concentrate in winter to give birth and nurture their pups. The Hope Basin is within the migration route of all ice-associated marine mammals which winter in the Bering Sea. The Beaufort Sea lease area is occupied by ringed seals and polar bears almost all year.

The different regions are subjected to different ice conditions. In turn, the variety of ice conditions support different marine mammal species in varying numbers.

The relevance of this project to problems of petroleum development is that we are attempting to determine (1) what major recognizable marine mammal habitats exist, (2) how these habitats are spatially and temporally distributed, (3) to what extent the various mammal species depend on them and, (4) how important aspects of the biology of marine mammals are related to the physical changes in a major component of their environment - ice.

The answers to these questions are necessary in order to determine what species are likely to be affected by development, in what numbers and to some extent, how.

III. CURRENT STATE OF KNOWLEDGE

Ice-associated mammals of the Bering, Chukchi and Beaufort seas include polar bears (*Ursus maritimus*), walrus (*Odobenus rosmarus*), spotted seals (*Phoca vitulina largha*), ringed seals (*Phoca hispida*), ribbon seals (*Phoca fasciata*), bearded seals (*Erignathus barbatus*), belukha (*Delphinapterus leucas*) and bowhead whales (*Balaena mysticetus*).

The biology of some of these species has been intensively studied (i.e., Burns, 1965, 1967; Burns et al., 1972; Gol'tsev, 1968; Kleinenberg et al., 1964; McLaren, 1958; Tikhonirov, 1961). However, the ecology of some species such as the bowhead whale and ribbon seal is poorly understood.

Recent studies (Burns, 1970; Fay, 1974) have focused attention on the role of sea ice in providing a variety of habitats, each of which supports a different faunal association. However, the characteristics of these habitats (and others which have since been recognized) and the physical and biological processes which produce them are only beginning to be investigated.

Recent studies of ice distribution and dynamics in the study area, using both LANDSAT and NOAA 2/3 satellite data, have been reported by Shapiro and Burns (1975a,b), Muench and Ahlnas (1976), Crowder et al. (1974), and Hibler et al. (1974). These illustrate the utility of satellite imagery for investigations of this type. However, the problem of using satellite data to define and identify those characteristics of the ice which determine its quality as habitat for particular species has not as yet been addressed. This constitutes an important part of this project.

IV. STUDY AREA

The study area includes all of the eastern Bering and Chukchi seas and the shelf of the Beaufort Sea.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Data about mammals are derived from several sources including the published literature, shipboard and aerial surveys, aircraft flights to coastal villages including those on St. Lawrence Island during which marine mammals are sighted, observation of marine mammal migrations past coastal hunting sites, analysis of records concerning characteristics of marine mammals harvested at different Eskimo villages, studies of the ecology of various species of marine mammals and occasional reports from interested individuals such as pilots and village residents.

Local ice conditions are monitored during the appropriate activities listed above. Additional data are available from aerial photographs and the results of other remote sensing flights in the study area. Finally, imagery from both LANDSAT and NOAA weather satellites is received at the remote sensing data library of the Geophysical Institute, University of Alaska. NOAA satellite data are available within one week of acquisition. Unfortunately, there is about a six-month delay in receipt of the LANDSAT data, plus time required for printing and preparation of special products.

The satellite data is useful for two related reasons. First, imagery which coincides with any type of ground truth data provides the opportunity to learn how to recognize, on that imagery, those ice conditions which various species utilize or, equally important, do not utilize. Second, all of the imagery can be studied for the purpose of defining the 'average' ice conditions in any area during some particular time of year. An example of this is given below, in which recurring features of the March-April ice cover of the Bering and Chukchi seas are described. This type of work will be more important, however, when the problem of identification of habitat from satellite imagery has been solved.

VI. RESULTS

A. Comparison of Winter Distribution of Pinnipeds with General Sea Ice Conditions

The generalized late winter distribution of reproductive adults of the pagophilic pinnipeds in the northern Bering and Chukchi seas, as reported in Burns (1970), is shown in Figure 1. This figure represents a compilation of sightings of animals made over a period of several years, and it is not meant to imply that these have been treated statistically.

Figure 2 is a summary of ice conditions in part of the same area for March and April of 1973 and 1974, modified from Shapiro and Burns (1975a). The data sources upon which the map is based included daily coverage of the area by the DAPP satellite for 1973, the NOAA 2/3 satellites for 1974, and all available LANDSAT (then ERTS-1) imagery for both years. The map is intended to represent 'average' conditions, in the sense that for about 50-75% of the time covered by the study, the configuration of the ice was similar to that shown.

Comparison of Figures 1 and 2 indicates the correlation between mammal distributions and ice conditions. As an example, breeding ringed seals are restricted to the landfast ice. In contrast, bearded seals occur throughout the Bering Sea, but north of Bering Strait their range is more restricted, apparently by the margin of the heavy pack ice. Thus, they tend to occur in the narrow shear zone along the west coast of Alaska (Figure 3), and to be more dispersed in the area just north of Bering Strait where the prevailing northerly winds tend to break the pack ice and drive it south through Bering Strait (Figure 4).

North of the pack ice edge in Bering Sea, walrus tend to congregate east, west and south of St. Lawrence and Nunivak islands, while apparently avoiding the north sides. The reason for this is apparent from Figure 2. The north sides of both islands are strong convergence zones in the ice drift pattern (Figure 5). In contrast, persistent polynya occur south of both islands, while their east and west margins are the sites of continuous breaking of the pack ice as it deforms in order to drift past the obstacles which the land masses represent. Note that the concentrations of walrus on the south side of the Diomede Islands are probably related to the small polynya at that location.

Finally, ribbon and spotted seals are associated with the marginal zone of the ice in the Bering Sea (Figure 6), which is characterized by small floes formed by disintegration of the heavier pack ice.

The discussion above shows a generalized correlation between the distribution of certain species and what has been defined as 'average' ice conditions. This result is particularly encouraging because the data sets upon which Figure 1 and 2 were based do not overlap in time. This implies a degree of repeatability, and hence, predictability in patterns of mammal distribution and ice characteristics. However, both the animals and the ice represent discrete dynamic systems. Ice conditions in any area can change rapidly, as can the density and types of mammals within that same area. It is thus important to accurately define those characteristics of the ice which each species utilizes in order to determine the extent of area which might be occupied by that species at any time.

Finally, it should be emphasized that the discussion above is concerned only with reproductive adults during the time the young are born. The question of how well ice conditions and mammal distribution will correlate at other times of year must still be considered.

B. Ice Classification

The objective of this part of the project is to develop a quantitative classification of sea ice conditions which defines the state of the ice as habitat for various species. That is, to determine the range of numerical values of various parameters which describe the ice conditions in any area within which each species will utilize that ice. Further, to be useful, the classification must be based upon measurements from satellite images in order to take advantage of the repetitive and synoptic aspects of this data. At present, only LANDSAT imagery is being used for this study.

There are two basic elements required for the development of such a classification. The first is to determine the parameters which define the character of the ice as habitat for various species and the second, to learn how to identify and measure these from satellite data. Data for the first requirement will be developed through ecological studies and survey flights, particularly those which coincide with satellite passes, while the second requires experimentation with procedures for extracting information from the satellite data. Surveys and ecological studies are in progress at present and more are planned in future (see the section on fourth quarter activities below). Most of the work to date has been on techniques for utilization of the satellite data, and progress in this area is reported below.

In the absence of any definitive data relating particular species to ice habitats the approach adopted has been to attempt to develop methods of statistically discriminating different ice conditions from LANDSAT data simply to learn what methods might be useful. In order to accomplish this in detail, some means of determining approximate ice thickness from the data is required. No methods are presently known by which this can be done (although a possible approach is given below). Therefore, as a starting point the ice has been divided into only two categories: 'thick' ice, which has high reflectivity and appears in tones of light gray on band 7 of the LANDSAT imagery, and open water or 'thin' ice, which ranges from black through the darker gray tones. Using these, it is possible to statistically define the floe size distribution and, equally important, the distribution of spacing between floes. It is anticipated, based upon the available data, that these will be important factors in defining ice habitats.

It is intended that in the remainder of the study digital tapes of the LANDSAT data will be used to produce the results described below. However, another method was adopted for the first attempt simply to test the idea with available equipment. In this method, a scanning microdensitometer is used to establish the film density along a number of lines on a 70mm negative transparency of a LANDSAT image. The density variation is recorded as a continuous curve on a strip chart recorder. The resolution of the system is thought to be about the same as that of the satellite images, but this still needs to be esablished. The scanning and recording speeds are known, so that distances along the curve can be scaled against distances on the image. Sharp changes in film density between thick ice floes and thin ice or open water are readily identified on the curve. The exact density value at which the transition is to be defined is determined by comparison of observed densities of thick ice and thin ice-open water areas on the image with the density scale which is supplied as part of the marginal information on the negative. Once this decision level is established, the path distances over thick ice and thin ice or open water can be determined by simply measuring the distances along the curve over which the density value is above or below the standard for the transition. The results can then be summarized to numerically define differences in ice conditions in different areas. Note that these steps can be done by computer directly from the digital tapes of the data.

