Environmental Assessment of the Alaskan Continental Shelf

Volume 1

Principal Investigators' Reports
July–September 1976

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

VOLUME 1. MARINE MAMMALS, MARINE BIRDS

VOLUME 2. FISH, PLANKTON, BENTHOS, LITTORAL

VOLUME 3. EFFECTS, CHEMISTRY AND MICROBIOLOGY, PHYSICAL OCEANOGRAPHY

VOLUME 4. GEOLOGY, ICE, DATA MANAGEMENT

Environmental Assessment of the Alaskan Continental Shelf

July - Sept 1976 quarterly reports 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.

ENVIRONMENTAL RESEARCH LABORATORIES
Boulder, Colorado
November 1976

VOLUME 1

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RU# 34

NO REPORT WAS RECEIVED

A final report is expected next quarter

Fifth Quarterly Report

Contract no. R7120804
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Period: 1 July 1976 to
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Baseline Characterization of Marine Mammals in the Bering Sea

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27 September 1976

Research Unit 67
FIFTH QUARTERLY REPORT
July 1 - Sept. 30 1976

I. Task Objectives.

The objectives of Research Unit 67 are to obtain information on the general life history, ecology, and seasonal distribution and abundance of marine mammals in the eastern Bering Sea. During the fifth quarter (July through September, 1976) our specific objectives were to finalize data formatting and to begin data reduction of aerial and shipboard survey data collected from June 1975 through August 1976. Also, our plans during the fifth quarter were to begin quantifying pinniped and cetacean distribution and abundance as they relate to ice condition, breeding location, and annual migration. These objectives were in part accomplished through a continuation of a review of the literature, and preparation of the data for computer analysis.

II. Field or Laboratory Activities.

A. Field Trip Schedule.

Dates, 1976	Survey Location	Species of Interest	Aircraft
19-21 August	Alaska Peninsula Fox Islands.	sea lions, harbor seals Gray whales	Widgeon
22-27 August	So. Chukchi Sea; E. Bering Sea.	all marine mammals	Goose

B. Scientific Party

1. 19-21 August 1976, Alaska Peninsula survey.

Dr. Howard Braham, P.I.
Mr. Robert D. Everitt, Asst.
Marine Mammal Division
Northwest Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
Seattle, Washington 98115

Mr. Orin Seybert, Pilot
President of Peninsula Airways
King Salmon, Alaska

2. 22-27 August 1976, No. Bering-Chukchi Sea survey. (United States Fish and Wildlife Service marine bird survey; Marine Mammal Division observer accompanied the flight at the invitation of the USF&WS)

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Seattle, Washington 98115

Mr. Craig Harrison
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U.S. Fish and Wildlife Service
Suite - 110, 800 "A" Street
Anchorage, Alaska 99501

C. Methods

1. 19-21 August, Alaska Peninsula survey.

Sightings of marine mammals were made from a Widgeon aircraft flying at altitudes between 200 and 500 feet. Visual estimates were made of the numbers of individuals observed in each group. Photographs were taken to verify species identification, and for large pods, numbers of animals seen. Northern sea lion (Eumetopias jubatus) and harbor seal (Phoca vitulina spp.) island rookeries and hauling grounds were flown at varying altitudes to lessen the disturbance to the pinnipeds and to nesting birds. Altitudes of 1,000 to 1,500 feet were flown for overview photographs of harbor seals at Port Moller and Port Heiden in order to determine exact pod location within each harbor.

Two observers were used during the surveys; one acted as a recorder and back up photographer, the other as primary observer-photographer. The pilot also contributed significantly to the observation effort. Communication between observer, recorder, and pilot was maintained using battery operated aircraft-type headphones and intercom system (Miniamp Intercom 2D, 9V battery powered, Genie Electronic Eng., Inc., Red Lion, PA.).

Systematic transects were flown along the coast of the Alaska Peninsula and around each island in the Fox Island group, eastern Aleutian Islands. An attempt was made to record all animals seen within ½ miles on either side of the aircraft. Animals directly below the aircraft could not be seen. This allows one to obtain duplicate samples from either side of the aircract during pelagic habitat surveys, should both sides of the aircraft be used. When surveying rookeries or hauling grounds, all observations were made from only one side of the aircraft.

2. 22-27 August, 1976, No. Bering-Chukchi Sea survey.

A marine mammal aerial survey was conducted concurrently with a USFWS-OCS bird survey from 22-27 August, 1976. Sightings of marine mammals were made from a turbo-powered Grumman Goose (N780, Office of Aircraft Services, Anchorage, Ak.) specifically modified for long range surveys. The plane was flown at 100-150 feet, at 120 knots. Visual numeric estimates were made of all individual marine mammals in each group observed. Photographs were taken to verify the estimated numbers present.

One Marine Mammal Division observer was used throughout the survey, making observations, recording data and taking photographs. The pilots and the bird observers contributed significantly to the marine mammal observational effort. An attempt was made to record all animals seen within a ½ mile strip on one side of the aircraft. Animals directly below the aircraft could not be seen.

The transects flown were pre-determiend by the bird observers. Deviations were made only when weather conditions would not permit adequate observation along the chosen trackline.

D. Aerial survey locations and tracklines flown (Figures 1-9).

1. 19 August; Alaska Peninsula (Figure 1).
2. 20-21 August; eastern Aleutian Islands - Alaska Peninsula (Figures 2-3).
3. 22-23 August; Chukchi Sea - Kotzebue Sound (Figures 4-5).
4. 24 August; Bering Strait - Norton Sound (Figure 6).
5. 25 August; northern Bering Sea (Figure 7).
6. 26 August; Norton Sound (Figure 8).
7. 27 August; Bering Sea (Figure 9).

E. Data collected or analyzed.

	*Data Recording	**Trackline mi.
1. 19-21 August 1976	510	1,350
2. 22-27 August 1976	442	4,190
Approximate totals	952	5,540

* A "data recording" is a single logged entry at a specific time and location, and represents one or more animal(s) sighted; or environmental data. All values are approximate at this time.

** In nautical miles (1nm = 0.87 stat. mi.).

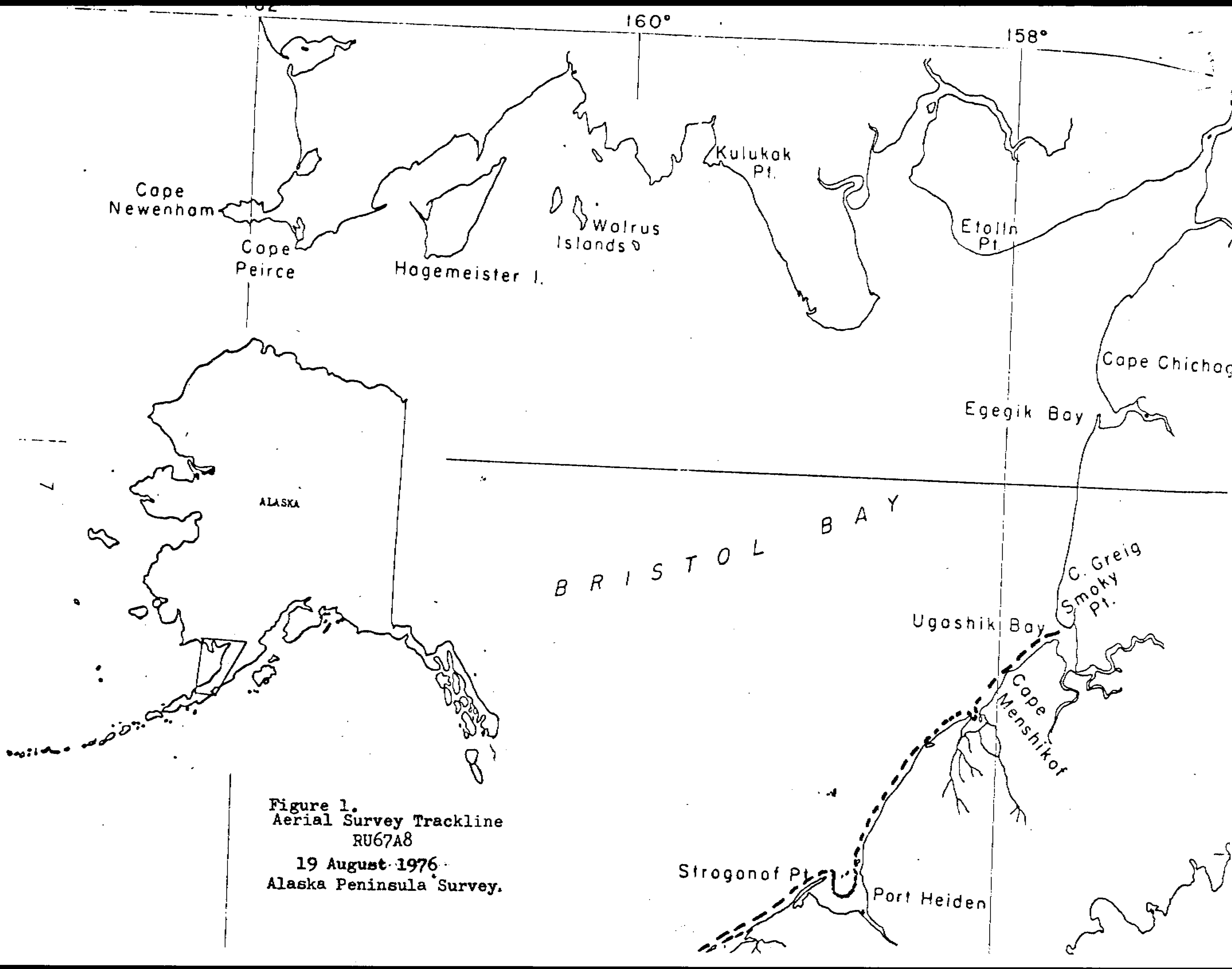


Figure 1.
Aerial Survey Trackline
RU67A8
19 August 1976
Alaska Peninsula Survey.

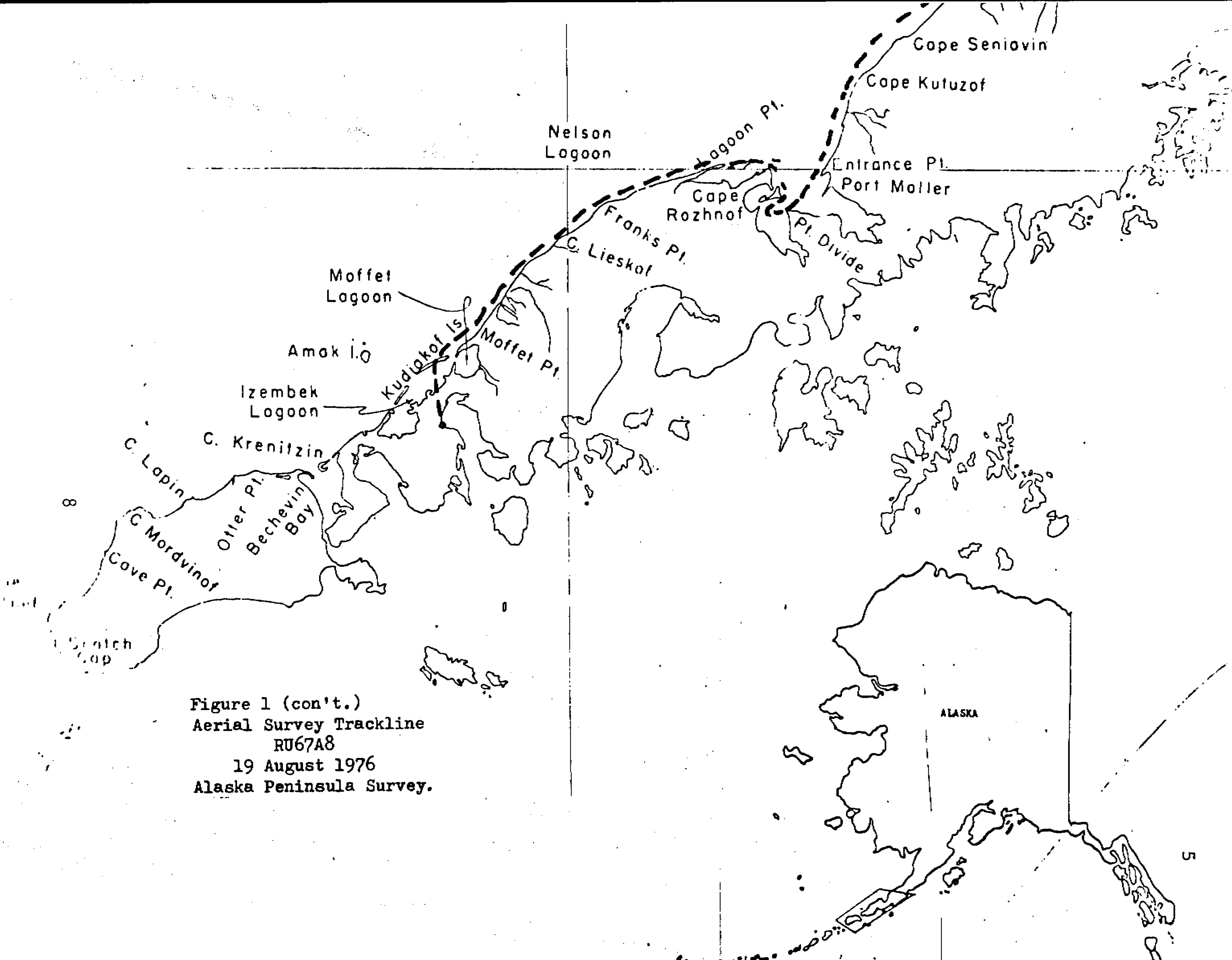


Figure 1 (con't.)
Aerial Survey Trackline
RU67A8
19 August 1976
Alaska Peninsula Survey.

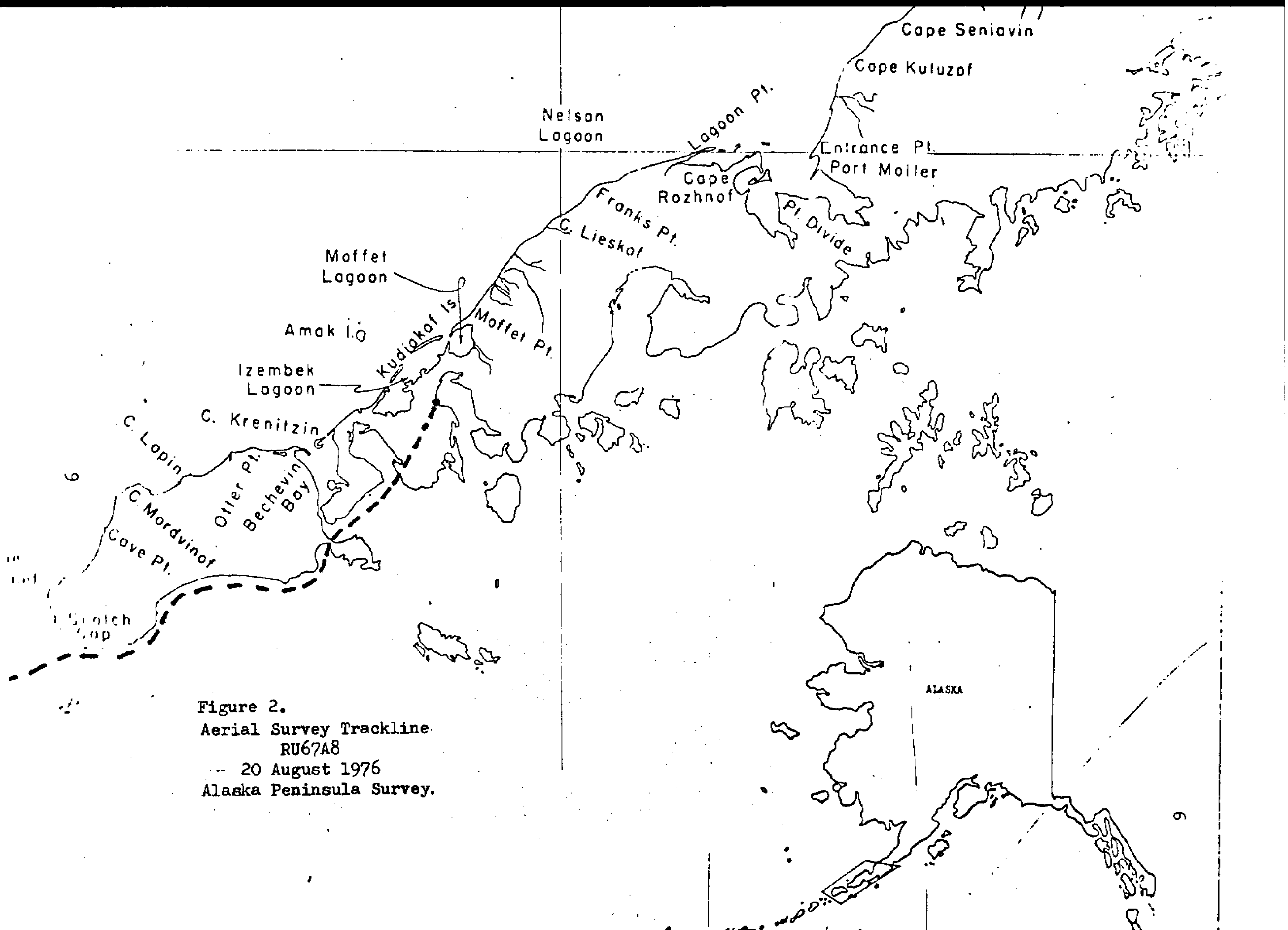


Figure 2.
Aerial Survey Trackline
RU67A8
20 August 1976
Alaska Peninsula Survey.

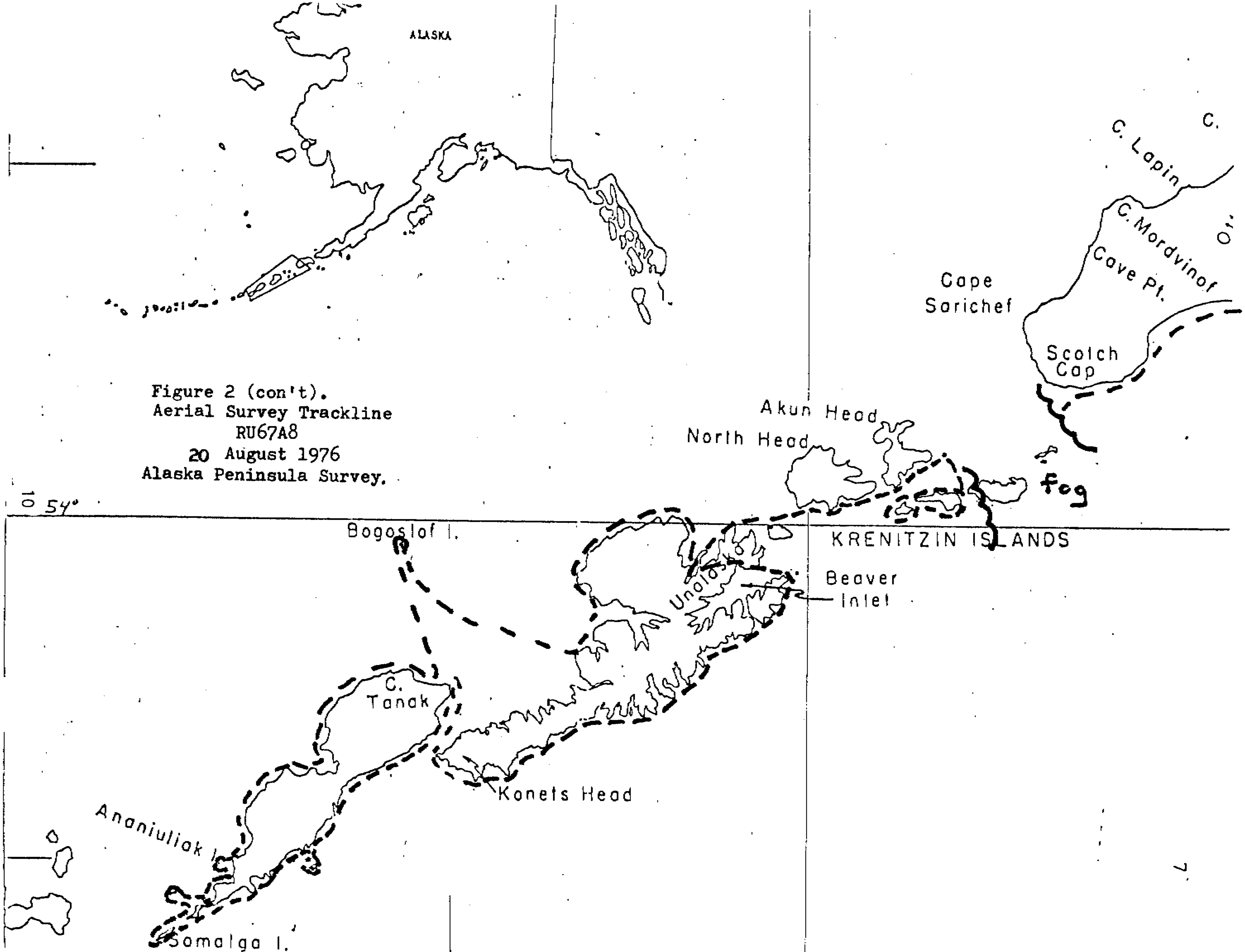


Figure 2 (con't).
Aerial Survey Trackline
RU67A8
20 August 1976
Alaska Peninsula Survey.