As an example, Figure 7 shows LANDSAT image number 1228-22273-7, acquired on March 8, 1973. The scene covers part of the southeastern Chukchi Sea, with Point Hope just west of the center of the northeast quadrant. Outlined on the picture are six areas, 35 km x 35 km in size, which were used for this study. Each area was scanned twelve times by the microdensitometer, six scans each in a north-south and east-west direction. The density level curves were processed as outlined above, and some results are summarized in Table I. The preliminary nature of these values must be emphasized, because several important questions are still to be investigated before any detailed interpretation is attempted. Among these are:

(1) Which band (or combination of bands) will yield the most suitable data? In this example, band 7 was used because of its high contrast which simplifies the interpretation of the microdensitometer curves. However, no comparisons have yet been made with results from other bands.

(2) Is the number of scans adequate to supply a statistically significant data sample?

(3) What is an appropriate size for the sample area and need this be the same in all cases. Note that the size of the sample areas selected above was arbitrary.

TABLE I

SUMMARY OF STATISTICAL DATA

	THICK ICE						THIN ICE - OPEN WATER					
Area	% Path	Mean (mm)	σ_I	γ_I	Median (mm)	Mode (mm)	% Path	Mean (mm)	σ_W	γ_W	Median (mm)	Mode (mm)
1	75.1	10.31	19.85	.821	4	2-4	24.9	2.86	4.7	2.85	1.5	2-4
2	90.2	27.63	35.66	1.72	18	16-32	9.8	3.50	7.69	6.87	2.25	2-4
3	90.1	30.40	45.42	3.17	12	16-32	9.9	3.74	4.24	1.64	2	1-2
4	70.1	11.70	24.16	5.07	2	2-4	27.9	4.66	9.84	6.16	1	2-4
5	83.1	24.17	31.04	1.87	13	4-8	16.9	5.53	8.81	2.50	3.5	1-2
6	91.3	27.17	50.98	3.50	9	16-32	8.7	2.90	2.83	2.61	2	2-4

Key: Conversion scale, 1mm on chart = .114 km

$\sigma_{(I,w)}$ - standard deviation of (thick ice, thin ice-open water) path length

$\gamma_{(i,w)}$ - slewness

(4) Exactly how should the decision level for the transition between open water-thin ice and thick ice be established? This is obviously critical, because it absolutely determines the values of the measured path lengths.

Finally, there is an extensive literature relating to the statistical treatment of particle size distributions in sedimentary rocks. This is analogous in many ways to the problem under study, and it is anticipated that at least some of this will be useful in the interpretation of this data.

The range of values in Table I do serve to indicate that differences in ice characteristics can be detected and expressed quantitatively. As an example, areas 1 and 4 primarily cover ice which is typical of that deformed in the shear zone along the coast. These areas have lower values of percent of ice cover, mean, medium and mode of thick ice path, σ_i and median water path than do the remaining areas, and these values appear to reflect the greater deformation in these areas than in the pack ice of the remaining areas. Areas 2, 3 and 6 are all dominated by thick ice. However, at the time the image was acquired, tension fractures were developing in areas 2 and 3 and the pack ice was thus probably diverging, while area 6 was drifting relatively uniformly to the south-southeast at a velocity of about 9-10 km/day (Shapiro and Burns, 1975b). From Table I, it is apparent that the values which describe the characteristics of the thick floes are similar for the three areas, except that the median floe size for area 6 is lower than those of areas 2 and 3. However, there is a marked difference in the values of the mean, σ_w, median and mode for the open water-thin ice path lengths for these areas. For area 6, all of these values are quite similar, indicating that these path lengths are relatively uniform in size, while they are more variable for areas 2 and 3. This is probably related to the difference in the dynamic state of these areas. The tension fractures in areas 2 and 3 tend to form long leads of variable width, while the open water-thin ice distribution in the uniform drift field of area 6 would be expected to be more even.

These results are considered to be encouraging, but more work is needed both to answer the questions outlined above, and to provide a wider range of sample areas.

A second method under study for obtaining the data for establishing the classification involves using the Fourier transforming properties of spherical lenses. The technique has been investigated in connection with problems of pattern recognition on aerial photographs, and may also be applicable in the present study.

In theory, the technique is straightforward. A point source of monochromatic light from a lasar is passed through a spherical lens to form a plane wave. The beam then passes through a small area of the photographic image which is placed at the back focal plane of a second spherical lens. The light collected by the second lens forms a diffraction pattern in the front focal plane. This diffraction pattern, which is the Fourier transform of the illuminated photographic image, provides information about the spatial frequency distribution of the photograph. The geometry and intensity of the light distribution in the diffraction pattern relates directly to the size distribution and spacing of objects in the photograph. Thus, in theory it would be possible to quickly and conveniently obtained detailed information about sea ice states by applying the technique to photographic products of the LANDSAT data.

In practice, however, the accuracy and utility of the method is limited by the noise in the system. For this project, the necessary apparatus was set up using available equipment which is too crude for detailed work, but is thought to be adequate for judging if the method is sufficiently promising to justify further effort. Light from a lasar source was passed through a small part of a 70mm transparency of a LANDSAT image, generating a diffraction pattern which changed as the image was moved through the beam. This indicates that, in fact, the changing pattern was reflecting changes in the image which the beam was sampling. However, the noise level of the resulting pattern was far too high for usable data to be taken. Efforts to remove this noise have been partially successful, but there is some question as to whether the difficulties caused by noise from the film grain can be overcome. Experiments to examine this possibility are in progress, and if a satisfactory result is not obtained, the program will be dropped.

It was noted above that the problem of estimating ice thickness from satellite data has not been solved. For the purpose of this project, however, a detailed knowledge of the thickness distribution of the pack ice is not required. Instead, the need is to determine thicknesses of the ice which set limits on its utility as habitat. Walrus can apparently break through ice up to 25 cm thick, so that, for the present, this is taken as the upper limit of thickness which it would be desirable to measure from the satellite data. A possible approach to making such a measurement is provided by the density curves described above.

LANDSAT imagery is acquired over any point for four consecutive days at the latitude of the Arctic Coast, and for three days at the latitude of St. Lawrence Island. Several sets of such consecutive images exist in which a lead or polynya is observed to be in the initial stages of formation on the first image, and then continues to grow throughout the time covered by the remaining images of the set. If new ice is forming as the lead or polynya opens, then obviously the ice thickness will grade from zero at the edge of open water to some greater thickness of the edge of the older ice. This thickness will depend upon the ambient air temperature. Given some value for the temperature, it is possible to estimate the ice thickness at some point in the lead or polynya, as a function of the time since its origin by using data on ice thickness growth versus temperature (see, for example, Stehle, 1965). When this is established, a density curve can be measured across the new ice. As noted above, gray levels associated with ice tend to become lighter as the ice thickens, and this should be reflected in the density curve up to the limit of light penetration into the ice. Thus, if the curve changes smoothly across the traverse, it may be reflecting thickness changes while it should flatten if the limit is reached.

If the procedure can be successfully applied, then a possibility of identifying ice thicknesses up to 25 cm exists. This is because from the growth curves it appears that at ambient air temperatures common along the Arctic slope in winter, ice thicknesses of up to 25 cm would be expected to form over a new lead within the time frame of four consecutive LANDSAT passes. This, therefore, would provide the necessary test data.

C. Ringed Seal Distribution

Aerial surveys of ringed seals were conducted between 10 and 18 June 1975. These surveys were in the areas of landfast ice between Point Lay and Barter Island. The timing, census procedures and survey areas coincided as closely as possible with a similar effort undertaken between 8 and 15 June 1970 (Burns and Harbo, 1972).

The 1975 surveys were undertaken for several reasons. During the winter of 1974-75, ice conditions in the Chukchi Sea, as far south as Bering Strait, were more severe than usual. Ringed seals were uncommonly numerous in the southern Chukchi Sea. Conversely, indications from several sources were that numbers of ringed seals in some areas of the Beaufort Sea were down (Lentfer, personal communication; Ehredt, personal communication). A downward trend has been reported for the past several years in the eastern Beaufort Sea and in Amundson Gulf (Smith and Stirling, 1975; Stirling et al., 1975).

Survey tracks flown in 1970 and 1975 are shown in Figures 8 and 9. The distribution of ringed seals along tracks flown on the most favorable days of each year is shown in Figures 10, 11, 12 and 13. Sea ice conditions were markedly different in these years.