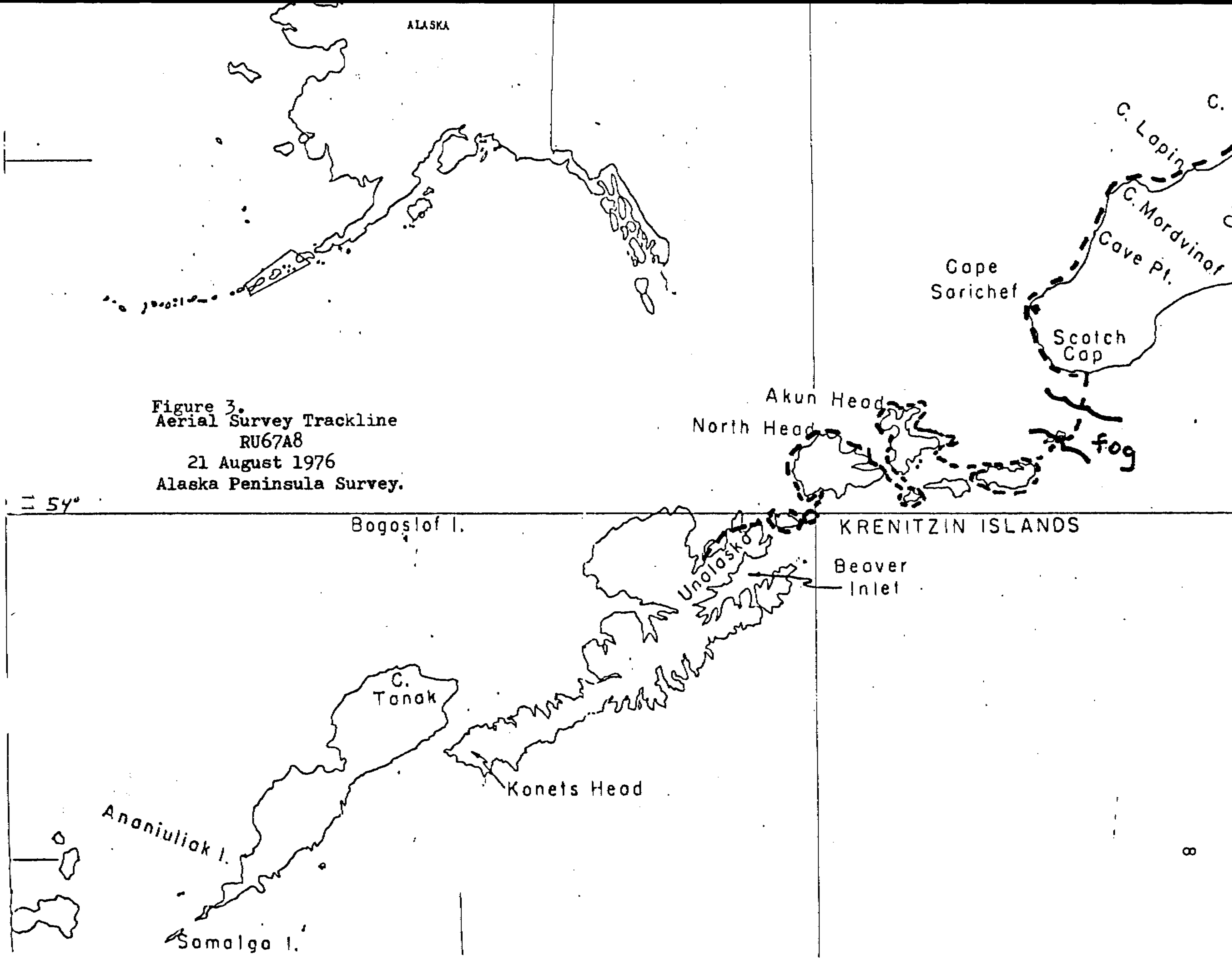


Figure 3.
Aerial Survey Trackline
RU67A8
21 August 1976
Alaska Peninsula Survey.

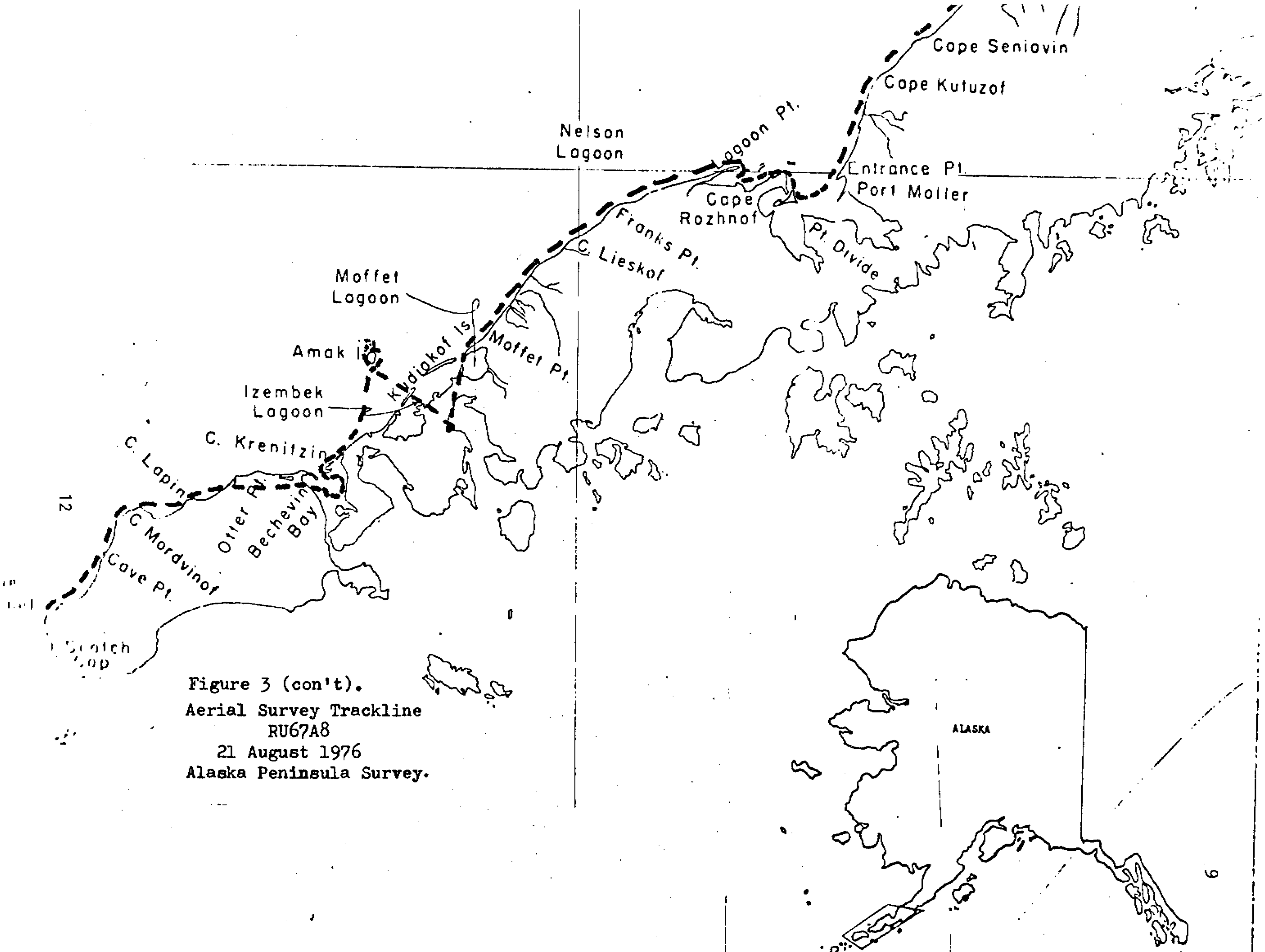


Figure 3 (con't).
Aerial Survey Trackline
RU67A8
21 August 1976
Alaska Peninsula Survey.

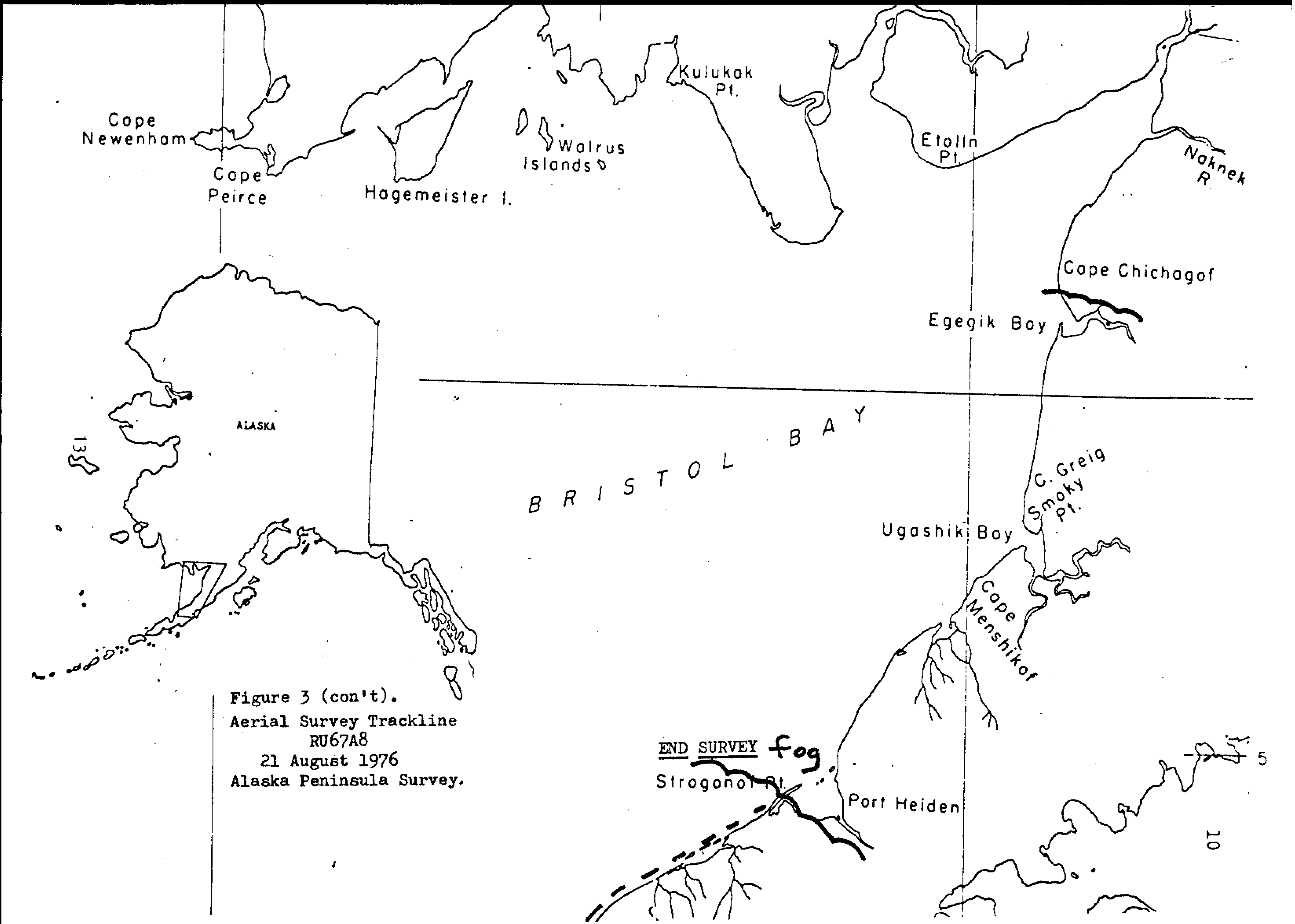


Figure 3 (con't).
Aerial Survey Trackline
RU67A8
21 August 1976
Alaska Peninsula Survey.

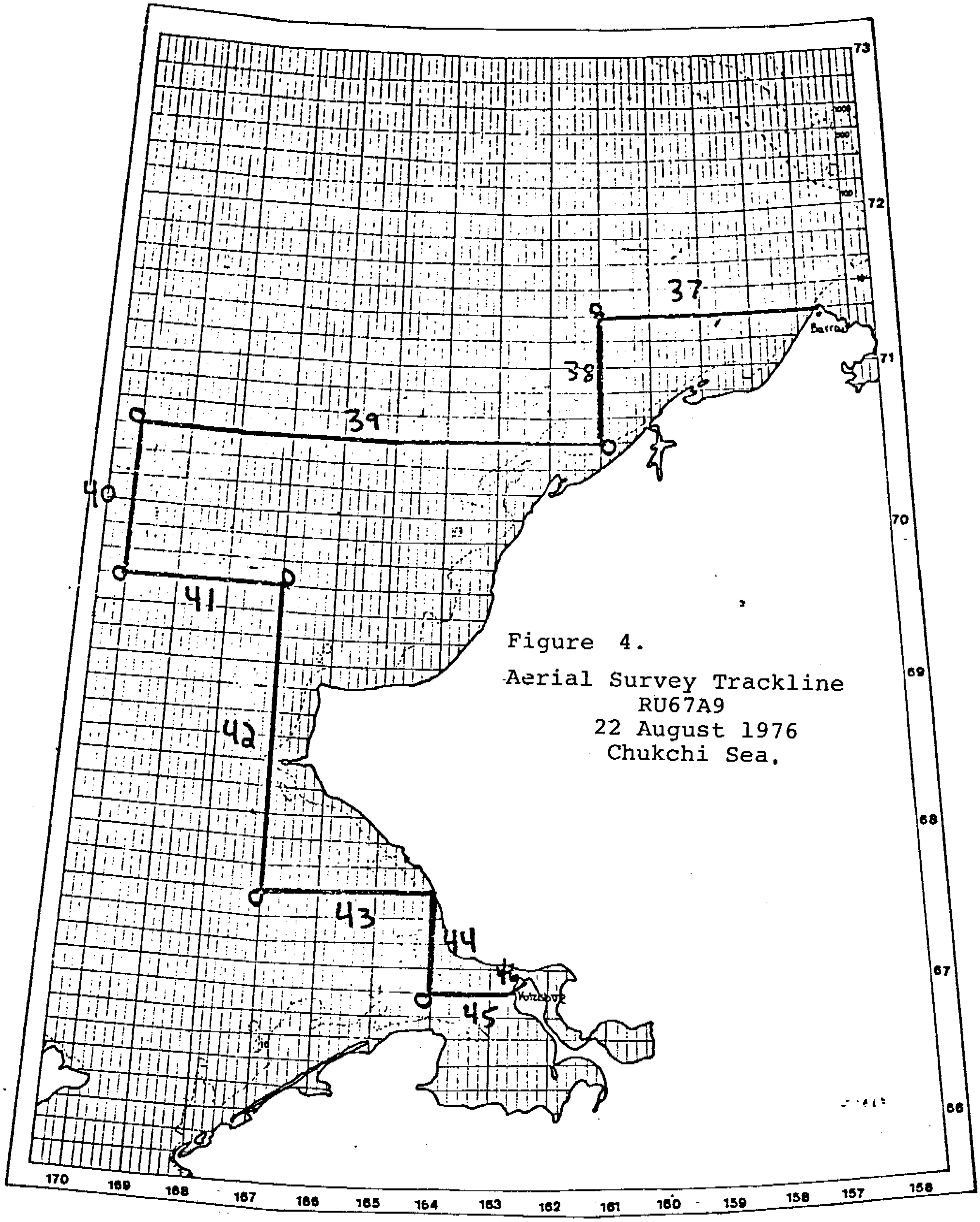


Figure 4.
Aerial Survey Trackline
RU67A9
22 August 1976
Chukchi Sea.

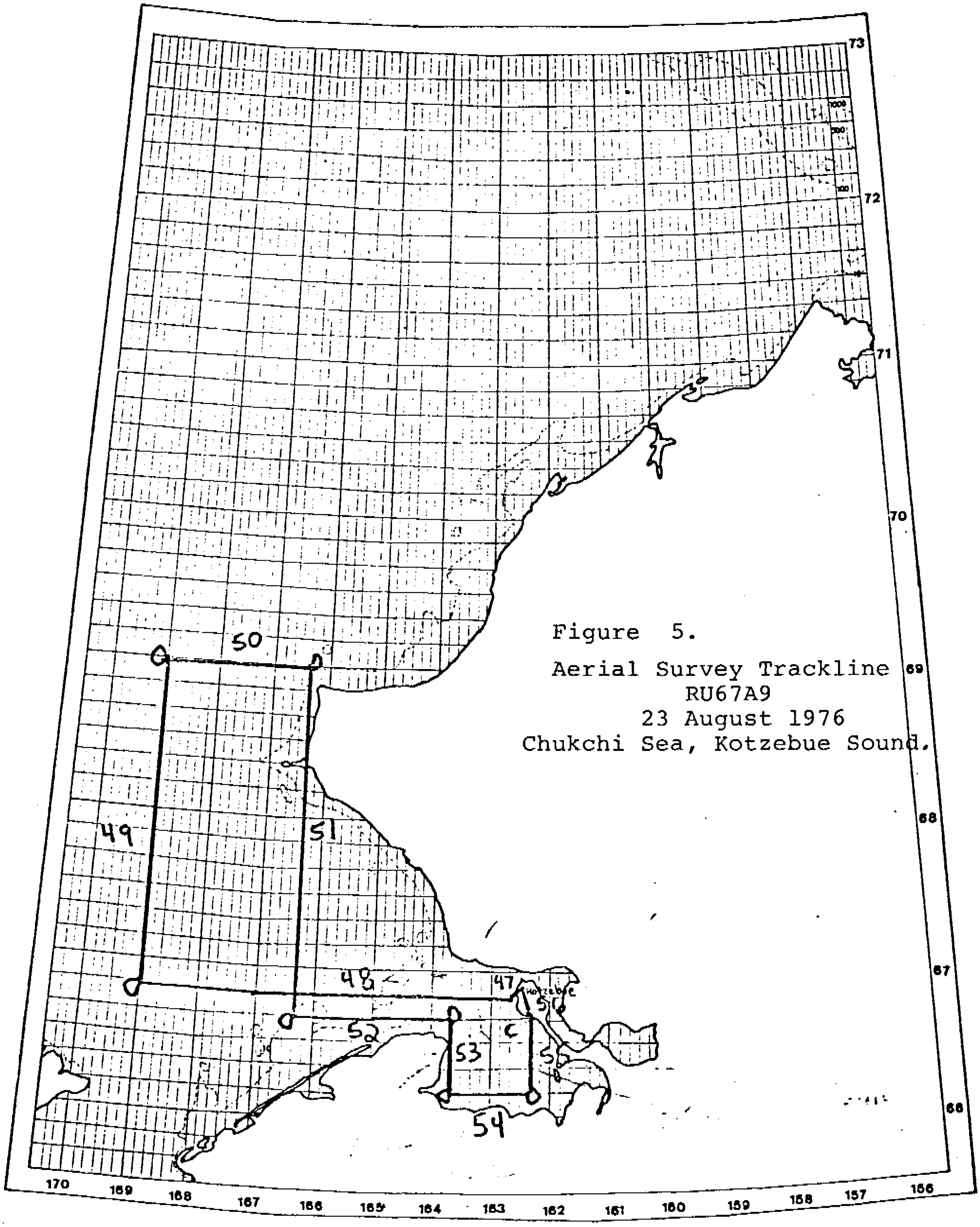


Figure 5.

Aerial Survey Trackline
RU67A9
23 August 1976
Chukchi Sea, Kotzebue Sound.

Figure 6.

Aerial Survey Trackline
Ru67 A9
24 August 1976
Bering Straits.