In 1970, the fast ice east of Barrow was extensive, very flat over broad areas and well covered by drifted snow. Dispersed, breeding seals were rather evenly distributed throughout the entire area and aggregations of seals were confined to a small number of extensive cracks. It appeared that these favorable ice conditions over such a broad area resulted from the presence of several hundred fresh water ice floes which were grounded during October and November 1968 along the 28m depth contour between approximately 146°W and 156°W (McKay, 1969). At least 200 of these floes still existed in 1970 although many of the smaller ones had broken up and were pushed into more shallow water. The main line of floes present in 1970 was grounded in 16 to 24 meters of water and in most cases marked the seaward boundary of landfast ice. These islands protected the area inshore from drifting pack ice, permitting the development of flat, stable ice.

Ice conditions in this same area during the spring and early summer of 1975 were entirely different. The fast ice was very rough and irregular. It appeared that during the process of freezing small floes had been driven toward shore and were piled up and consolidated by freezing into an extensive cover largely dominated by low, pressure ridges. The most extensive areas of flat ice occurred approximately 17 km from shore in the area between Point Barrow and Lonely. Other limited areas of thick flat ice were randomly distributed in the rough ice between Barrow and Barter Island.

The condition of the landfast ice in the Chukchi Sea between Barrow and Point Lay in the two survey years was different in two respects. In June 1970 the fast ice did not extend very far from shore and approximately 30 to 40% of that which was present was very rough. In June 1975 the reverse was true. There was unusually extensive shore ice along the entire coast in some areas extending out more than 40 km from shore, and large areas of the ice were flat. The only regions where rough, pressured ice predominated were near points of land and along the seaward margin.

The distribution of ringed seals reflects the ice conditions which prevailed.

As noted above, in the Beaufort Sea during June 1970, ringed seals were rather evenly distributed throughout the fast ice (Figure 10). Large aggregations were encountered only along occasional cracks and infrequently along the seaward margin of the fast ice. In 1975, the distribution of seals was quite different in that there were restircted areas of flat ice in which large numbers of seals were present in aggregations and extensive areas dominated by rough ice in which very few if any seals were sighted (Figure 11).

The total area of fast ice in the Beaufort Sea was comparable in both years. Although statistical analyses of the 1975 surveys have not been completed, it appears there were significantly fewer ringed seals than in 1970.

In the Chukchi Sea during June 1970 there were few seals per square mile of track line, and the total area of landfast ice was comparatively small (Figure 12). In 1975 seal density was higher and the total area of favorable fast ice habitat was much greater. Ringed seals were rather evenly distributed near shore, but occurred in large aggregations along the seaward margin (Figure 13).

The LANDSAT imagery of the survey area arrived too late for any attempt to correlate the distribution and density of seals with specific features of the ice cover to be made for this report. If possible, this will be accomplished in the next quarter.

D. The 'Ice Remnant'

Previous study of the natural history of ribbon seals (Phoca (Histrigshoca) fasciata) indicated that they make use of an unusual feature of the late-spring sea ice cover in the Bering Sea. Ribbon seals remain in association with ice until it seasonally disappears from the Bering Sea in mid- to late-June. Some ribbon seals migrate north through Bering Strait, but most appear to remain in Bering Sea and to become pelagic when the ice disintegrates. In early June of 1968 a significant number of ribbon seals were observed in association with a band of sea ice which persisted in the eastern Bering Sea far to the south of the main body of receding pack ice.

Investigation of the limited information available concerning winds, currents and the build-up of sea ice over the winter and early spring months led to the suggestion that, 'the occurrence of a disjunct band or remnant of seasonal ice, far south of the normally receding ice edge, may be a normal annual occurrence....' (Burns, 1969). There was no opportunity to verify this until satellite imagery covering the appropriate areas during late May and June became available. Data were acquired in 1973 by the DAPP system, and in 1974 and 1975 by the NOAA weather satellite. These confirmed the existence of such remnants in each year. Data from Muench and Ahlnas (1976) shows the formation, movement, and disintegration of these during 1974. Figure 14, a composite of two images acquired by a NOAA satellite on May 22, 1974, gives a view of the ice conditions in Bering Sea after the formation of a large remnant. A more detailed view of this feature is shown in Figure 15, prepared from LANDSAT images acquired on June 1, 1974.

As noted, it is known that the ice remnants are utilized by ribbon seals, and they are probably of importance to other marine mammals, birds and plants as well. Further biological studies of these features are planned when ship time is available.

In addition, it is important to determine whether the remnants follow any predictable, repetitive drift pattern if the possible impact of offshore development on them is to be estimated. At present, therefore, an attempt is being made to calculate the average geostrophic wind fieled in this area using weather data acquired over several years. Muench and Ahlnas (1976) have indicated that most of the ice movement which they observed in the Bering Sea can be accounted for in this manner. The results will, however, be evaluated in light of available oceanographic information. Finally, satellite data will be used to track the movements of the ice remnants. These data sources should be adequate to answer the question posed above.

REFERENCES CITED

Burns, J. J., 1965, The walrus in Alaska, Alaska Dept. Fish & Game, Juneau, 48 pp.

Burns, J. J., 1967, The Pacific bearded seal, Alaska Dept. Fish & Game, Juneau, 66 pp.

Burns, J. J., 1969, Marine mammal investigations, Alaska Dept. Fish & Game, Juneau, 25 pp.

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

Burns, J. J., 1971, Biology of the ribbon seal, *Phoca (Histriophoca) fasciata*, in the Bering Sea (Abstract), Proc. 22nd Alaska Sci. Conf., p. 135.

Burns, J. J., G. C. Ray, F. H. Fay and P. D. Shaughnessy, 1972, Adoption of a strange pup by the ice-inhabiting harbor seal, *Phoca vitulina largha*, J. Mammal, 53:594-598.

Crowder, W. K., H. L. McKim, S. F. Ackley, W. D. Hibler III, and D. M. Anderson, 1974, Mesoscale deformation of sea ice from satellite imagery, Proc. Interdisciplinary Symposium on Advanced Concepts and Techniques in the Study of Snow and Ice Resources, Monterey, Calif., December 1973.

Fay, F. H., 1974, The role of ice in the ecology of marine mammals of the Bering Sea, in Oceanography of the Bering Sea, D. W. Hood and E. J. Kelly, eds., Inst. Mar. Sci., Univ. Alaska, Fairbanks, p. 393-399.

Gol'tsev, V. N., 1968, Dynamics of coastal walrus rookeries in connection with distribution and numbers of walruses, Izv. TINRO 62:205-215.

Hibler, W. D. III, S. F. Ackley, W. K. Crowder, H. L. McKim and D. M. Anderson, 1974, Analysis of shear zone deformation in the Beaufort Sea using satellite imagery, in The Coast and Shelf of the Beaufort Sea, ed. J. C. Reed and J. E. Sater, Arctic Inst. of North America, 285-296.

Kleinenberg, S. E., A. V. Yablokok, V. M. Bel'kovich and M. N. Tarasevich, 1964, Belukha (Delphinapterus leucas): A monographic investigation of the species, Akad. Nauk SSSR, Inst. Morfol. Zhivotnikh, Moscow, 456 pp (Israel Prog. Sci. Transl. 1969).

McKay, R. A., 1969, Sea ice activity and pressure ridge growth in the vicinity of surcharged grounded ice islands Unak 1 and Unak 2, ms. Rept. Inst. Arctic Environ. Engin., Univ. of Alaska, Fairbanks, 78 pp.

McLaren, I. A., 1958, The biology of the ringed seal (Phoca hispida Schreber) in the eastern Canadian Arctic; Fish. Research Bd. Can., Ottawa, Bull. 118:97 pp.

Muench, R. D. and K. Ahlnas, 1976, Ice movement and distribution in the Bering Sea, March-June 1974, J. Geophys. Res. (in press).

Shapiro, L. H. and J. J. Burns, 1975a, Major late-winter features of ice in northern Bering and Chukchi seas as determined from satellite imagery, Univ. of Alaska, Fairbanks, Sea Grant Report No. 75-8.

Shapiro, L. H. and J. J. Burns, 1975b, Satellite observations of sea ice movement in the Bering Strait region, in Climate of the Arctic, edited by G. Weller and S. A. Bowling, Univ. of Alaska, Fairbanks, pp. 379-386.

Smith, T. G. and I. Stirling, 1975, The breeding habitat of the ringed seal (Phoca hispida). The birth lair and associated structures, Can. J. Zool., 53:1297-1305.

Stehle, N. S., 1965, Ice engineering, growth rate of sea ice in a closed system: Tech. Rept. R396, U. S. Naval Civil Eng. Lab., Port Hueneme, Calif., 21 pp.

Stirling, I., R. Archibald and D. DeMaster, 1975, The distribution and abundance of seals in the eastern Beaufort Sea, Beaufort Sea Tech. Rept. #1, Victoria, Canada, 58 pp.

Tikhomirov, E. A., 1961, Distribution and migration of seals in waters of the Far East, in Transactions of the Conference on Ecology and Hunting of Marine Mammals, E. H. Pavlovskii and S. K. Kleinenberg, eds., Akad. Nauk SSSR, Ikhtiol. Comm., Moscow, p. 199-210.

Tikhomorov, E. A., 1964, Distribution and biology of pinnipeds in the Bering Sea, Izv. TINRO, 52:272-280.