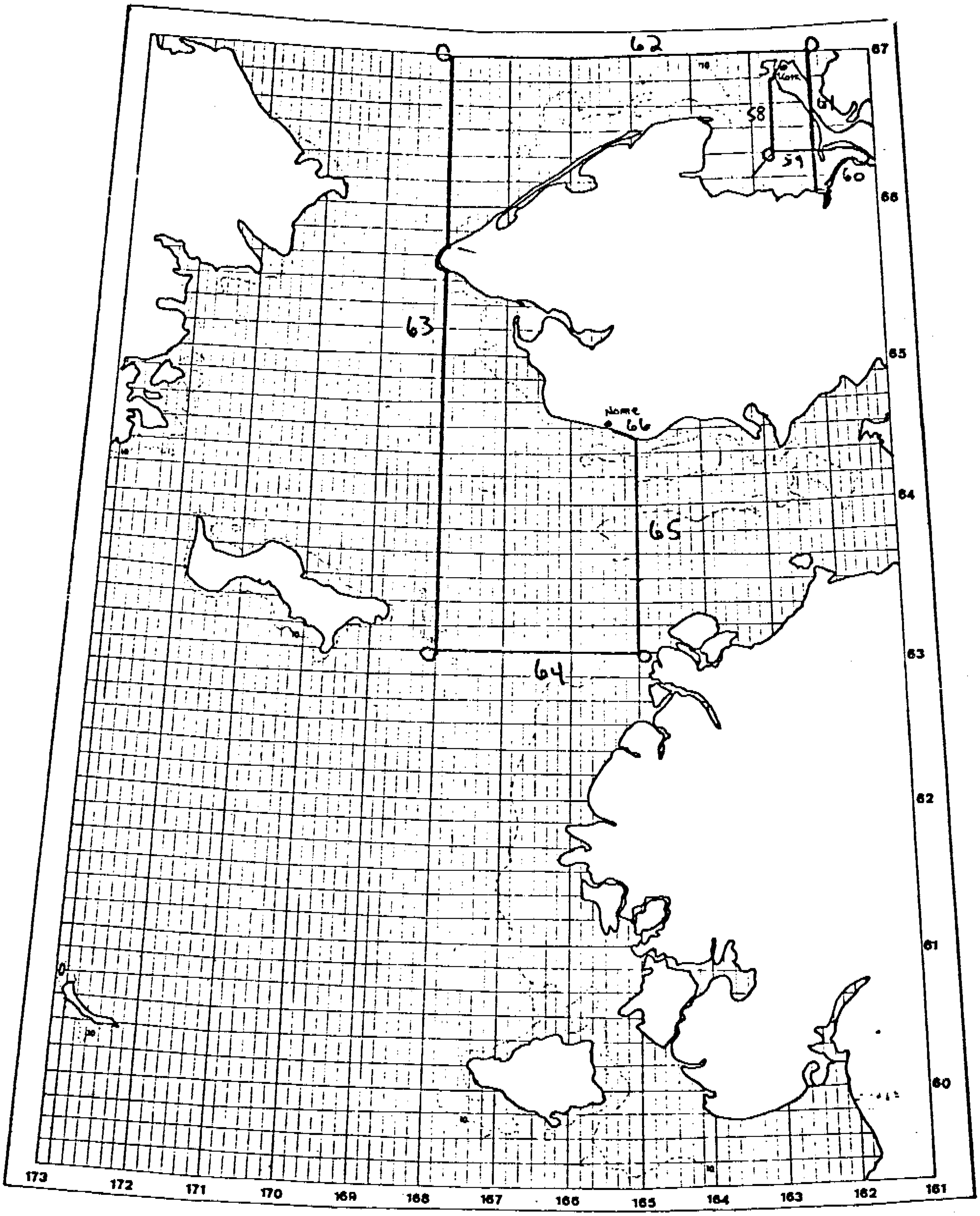


Figure 7.
Aerial Survey Trackline
RU67A9
25 August 1976
Bering Sea.

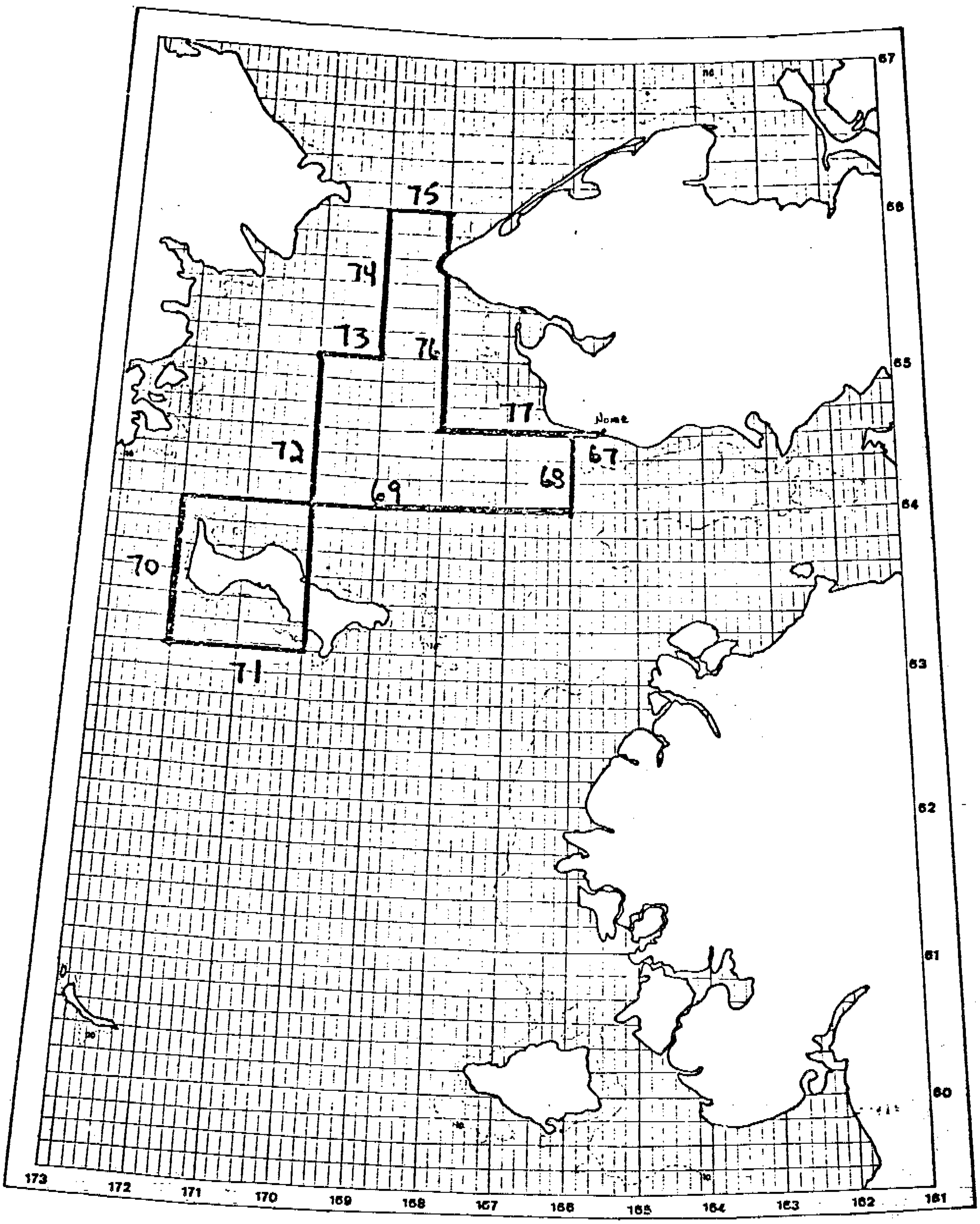


Figure 8.
Aerial Survey Trackline
RU67A9
26 August 1976
Norton Sound.