VII, VIII. DISCUSSION AND CONCLUSIONS

The results given above are merely descriptions of work in progress. The field work which will provide most of the ground truth for the project has just begun, and until these results are analyzed, even preliminary conclusions will not be available. An exception to this is the discussion of the correlation between certain mammal species and ice conditions in the Bering and Chukchi seas during March and April.

Finally, other work is in progress which has not been reported on. This includes collection and organization data from previous surveys and incidental sightings of species under study, and preparation of maps of ice conditions from satellite data.

IX. NEEDS FOR FURTHER STUDY

To date, we have examined only a small portion of the available imagery and analyzed short-term changes in ice cover for a few selected areas. Results of these analyses have been correlated with information about mammal distribution. The major tasks are yet to be accomplished. These include analysis of seasonal changes in sea ice, detailed studies of each of the major sea ice habitats as indicated by LANDSAT imagery from several successive years, and correlation with a rapidly increasing body of information concerning the marine mammals.

Specific aspects which should be examined include study of the formation, extent, persistence and disintegration of the ice front, persistent polynya, major shear zones and landfast ice over several years. Changes in the 'quality' of these habitats must be correlated with annual differences in their use by marine mammals, such as is being done at present for ringed seals.

Correlations of quality of ice habitats with distribution and movements of marine mammals are extremely important. Why are polar bears only sporadically abundant in northern Bering Sea? It is known that the winter of 1975-76 was a heavy ice year in northern Bering Sea and that polar bears were unusually abundant as far south as St. Lawrence Island. In most years, they occur in low numbers near this island. What ice conditions account for these annual differences? It also appears that particular year classes of some species of seals are poorly represented in the samples acquired for other studies. This is the result of unusually low survival of pups. How is this related to quality of the specific ice habitat utilized by the seals during a year when survival of pups is poor? Conversely, what conditions prevail during years of average or good survival?

In view of the rudimentary stages of sea ice habitat studies in the Bering, Chukchi and Beaufort seas, work presently in progress should be continued until such time as a reasonable understanding of the major habitat associations and dynamics of the seasonal ice cover is achieved.

X. SUMMARY OF 4TH QUARTER ACTIVITIES

As indicated previously, ground truth verification of sea ice conditions, distribution and seasonal activity patterns of marine mammals and mammal-ice associations are obtained from many different sources.

Field programs planned for the fourth quarter (April-June) which will provide data for this project are as follows:

(1) The cruise of the Soviet research vessel Zagoriani in the central Bering Sea. F. H. Fay, a co-principal investigator, will be aboard this vessel from 15 March to 30 April. Information will be obtained on the distribution and density of walrus and ribbon seals as well as the ice conditions in areas where they occur.

(2) The American research vessel Surveyor will be operating in eastern Bering Sea during March and April. The Surveyor will be working in the ice front and will be engaged in surface surveys of all marine mammals, but primarily spotted seals. Personnel will include Lloyd F. Lowry, Kathryn Frost and Edward S. Muktvyuk (see annual report for project number 231).

(3) Extensive aerial surveys will be conducted in the ice front during April. These surveys will be undertaken to assess the distribution, density and total number of spotted seals in the front. The surveys will also produce information about the distribution of other species including whales, ribbon seals, bearded seals, walruses and sea lions. Personnel involved in the aerial surveys will include John J. Burns, Samuel J. Harbo Jr., and Lewis H. Shapiro. Flights are being planned to coincide with the timing of LANDSAT-2 passes over the survey areas.

(4) Intensive studies of ringed seals and polar bears will be conducted during March and April on the ice of the Chukchi

Sea. A helicopter and fixed wing support aircraft will be operating out of Cape Lisburne. This effort will provide ground truth information concerning characteristics and changes in the extensive shear zone which occurs along the northwest coast. Information will also be obtained on the distribution and density of bears and seals as well as migration of bowhead and belukha whales. Mr. Thomas J. Eley (Project RU 230) will be in charge of this effort.

(5) In May a collection of ringed seals will be obtained from the Beaufort Sea north of Colville River. Seals will be collected from leads at the edge of the shore fast ice. This effort will provide ground truth information about characteristics of the fast ice, leads and adjacent drifting ice during the May passes of LANDSAT-2. This field work will be conducted by John J. Burns and other investigators as yet not designated.

Each of these programs involves personnel who are either involved with this project (RU 248/249) or who have agreed to record information in a manner which is directly usable to this project.

Finally, the studies of ice classification discussed above will be continued.

FIGURE CAPTIONS

Figure 1. Distribution of reproductive adults of the pagophilic pinnipeds in the northern Bering and Chukchi seas during March and early April (from Burns, 1970).

Figure 2. "Average" ice conditions in the northern Bering and Chukchi seas during March and April, 1973 and 1974 (from Shapiro and Burns, 1975a).

Figure 3. Shear zone off Cape Lisburne, March 8, 1973. Photo from LANDSAT image E-1228-22270. Scale 1:1,000,000.

Figure 4. Area just north of Bering Strait, with Chukchi Peninsula in lower left. Photo from LANDSAT image E-1623-22160, April 7, 1974. Scale 1:1,000,000.

Figure 5. Convergence zone north of St. Lawrence Island, March 6, 1973. Photo from a mosaic of LANDSAT images E-1226-22165, 22171, 22174. Scale 1:1,000,000.

Figure 6. Marginal zone of pack ice in the Bering Sea, March 23, 1973. Photo from a mosaic of LANDSAT images E-1243-22134, 22131. Scale 1:1,000,000.

Figure 7. LANDSAT image E-1228-22273-7 with sample areas indicated.

Figure 8. Flight lines of ringed seal survey, June 1970.

Figure 9. Flight lines of ringed seal survey, June 1975.

Figure 10. Ringed seals sighted on best survey day east of Pt. Barrow, June 1970.

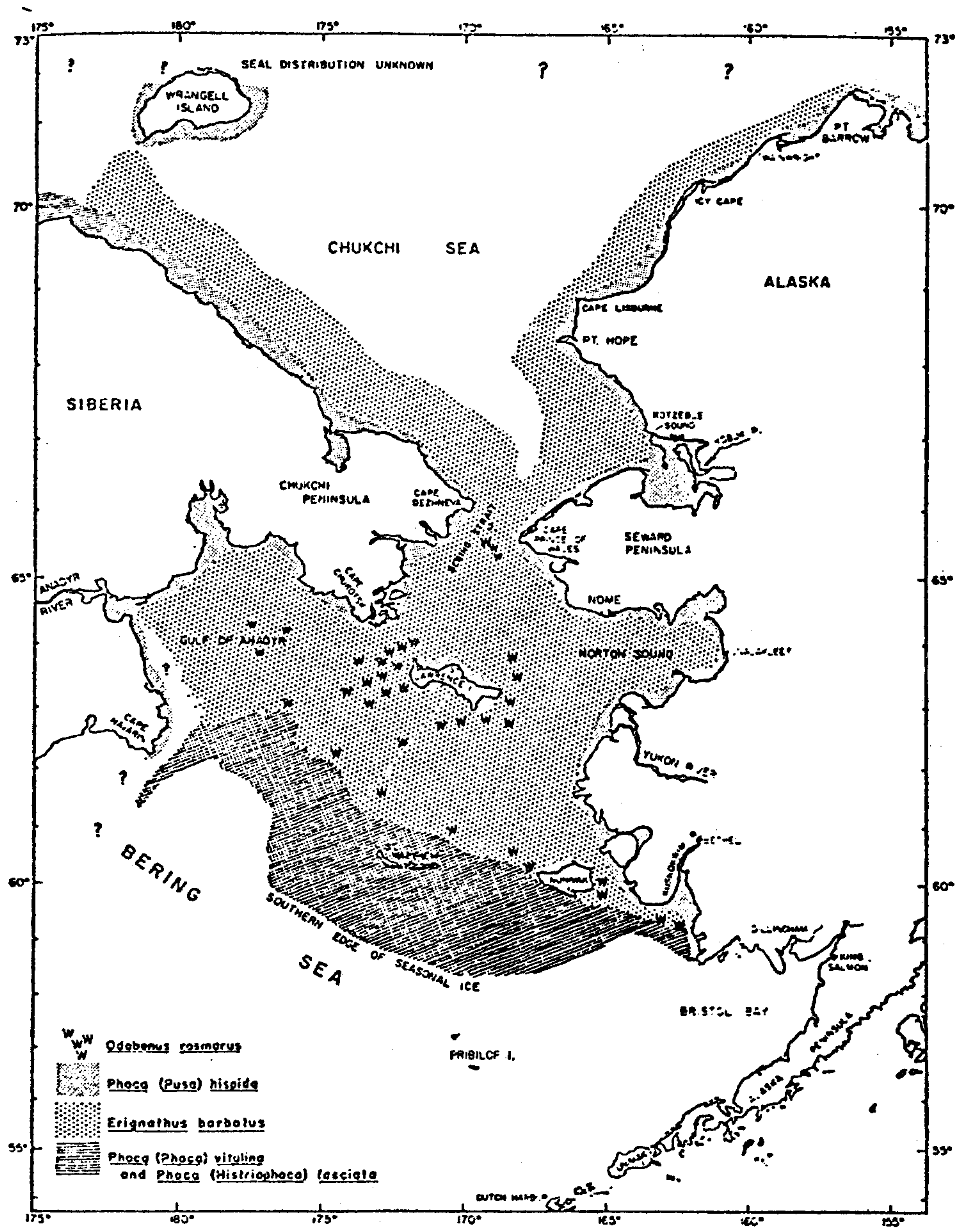
Figure 11. Ringed seals sighted on best survey day east of Pt. Barrow, June 1975.