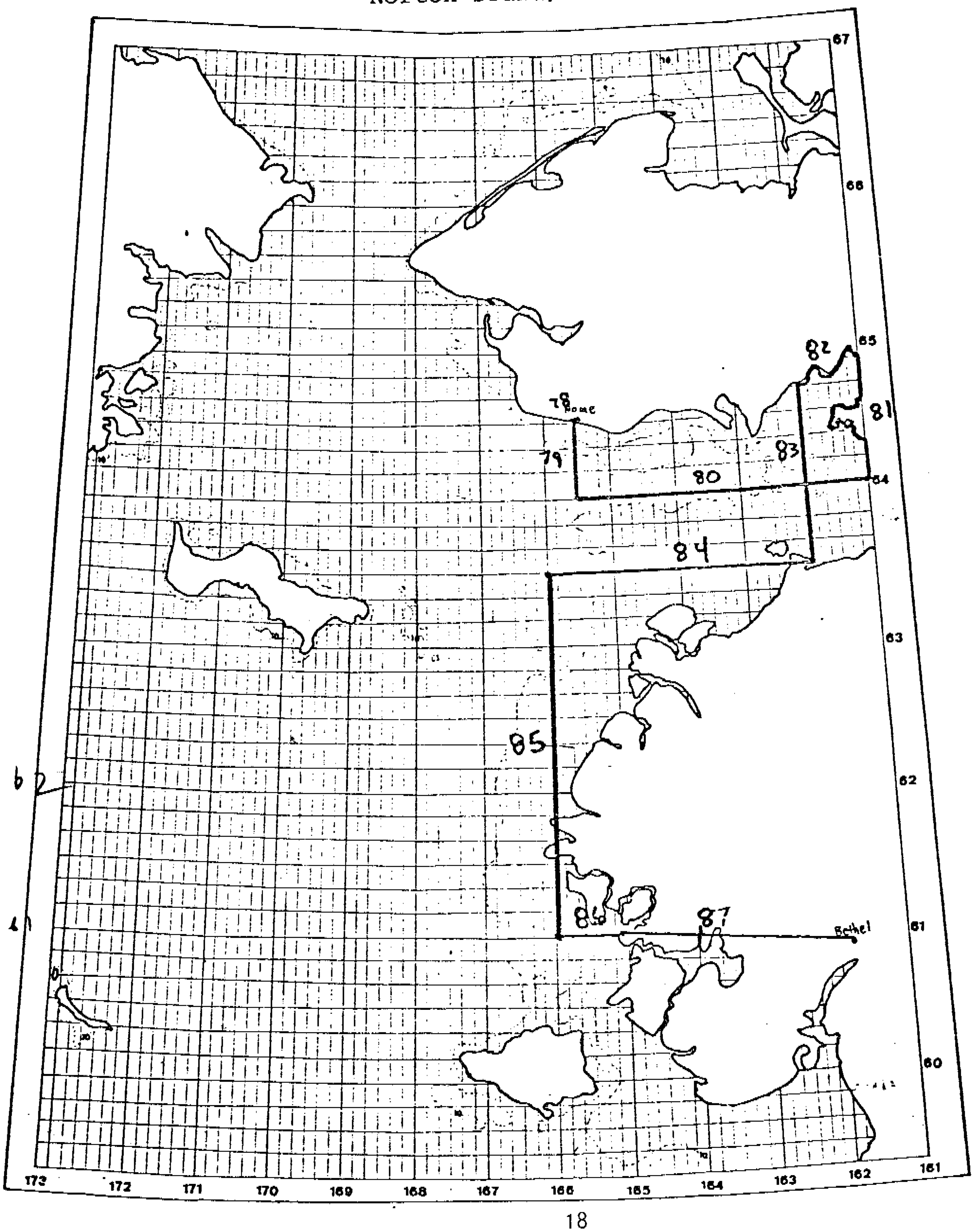
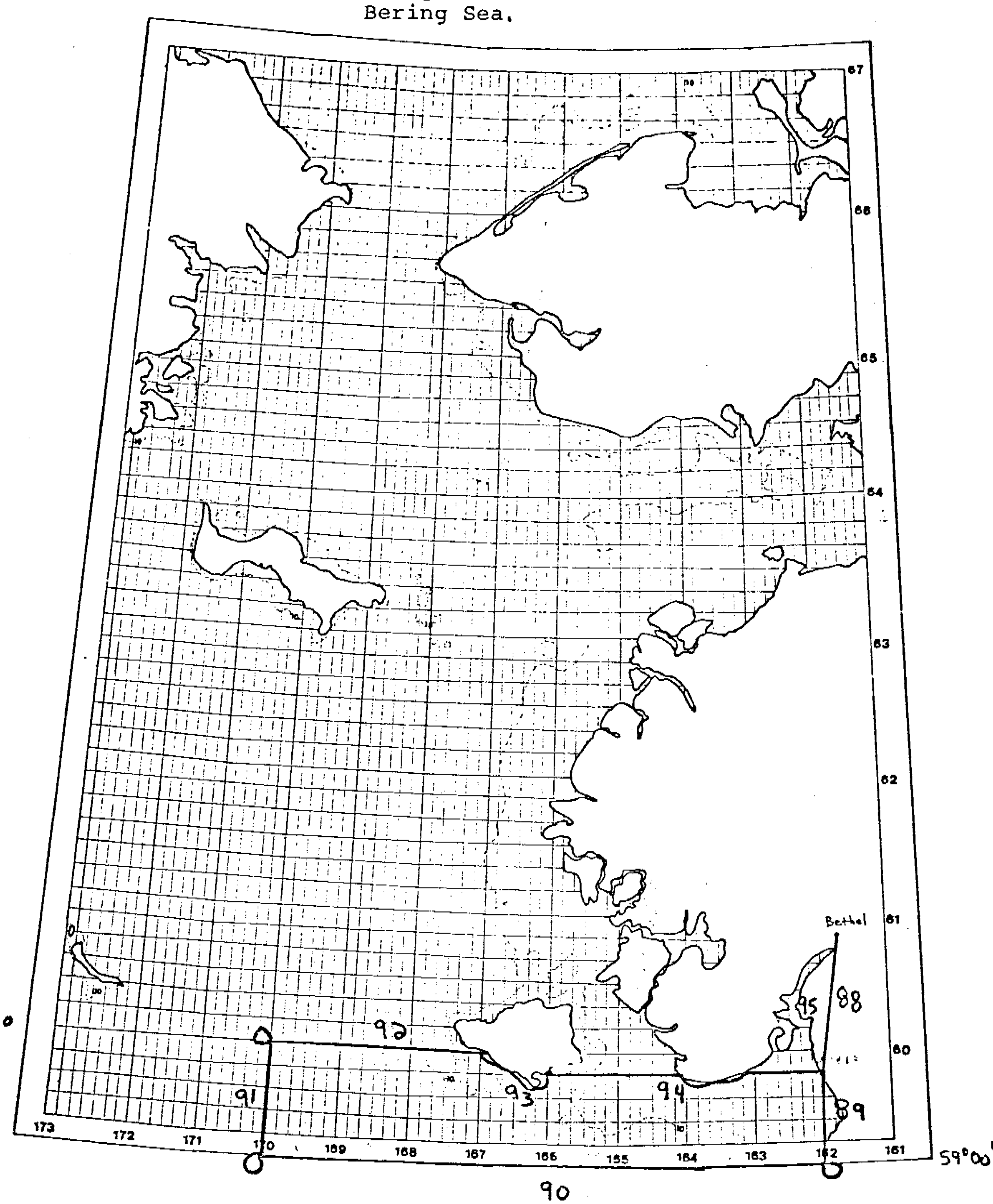


Figure 9.

Aerial Survey Trackline
RU67A9
27 August 1976
Bering Sea.



III. Results and Discussion

A. Alaska Peninsula Survey, 19-21 August, 1976.

The number of marine mammals observed along the north coast of the Alaska Peninsula and throughout the eastern Aleutian Islands is summarized in Table 1. The total number of harbor seals observed (10,173) reflects the total of all days flown (N=3 days), and includes replicate areas surveyed along the Alaska Peninsula on 19 and 21 August (Table 1). Undoubtedly, many if not most of these animals were counted on both days. Fewer harbor seals were seen in August, 1976 compared with the numbers seen during the June 1976 survey (22,741); probably as a result of tidal differences. The tide levels were much higher at Port Moller (8.21 feet and rising; range 9.92 ft.) and Port Heiden (10.21 feet and rising; range 10.97 ft.) when these areas were surveyed on 19 August than when surveyed on 20 June (Port Moller 4.28 feet and rising; range 9.13 ft.: Port Heiden 3.28 feet and rising; range 10.11 ft.). Since these two areas usually account for over fifty percent of the total number of harbor seals seen during a survey, it is probable that the high tide in August accounted for the lower number of animals seen.

The number of sea lions observed in August, 1976 (19,834) was lower than expected because of reduced visibility at several major rookery and hauling out areas (Table 1). Ugamak Island (Unimak Pass), a major breeding island for *Eumetopias*, was not completely surveyed because of fog. Adugak Island (North of Umnak Island) was poorly surveyed for the same reason.

The total number of animals for all species scored is preliminary and does not necessarily reflect the actual number of animals present in each area surveyed. Additional estimates of animal numbers (i.e. relative abundance) will be provided in the annual report (April 1977) after a systematic analysis of the aerial photographs and other aerial survey data can be performed.

Heavy fog along the Alaska Peninsula and on the northern side of the eastern Aleutian Island not only hindered our survey of pinniped rookery and hauling areas but also made observing for cetaceans difficult. Undoubtedly, the number of cetaceans seen does not reflect the total number in this area at this time of the year.

The number and kind of marine mammal carcasses observed during the August, 1976 survey are summarized in Table 2. Periodically fog obscured the coastline, hence it is probable that many carcasses were not observed. The location of a Goosebeaked whale (*Ziphius cavirostris*) carcass was given to us by Mr. Robert Nelson (ADF&G, Unalaska, AK). It was photographed by us on 21 August 1976.

Table 1. A summary of the visual estimates of the number of marine mammals observed during aerial surveys along the northern coast of the Alaska Peninsula and the eastern Aleutian Islands, 19-21 August, 1976.

Species	Survey Dates			Totals
	19 Aug.	20 Aug.	21 Aug.	
Pinnipeds				
Harbor seal	3,998	2,026	4,149	10,173
Northern sea lion	0	4,960	14,875	19,834
Carnivores				
Sea otter	166 (22 pups)	107	482	755
Cetaceans				
Gray whale	1	0	3	4
Harbor porpoise	10	0	2	12
Dall porpoise	1?	0	0	1?
Killer whale	0	8	0	8
Minke whale	0	0	2	2
Unid. whale	0	2	0	2

Table 2. Marine mammal carcasses observed during the Alaska Peninsula - eastern Aleutian Islands aerial survey, 19-21 August 1976.

Date/Time	Location Lat(N)	Long (W)	Species	Remarks
19 Aug - 1619	56°36.0'	159°44.0'	1 walrus	Seal Islands
19 Aug - 1704	56°01.5'	160°49.5'	1 walrus	Walrus Is. Port Moller
19 Aug - 1708	56°01.4'	160°58.3'	1 Gray whale	Kritskoy Is. Port Moller
21 Aug - 1155	53°54.0'	166°37.5'	1 Goose-beak whale	Summer Bay, Unalaska Is.
21 Aug - 1316	54°09.7'	164°59.0'	1 unid. whale	rocks N/E of Tigalda Is.
21 Aug - 1839	56°45.0'	159°12.5'	1 harbor seal	north of Seal Islands
21 Aug - 1839	56°45.0'	159°12.5'	1 harbor porpoise	north of Seal Islands
21 Aug - 1843	56°51.0'	158°58.0'	2 harbor seals	Strogonof Pt., Port Heiden

B. Bering Sea Survey, 22-27 August 1976.

A summary of the marine mammal observations during the 22-27 August 1976 survey is given in Table 3. Four points must be considered concerning sighting data in Table 3. First, only one marine mammal observer was used instead of the normal three during previous surveys; thus, only one side of the aircraft was used for observation purposes. Second, the methods employed in this survey (e.g. flight altitudes of 100 feet) were designed specifically for marine bird surveys; thus reducing the effectiveness of the marine mammal observer. Third, since all transects were drawn at random, marine mammal habitats (e.g. pack ice) were not stratified prior to sampling. Hence, data collected on some dates are undoubtedly a reflection of the clumped nature of marine mammal behavior (25 Aug.) or because of the general survey area where certain animals are more likely to be found (27 Aug.). Fourth, intermittent fog also reduced the observational effort, thus, not all areas flown were surveyed.

A comparison of these data with those collected from vessel cruises in the Chukchi and Bering Sea during approximately the same time period will be made prior to a detailed discussion of the results. Preliminary indications are, however, that species such as the Gray whale (Eschrichtius robustus) can be effectively surveyed in open water by means of aerial surveys. This survey may have located an area of heavy feeding activity. A synthesis of all FY 76 sightings will be made available in the annual report (1 April 1977).

Table 4 summarizes the marine mammal carcasses observed during this survey. Undoubtedly, more carcasses were present but not recognized as such because of low altitude flying at high air speeds (120-140 knots).

IV. Preliminary interpretation of results.

A. 19-21 June, 1976, Alaska Peninsula - eastern Aleutian Island survey.

It is beginning to appear that the number of sea lions in our survey area has been decreasing over the past 20 years. Aerial surveys flown in 1956-57 (Mathisen and Lopp, 1963) indicate that over 55,000 sea lions were present in the survey area; while a survey taken in 1960 (Kenyon & Rice, 1961) showed that over 52,000 sea lions were present. Fewer numbers of sea lions were observed during our 1975-1976 surveys (June 1975 - 12,908; Aug. 1975 - 22,375; June 1976 - 23,381; and Aug. 1976 - approx. 19,834) than by other investigators (Kenyon and Rice, 1961; Mathisen and Lopp, 1963; Kenyon and King, 1965).

Table 3. Summary of the visual estimates of marine mammals observed during aerial surveys in the Chukchi Sea, Kotzebue Sound, Norton Sound, and Bering Sea, 22-27 August, 1976.

Species	August 22	23	24	25	26	27	Totals
Pinnipeds							
Walrus	2	1	3	3	6	2	17
Ringed seal	2	0	0	0	0	0	2
Harbor seal	0	0	0	0	0	23	23
unid. seal	1	1	1	0	2	0	5
Cetaceans							
Belukha	0	0	0	0	5	0	5
Killer whale	0	0	3	0	0	0	3
Gray whale	0	7	8	66	0	0	81
Humpback whale	0	0	10	4	0	0	14
Harbor porpoise	1	0	1	0	0	0	2
Unid. whale	0	0	4	0	0	0	4

Table 4. Marine mammal carcasses observed during an aerial survey in the Bering Sea, 20-27 August 1976.

Date	Location Lat. (°N)	Long. (°W)	Number and species	Comments
20 Aug.	70°30'	167°30'	1 walrus	floating at sea
22 Aug.	66°15'	162°00'	1 walrus	on beach, no tusks
23 Aug.	66°50'	162°20'	1 seal	on beach, ~~no tusks~~
23 Aug.	67°55'	169°00'	1 Gray whale	floating at sea
23 Aug.	66°53'	162°37'	1 walrus	on beach, no tusks
23 Aug.	66°53'	162°37'	6 ringed seals	on beach, ~~no tusks~~
24 Aug.	65°50'	168°00'	1 walrus	on beach, no tusks
24 Aug.	65°30'	165°00'	1 walrus	on beach, no tusks
24 Aug.	65°30'	168°00'	3 walruses	on beach, no tusks
26 Aug.	64°20'	161°00'	1 belukha	on beach
26 Aug.	64°22'	161°00	5 walruses	on beach, no tusks
26 Aug.	64°40'	162°00	1 walrus	on beach, no tusks
27 Aug.	59°50'	164°10'	1 walrus	on beach, no tusks
27 Aug.	59°53'	166°42'	1 walrus	on beach, no tusks

It is possible that our survey methods account for fewer animals than are actually present. For instance, we may not be making accurate visual estimates, or we may not be photographing all animals hauled out at the time of the survey. However, an ADF&G OCS project (RU 243), using a similar method, has reported counts from aerial surveys to be similar to those obtained by ground observers (Calkins, pers. commun.). It will be necessary for us to verify our own aerial counts with ground truth counts before we can be certain of the accuracy of our method. Also, ground truthing will help us to reduce the variability in the actual number of animals present.

Other factors also play a role in sea lion hauling behavior. Such effects as weather, tides, and time of day are presently being analyzed to determine to what degree they may influence our counts. Obviously, the reduced visibility due to fog encountered in August 1976 hindered our ability to see all sea lions present.

The number of harbor seals seen varied greatly from day to day and between tide cycles. Hence, reliable estimates of the numbers of animals in the survey area are extremely difficult to obtain. All harbor seal data are going to be analysed soon and an estimate of relative distribution and abundance will be available for the annual report.

Several Gray whales (N=4) were observed in and around the Port Moller area. One appeared to be diving in the surf zone on the ocean side near the south end of Nelson Lagoon. No other Gray whales were seen along the Alaska Peninsula indicating that their northern migration had ended prior to our survey. Those whales observed at Port Moller may be summer residents.

B. 22-27 August, 1976, Bering Sea survey.

Until a comprehensive and systematic analysis of this survey, and the other surveys is completed, no reasonable estimate of distribution of marine mammals in the Chukchi and Bering Seas can be made.

The most important observation during this survey was that of an apparent major feeding ground of the Gray whale in the Chukchi Sea. On 25 August, over 50 whales were observed feeding in an area approximately 20 miles square. This information will help greatly in our final evaluation of the seasonal distribution of the Gray whale related to OCS oil lease areas.

Little can be said about the distribution and abundance of the other species of marine mammals observed in the survey area during August 1976. A detailed analysis of all data collected in FY 75-76 will be required, along with information in the literature, before any definitive statements can be made.

V. Problems Encountered/Recommended Changes.

A delay in securing a computer terminal at the Marine Mammal Division resulted in our reliance on overcrowded facilities at the University of Washington and the Northwest Fisheries Center. This has increased the amount of time necessary to edit and tape all survey data, resulting in our inability to meet EDS data submission deadlines and our own deadlines for data analysis.

We have been informed, indirectly, that the cost of aircraft flight time with the Office of Aircraft Service's Grumman Goose (N780) has again been increased. In the past year the flight hourly cost has risen from $250.00/hour to $275.00/hour to $325.00/hour to $350.00/hour, where it presently remains. If these costs continue to increase, it will be very difficult to adequately budget for realistic flight needs for next year.

We desperately need good ground truth data, coupled with reliable predictions of production for northern sea lions and harbor seals. Baseline data on relative abundance cannot be evaluated properly without a reasonable estimate of variability. By putting a 2-man counting crew onto a known rookery/hauling ground area for a period of one to two months, we can realistically address the problem of reliability in our sightings. We ask that the evaluators of the FY 77 RU 67 contracts seriously consider this problem as one that should be evaluated under the baseline study (RU 67) rather than for a potential integrated future study.

VI. Estimate of Funds Expended.

Fifth quarter - 1 July to 30 September 1976.

	Allotted	5th quarter	Est. expenditure to date	Balance
Salaries,etc.	33.2K	13.5K	33.2K	-
Supplies/equipment	6.2K	-	6.2K	-
Travel/Per Diem	16.3K	2.0K	16.3K	-
Other(contracts, computers, etc.)	9.5K	1.5K	9.5K	-
Total	65.2K	17.0K	65.2K	-

VII. Data Management.

Data from the April and June 1976 aerial survey flights were converted into numerical/computer format during the fifth quarter. Slides of the different rookeries were evaluated, counted, labled, and stored. The more accurate counts, those from photographs, were substituted onto the field logs for the visual estimates made during the surveys.

Computer listings were made from the returned computer cards and staff members compared these listings to the original log sheets correcting any logging or keypunching errors. All errors were edited at the University of Washington computer center. Several computer programs were written to accomplish data management requirements.

When all corrections had been made, the data were placed on tape and stored on our permanent file. These data were also converted from our "in house" format to EDS format (file type 026) and taped onto magnetic tape.

Data to be sent to the Juneau Project Office on magnetic tapes will be finalized for shipment on or before the following dates, pending final approval of the aerial survey format.

	Survey dates	Survey Area	Dates to Juneau
1976	14-21 March	No. Bering Sea	Submitted
	6-19 April	Bristol Bay Basin	15 October 1976
	13-23 April	Norton/Hope Basins	15 October 1976
	8-14 June	Norton/Hope Basins	15 October 1976
	15-20 June	Alaska Peninsula	15 October 1976
1975	17-20 June	Alaska Peninsula	30 November 1976
	9-13 August	Alaska Peninsula	30 November 1976
	9-14 October	Norton Basin	30 November 1976
1976	19-21 August	Alaska Peninsula	30 January 1977
	22-27 August	Bering-Chukchi Sea	30 January 1977

Literature Cited

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Kenyon, K.W. and J.G. King. 1965. Aerial survey of sea otters and other marine mammals. Alaska Peninsula and Aleutian Islands 19 April - 9 May, 1965. USF&W 20 May, 1965. 61 pages.

Mathisen, O.A. and R.J. Lopp. 1963. Photographic census of the Stellar sea lion herds in Alaska, 1956-1958. USF&W Special Report No. 424. 20 pg.

FIFTH QUARTERLY REPORT

Contract No. R71208606
Research Unit 68
Period: 1 July 1976 to
30 September 1976
Number of Pages: 2

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

Principal Investigators:

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National Marine Fisheries Service
Northwest Fisheries Center
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28 September 1976

RU 68

Fifth Quarterly Report

1 July - 30 September 1976

I. Task Objectives.

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

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

II. Field or laboratory activities.

A. Ship schedules:

NOAA ship Miller-Freeman 9/7/76 to 9/18/76 NEGOA, Marine Mammal Division member Mr. Ronald Sonntag.

NOAA ship Surveyor 8/25/76 to 9/4/76 Cook Inlet; 9/7-30/76 NWGOA, no Marine Mammal Division observer aboard.*

*Sightings were complied by the ship's Marine Mammal Officer during periods for which no Marine Mammal Division observers were aboard.

1.

B. Methods:

1. Sightings are coded and carded for species, number seen, location, behavior, direction of travel, and related information.

2. Marine mammal observers aboard NOAA ships (Platform of Opportunity Program) will have little input into track-line selection. Hence, there is no systematic sampling method behind data collection efforts using NOAA vessel personnel.

3. Distributional data are examined through computer programs by month, where sufficient sightings are available Sightings per unit effort are compared and displayed in a manner similar to that used in studies on pelagic fur seal distribution.

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

C. Sample localities/ship tracklines.

Miles of trackline will be available upon completion of data plotting.

III. Results.

Data have been gathered and arebeing prepared for submission to NODC. No analysis of the data have been done to date.

IV. Preliminary Interpretation of Results.

None.

V. Problems Encountered/Recommended Changes.

Some problems have been experience in obtaining computer time for plotting, and in developing translation programs for NODC-EDS requirements.

VI. Estimate of Funds Expended.

	5th Quarter	Allotted	Est. spent to date	Balance
Salaries/Overtime	5.3K	24.3K	24.3K	
Travel/Per Diem	3.1K	11.3K	7.6K	3.7K
Equip., Misc. "other"	1.9K	9.0K	5.7K	3.3K
	10.2K	44.6K	37.6K	7.0K

Fifth Quarterly Report

Contract No. R7120807
Research Unit 69
Period: 1 June to
30 September 1976
Number of Pages:

Distribution and Abundance of Bowhead and Belukha Whales in the Bering and Chukchi Seas

Principal Investigators

Mr. Clifford H. Fiscus
Dr. Howard W. Braham

Research Assistant

Mr. Bruce D. Krogman
Mr. Robert D. Everitt

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Center
Marine Mammal Division
7600 Sand Point Way N.E.
Seattle, Washington 98115

27 September 1976

Research Unit 69

Fifth Quarterly Report, July - September, 1976

I. Task Objectives:

The objectives of RU 69 are to make estimates on the distribution and abundance of bowhead (Balaena mystecetus) and belukha (Delphinapterus leucas) whales in the Bering and Chukchi Seas. Aerial surveys are used in an attempt to locate wintering areas, and to identify time and location of movements of these whales from March through June. We also hope to determine if bowheads breed and/or calve within the Norton and Hope Basins. Surveys in March are designed to survey areas in the south and western Bering Sea where whales might be over-wintering in polynas. April-May surveys are flown to provide information on timing of migration from the Bering Sea in to the Beaufort Sea, and June flights attempt to delineate the extent of the migration period. Population abundance and distribution data are also collected on other species; walrus (Odobemus rosmarus), bearded seal (Erignathus barbatus) and ringed seal (Phoca hispida), as they are encountered.