Figure 12. Ringed seals sighted on best survey day southwest of Pt. Barrow, June 1970.

Figure 13. Ringed seals sighted on best survey day southwest of Pt. Barrow, June 1975.

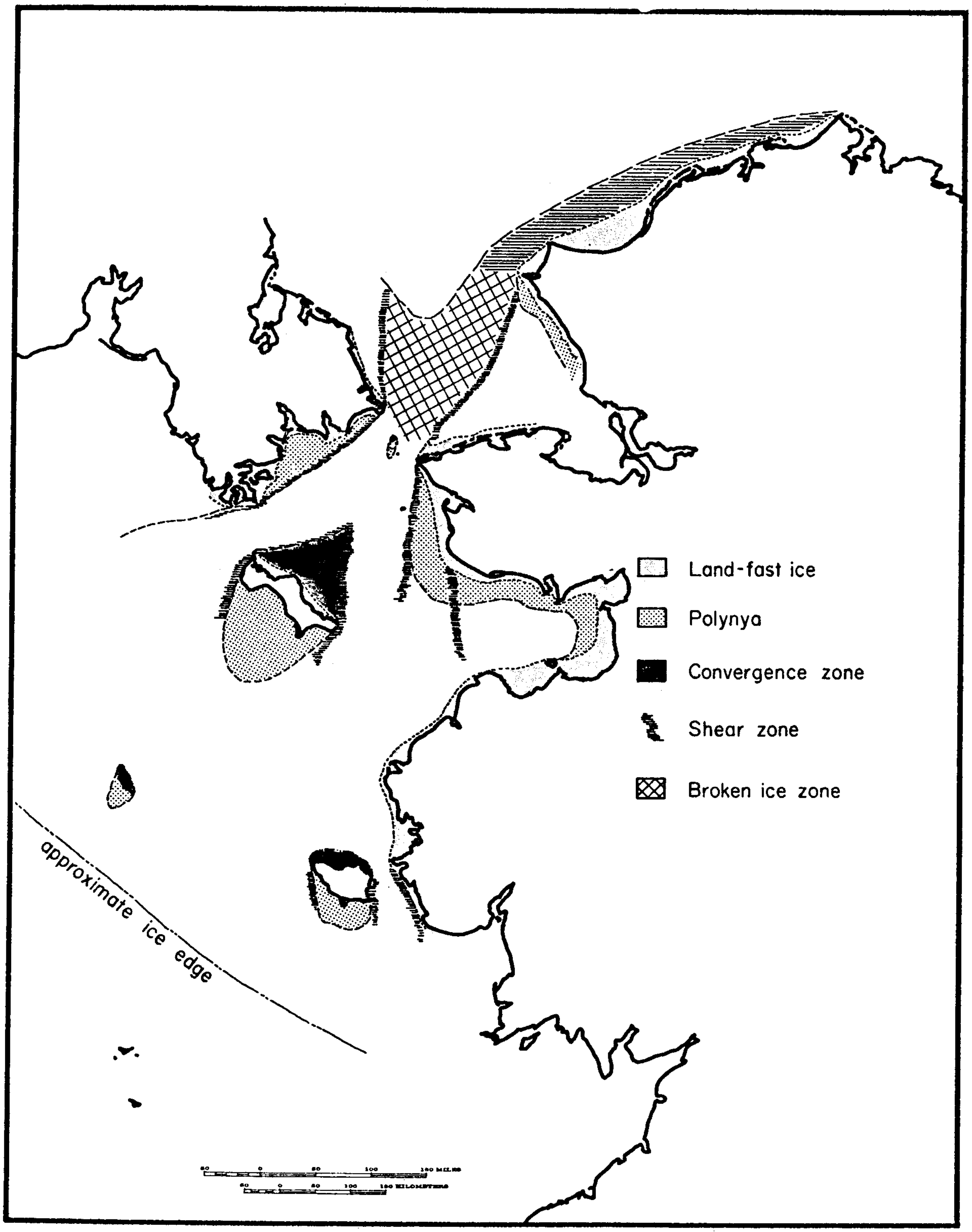
Figure 14. Pack ice "remnant" southwest of St. Lawrence Island. Photo from NOAA 2/3 satellite image acquired May 22 1974.

Figure 15. Pack ice "remnant" southwest of St. Lawrence Island, June 1, 1975. Photo from a mosaic of LANDSAT images E-1678-22220, 22213, 22211. Scale 1:1,000,000.



SEAL DISTRIBUTION UNKNOWN
WRANGELL ISLAND
CHUKCHI SEA
ALASKA
SIBERIA
CAPE LISBURNE
PT. HOPE
ICY CAPE
PT BARROW
CHUKCHI PENINSULA
CAPE DEZHNEVA
SEWARD PENINSULA
NOME
NORTON SOUND
GULF OF ANADYR
ANADYR RIVER
YUKON RIVER
BERING SEA
SOUTHERN EDGE OF SEASONAL ICE
BRISTOL BAY
PRIBILOF I.
Odobenus rosmarus
Phoca (Pusa) hispida
Erignathus barbatus
Phoca (Phoca) vitulina
and Phoca (Histriophoca) fasciata

Figure 1



Land-fast ice
Polynya
Convergence zone
Shear zone
Broken ice zone
approximate ice edge

Figure 2

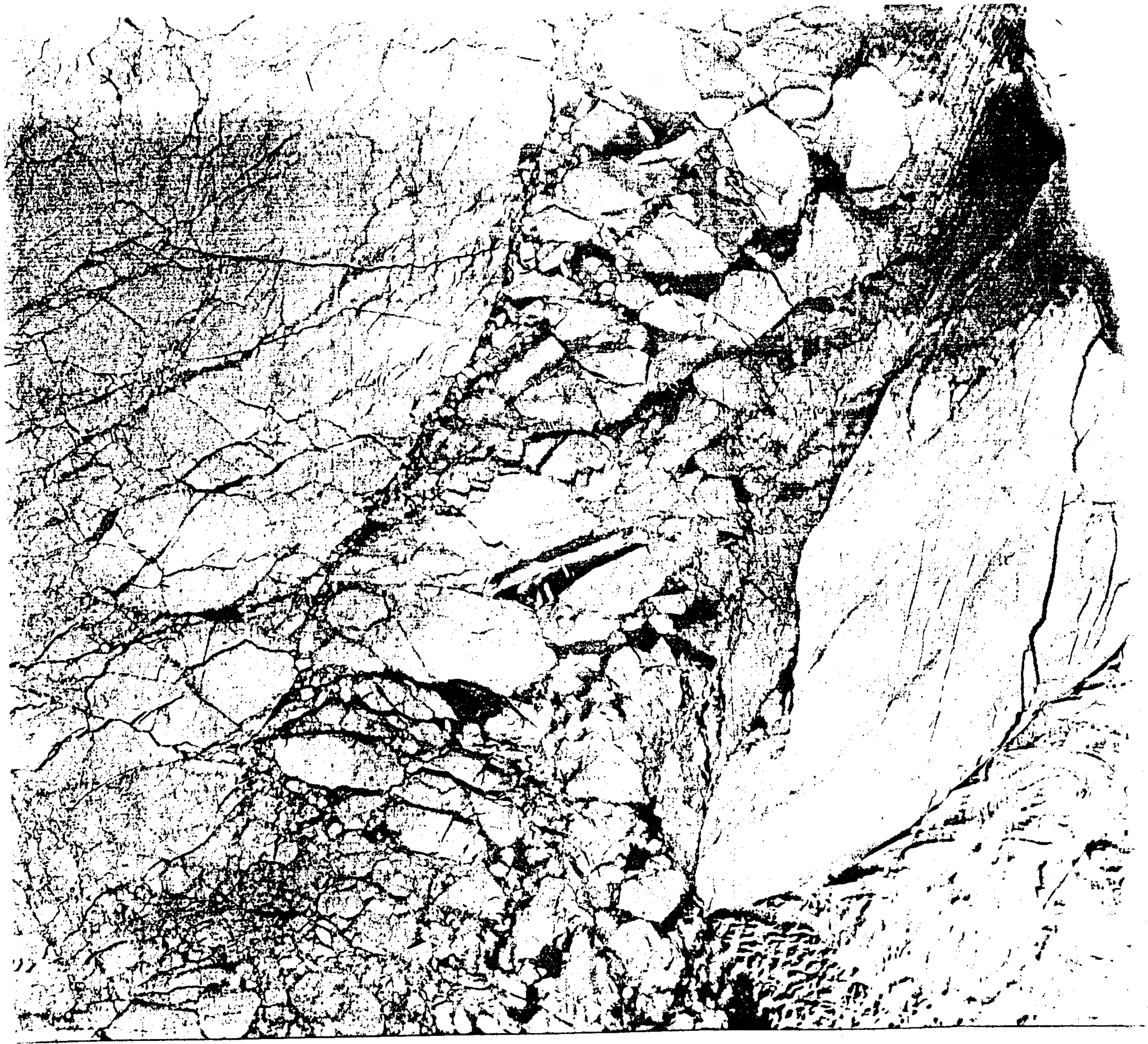


Figure 3

Figure 4

Figure 5

Figure 6

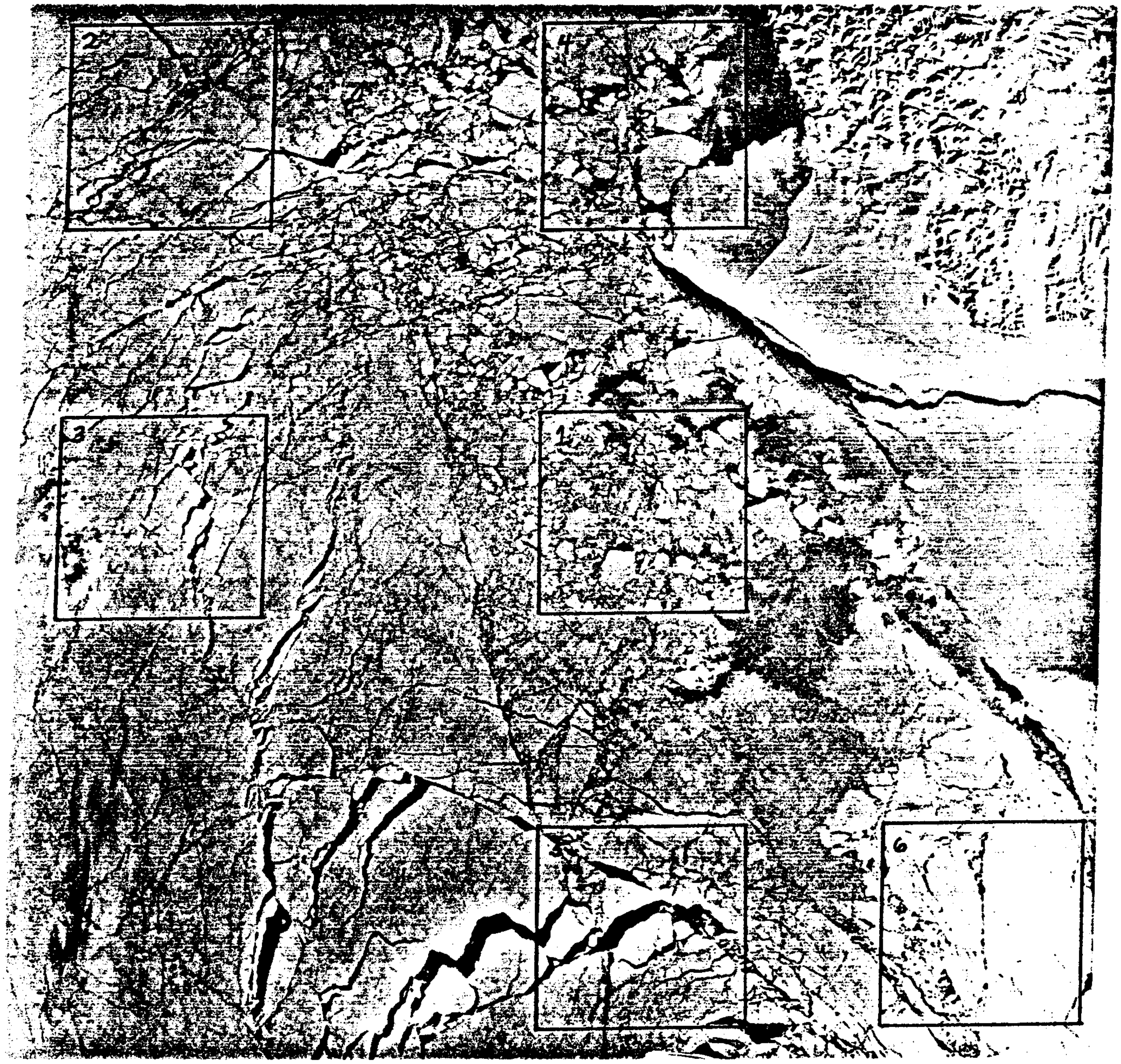
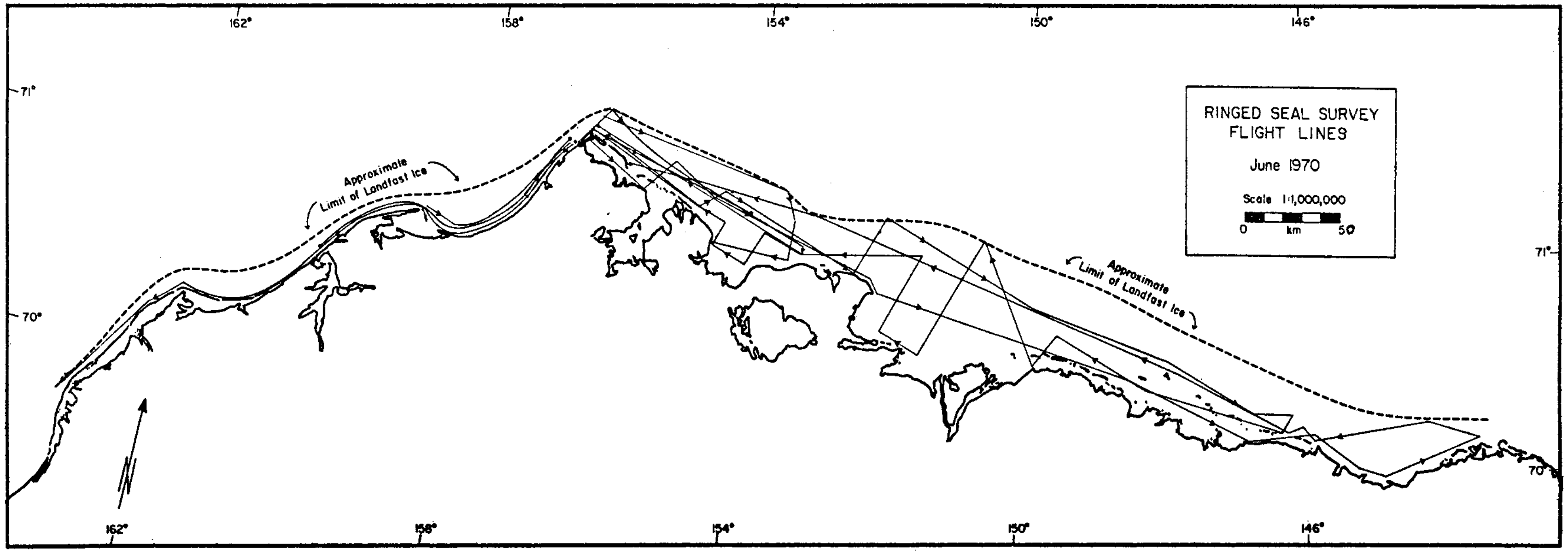


Figure 7



RINGED SEAL SURVEY
FLIGHT LINES
June 1970
Scale 1:1,000,000
0 km 50
Approximate Limit of Landfast Ice
Approximate Limit of Landfast Ice
162°
158°
154°
150°
146°
71°
70°

Figure 8

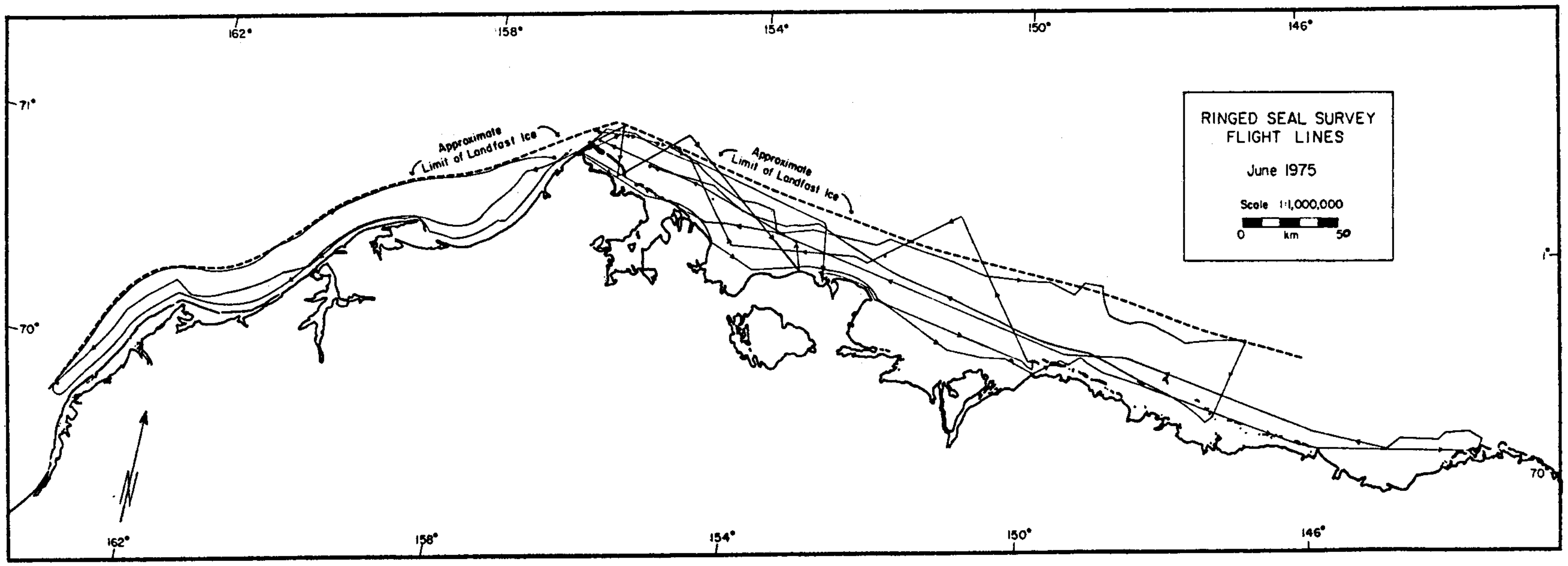
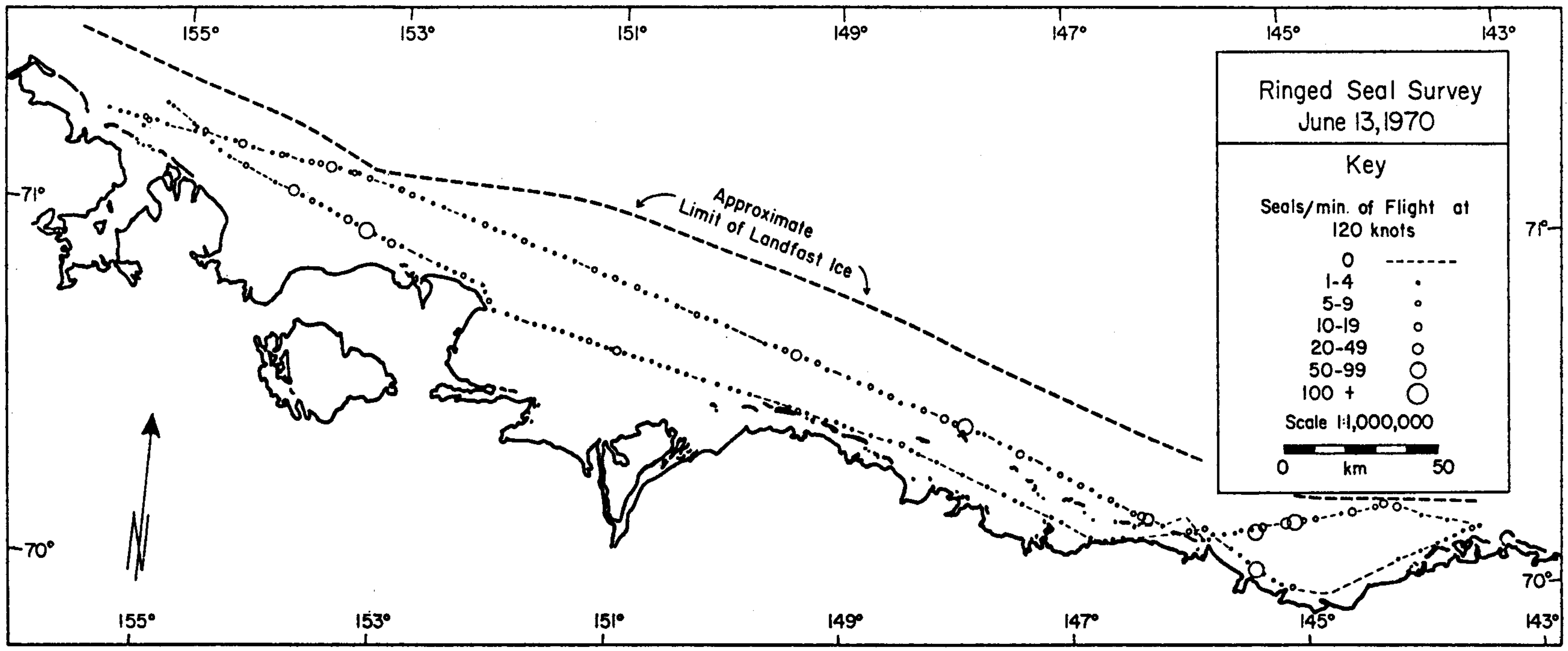
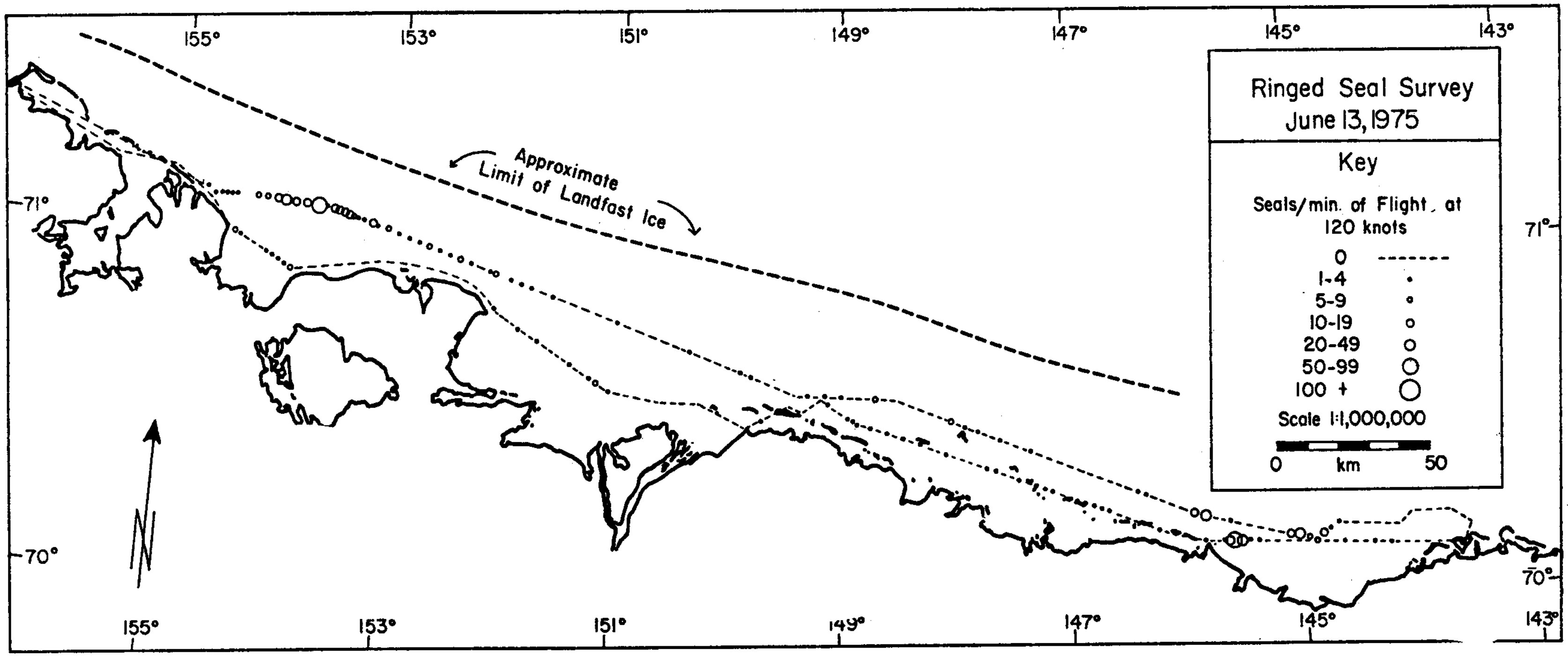

RINGED SEAL SURVEY
FLIGHT LINES
June 1975
Scale 1:1,000,000
0 km 50
Approximate
Limit of Landfast Ice
Approximate
Limit of Landfast Ice
162°
158°
154°
150°
146°
71°
70°
70°

Figure 9



Ringed Seal Survey
June 13, 1970
Key
Seals/min. of Flight at 120 knots
0
1-4
5-9
10-19
20-49
50-99
100 +
Scale 1:1,000,000
0 km 50
Approximate Limit of Landfast Ice
155°
153°
151°
149°
147°
145°
143°
71°
70°
N

Figure 10



155°
153°
151°
149°
147°
145°
143°
71°
70°
Approximate Limit of Landfast Ice
Ringed Seal Survey
June 13, 1975
Key
Seals/min. of Flight, at 120 knots
0
1-4
5-9
10-19
20-49
50-99
100 +
Scale 1:1,000,000
0 km 50
N

Figure 11

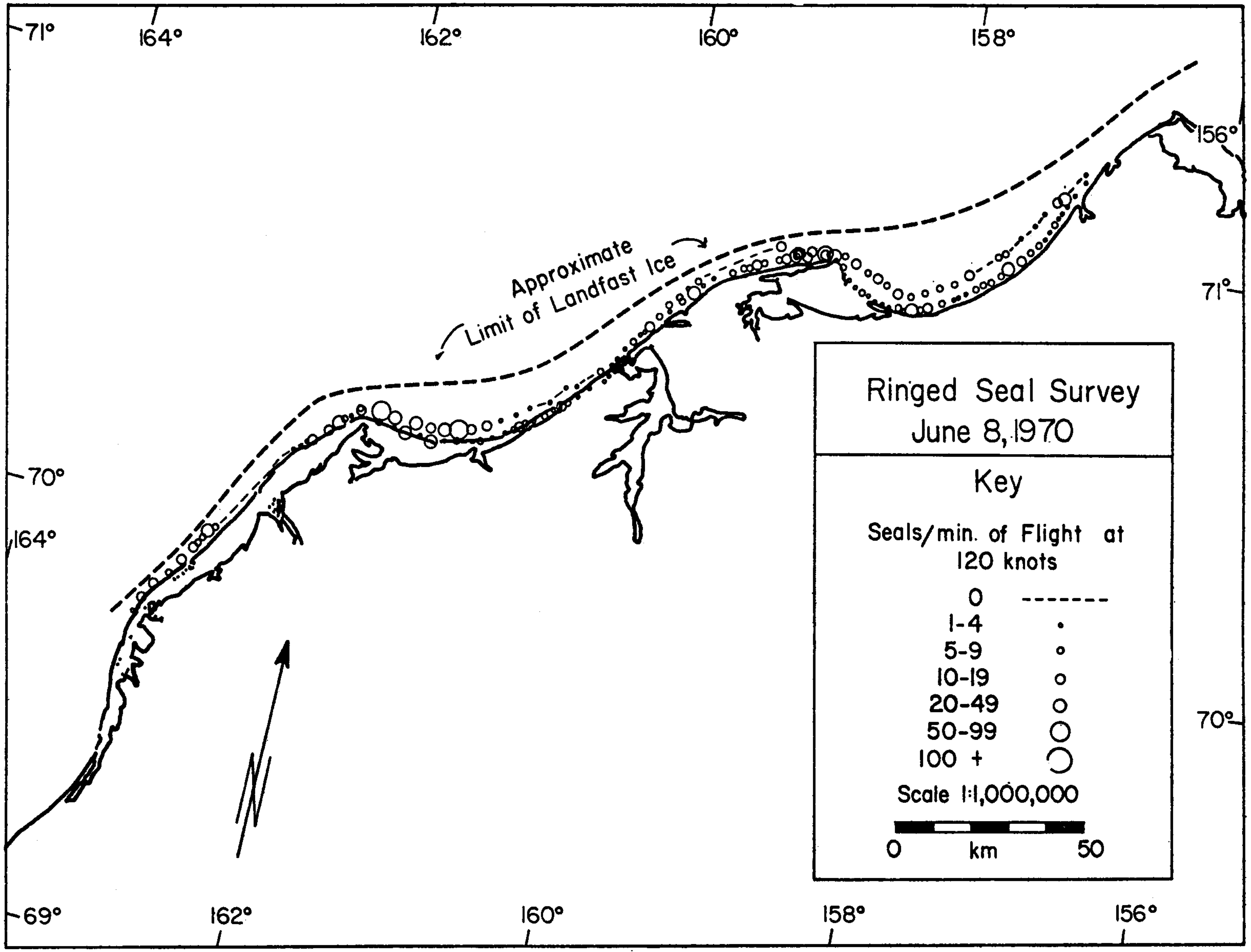
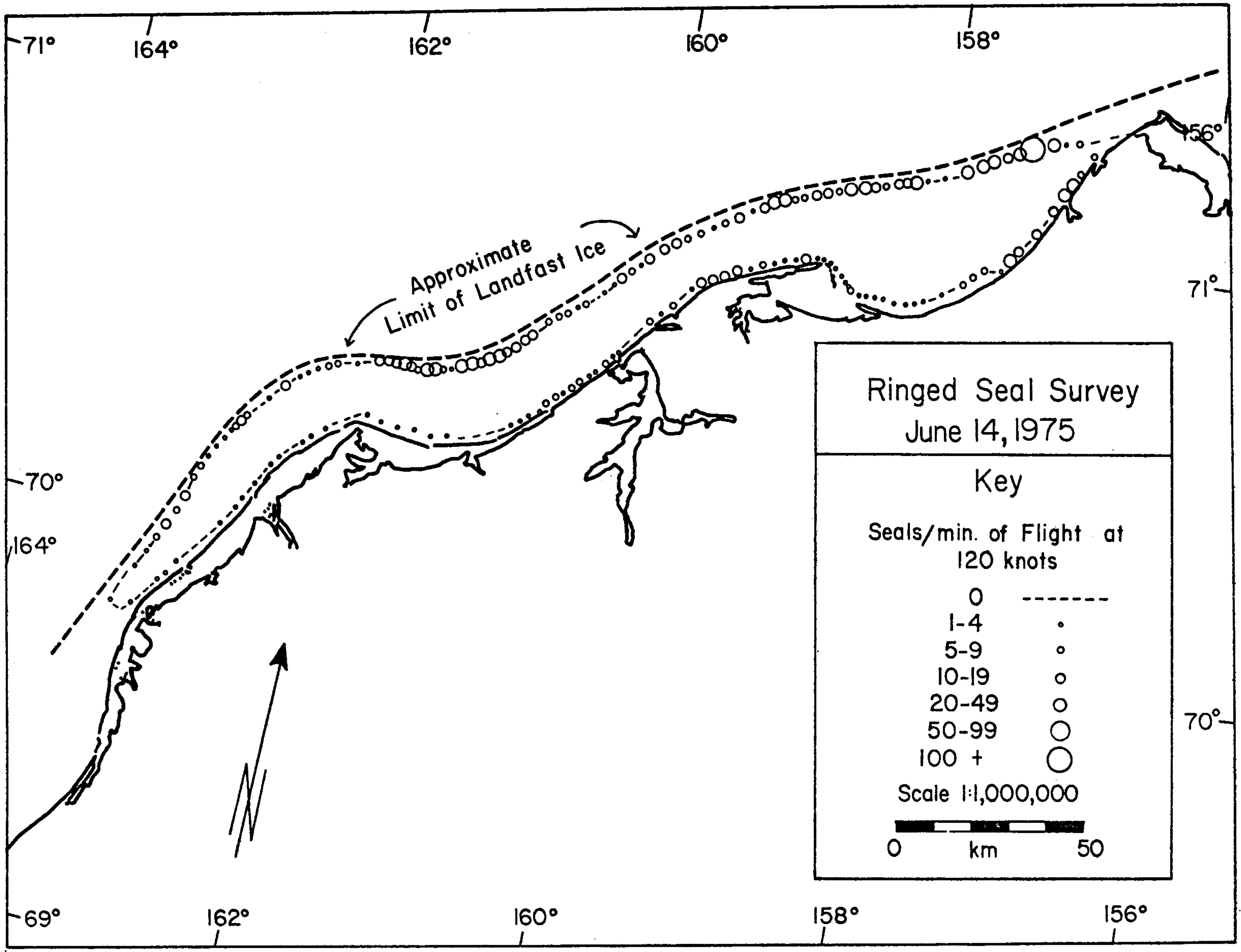

71°
164°
162°
160°
158°
156°
71°
70°
164°
70°
69°
162°
160°
158°
156°
Approximate
Limit of Landfast Ice
Ringed Seal Survey
June 8, 1970
Key
Seals/min. of Flight at
120 knots
0
1-4
5-9
10-19
20-49
50-99
100 +
Scale 1:1,000,000
0
km
50

Figure 12



71°
164°
162°
160°
158°
156°
71°
70°
164°
70°
69°
162°
160°
158°
156°
Approximate Limit of Landfast Ice
Ringed Seal Survey
June 14, 1975
Key
Seals/min. of Flight at 120 knots
0
1-4
5-9
10-19
20-49
50-99
100 +
Scale 1:1,000,000
0
km
50

Figure 13

Figure 14

Figure 15

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