II. Field and Laboratory Activities:

A. Ship or Field Trip Schedule:

1. Aerial surveys: no surveys were flown during the fifth quarter.

2. Ship surveys and personnel:

a. Discoverer. 18 August-24 September; Northern Bering and southern Chukchi Seas; Ms. Rene Engel, Marine Mammal Division, NWFC, NMFS.

b. Moana-Wave. 3-27 August; Bering Sea and N/E Gulf of Alaska; Mr. Andrew Anschell, Marine Mammal Division, NWFC, NMFS. 29 August-5 October; Norton Sound and Chukchi Sea; Mr. Carl Brooks, Marine Mammal Division, NWFC, NMFS.

B. Methods:

1. Ship cruises. Observations on marine mammals were made throughout the daylight hours; other data recorded were animal behavior, environmental parameters (weather, etc.), exact position, etc. Observations were made from the flying bridge or cabin bridge.

2. Laboratory activities. Computer programs were written during the fifth quarter which will allow us to plot all bowhead and belukha sightings by time and position. The plots will be forthcoming in the sixth quarterly report. Format transcription, verification and editing of the spring aerial survey data took place during the fifth quarter. Additional procedures employed to put our sighting data into a form ready for analysis has been summarized in the RU 70 fifth quarterly report.

III. Results.

Bowhead and belukha whales were sighted by Marine Mammal Division personnel, aboard NOAA ships, during the fifth quarter. These data will be reported on in the sixth quarter.

IV. Preliminary interpretation of results.

Ru 69 will be absorbed into research Unit number 70 starting 1 October 1976 (FY 77). For that reason, all data in RU 69 and 70 will be analyzed and discussed together as a summary of the first years work in the annual report (1 April 1977).

V. Problems encountered/recommended changes.

None.

VI. Estimate of funds expended.

	5th quarter	Alloted	Est. spent to date	Balance
Salaries/overtime	2.5 K	12.4 K	3.7 K	8.7 K
Travel/Per diem	-	7.0 K	2.4 K	4.6 K
Equip., misc., "other"	6.0 K	18.9 K	16.3 K*	~~12.6~~ 7.6 K
Total	8.5 K	38.3 K	22.4 K	~~15.9~~ K 10.9

* includes 4.5 K that should have been retained by OCSEAP, Boulder, Colo.; they have requested that this amount (4.5K) be subtracted as an over-budget.

Fifth Quarterly Report

Contract No. R7120808
Research Unit 70
Period: 1 July 1976
to 30 Sept. 1976
Number of Pages: 6

Distribution and Abundance of Bowhead and Belukha Whales in the Beaufort and Chukchi Seas

Principal Investigators:

Mr. Clifford H. Fiscus
Dr. Howard W. Braham

Research Assistants:

Mr. Bruce D. Krogman
Mr. Robert D. Everitt

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Center
Marine Mammal Division
2725 Montlake Boulevard East
Seattle, Washington 98112

23 September, 1976

Research Unit 70

Fifth Quarterly Report, July - September, 1976

I. Task Objectives.

RU 70 objectives are to delineate the abundance and seasonal distribution of bowhead whales (Balaena mysticetus) and belukha whales (Delphinapterus leucas) in the Beaufort and Chukchi Seas. For the fifth quarter of FY 76 our objectives were to: 1) conduct fall aerial surveys and use the data collected to describe distribution prior to and during movements of these whales south into the Bering Sea; and 2) data previously collected during FY 75-76 were to be processed so as to be in a form compatible for computer analysis and National Oceanic Data Center (NODC) formatting.

II. Field or Laboratory Activities.

A. Field Activities:

1. Ship or Field Trip Schedule:

Fall aerial surveys were initiated 20 September and were still being conducted as of 27 September. Five aerial surveys (5 hours @) were scheduled. Flights were being made east and west of Barrow, AK along the coast, as well as over offshore areas extending out to the edge of the pack ice approximately 15-20 miles from shore. Survey flights in the Chukchi and Beaufort Seas originated from the Naval Arctic Research Laboratory (NARL) and were conducted aboard the Twin Engine Otter (N127RL) aircraft. As of this date, weather was favorable enough to anticipate additional surveys to at least 1 October, 1976.

2. Scientific Party.

Aerial surveys are being conducted by Mr. Robert Everitt and J.R. Patee, field research assistants with the Marine Mammal Division, National Marine Fisheries Service, Seattle, Washington.

B. Laboratory Activities (Data Processing).

Table 1 provides a summary of our data processing. We are now entering the second phase of data processing, i.e., editing and rechecking the data. We anticipate that phase 2 will require less than one month to complete and that phase 3, taping and storing cards, should require only a few hours to a few days to complete as soon as the EDS (Environmental Data Service) aerial survey format (026) revisions have been completed. We are currently able to convert our field formatted data into existing EDS format, via computer programing. If that format is to be changed further in the near future, we will require more time to make compensatory programing modifications.

At this time we are slightly behind schedule on RU 70 data processing because of 1) need for manpower efforts on two other final reports, 2) loss of personnel at the completion of the field season, 3) format finalization incomplete and 4) a back log in data processing and graphics-plotting at the NWFC and Univ. of Washington.

C. Methods.

1. Aerial Survey (Field Sampling):

Aerial surveys were conducted on all days when weather was favorable. Wind and fog are our limiting factors. Surveys for bowhead and belukha whales were conducted from 200 to 1000 feet depending on weather conditions; altitudes from 700 to 1000 feet are generally optimum for sampling.

Three observers (including the pilot) are commonly used during each survey, but during this survey some flights were made with only two observers. Visual estimates were made and photographs taken to verify species identificati and numbers of animals seen.

2. Laboratory Analysis (Data Processing).

We have developed a four phase program for data managemen Phase 1 - coding and punching; Phase 2 - verification and editing; Phase 3 - EDS taping and submittal procedures; Phase 4 - Data analysis. Phase 1 was completed on FY 75-76 data during the fifth quarter. Phases 2-4 will be completed during the next two quarters.

The first phase (Phase 1) of the data processing sequence is as follows: 1) data were transcribed from field log sheets onto keypunch abstracts. Coding of information was sometimes necessary, but we have developed an internal computer format which reduces this slow (coding) process to a minimum; 2) keypunch abstracts checked for gros transcription errors; 3) abstracts were submitted to the NWFC for computer card punching; and 4) cards were processed through the program CHECKS for listing. Program CHECKS produces an output which lists the data in a decoded format "identical" to the field log sheets. Also, CHECKS flags common transcription errors, and errors which are difficult to check manually. The CHECKS output is then compared with field log sheets and discrepancies are demarcated on the output.)

Phase 2 sequence is as follows: 1) cards are read into the computer and stored on a magnetic disk file; 2) using a remote intercom terminal, a user interacts with the disk file using program EDITS, whereupon data corrections are made and program EDITS punches out the corrected data set on cards; 3) the corrected data set is then re-submitted to CHECKS and the new listing compared to the old CHECKS listing to verify that all corrections were made. If more errors are encountered, they are corrected manually and noted on the new CHECKS listing.

Phase 3 is the taping and storing of the corrected cards. A re-formatting program (program EDS) is used to convert the MMD internal format to the approved EDS-NODC standardized format for tape submittal. Program EDS also produces an output of reformatted data as it exists on tape. Cards which were used to produce the tape are stored at the Marine Mammal Division(MMD).

Phase 4 is simply data analysis; the manipulation of the data in order to make abundance and distribution projections.

Figure 1 provides an abbreviated flow diagram which summarizes the data processing sequence.

D. Sample localities/ship or aircraft tracklines.

Fall survey tracklines will not become available until the aerial survey crew returns from the field in October.

E. Data Collected or analyzed.

Data collected during the fifth quarter have not been received in total as of this writing. Mr. Everitt reports that he sighted 41 bowhead whales near Cape Simpson during the early p.m. of 21 September. Four Gray whales were also observed by Mr. Everitt on 20 September just off-shore at Cape Lisbourne.

III. Results.

None at this time. We will report on our latest survey in the sixth quarterly report.

IV. Preliminary interpretation of results.

None at this time.

V. Problems encountered,

See Section II.B. of this report.

VI. Estimate of funds expended.

	5th Qtr.	Alloted	Est. spent to date
Flight time	$7,000	-	
Salaries/overtime	$4,000	$11,200	$11,200
Travel/per diem	800	$13,900	$13,900
Equip., misc.	200	$18,400	$18,400
Computer time, etc.	$2,000		
	$14,000	$43,500	$43,500

VII. Revised data submission schedule.

All FY 75-76 RU 70 data will be submitted on EDS format to the Juneau Project Office on or before the next quarterly report 1 January, 1976. If programing, editing and verification go as smoothly as they have prior to final report writing of RU 14 and 68, we should have all RU 70 data into Juneau no later than the end of November.

VIII. Revised milestone.

	Activity	time period
1)	Fall aerial survey	late Sept, - early Oct.
2)	Fall summary data-phase 1	October
3)	Phase 2 FY 75-Spring 76 data	October
4)	Phase 3 and 4 FY 75-Spring 76 data	November-December
5)	Phase 1-4 on aerial survey data collected in 1974 (non-OCS related)	October-December

Table 1. Survey of our progress on data processing of spring survey data for RU 70.

Survey dates	Phase 1: Coded onto key-punched abstracted	Phase 1: Punched	Phase 1: Checked	Phase 2: Edited	Phase 2: Rechecked	Phase 2: Re-edited	Blue 3: Taped Stored
30 April	X	X	X				
1 May	X	X	X				
3 May	X	X	X				
8 May	X	X	X				
9 May	X	X	X				
12 May	X	X	X				
15 May	X	X	X				
19 May	X	X	X				
20 May	X	X	X				
22 May	X	X	X				
24 May	X	X	X				
28 May	X	X	X				
31 May	X	X	X				
1 June	X	X	X				
4 June	X	X	X				
5 June	X	X	X				
18 June	X	X	X				
19 June	X	X	X				
20 June	X	X	X				

PHASE I	Field log sheets Key punch abstract Punched cards CHECKS program listing Discrepancies noted
PHASE II	Data file created Edited using EDITS program Editing cards produced New CHECKS listing Final error corrections
PHASE III	Data reformating using EDS program NODC-EDS tape produced/submitted Cards stored at the Marine Mammal Divis
PHASE IV	Data analysis

Figure 1. Summarization of data processing for all research units at the Marine Mammal Division (RUs 67, 68, 69/70).

Quarterly Report

Contract #03-5-022-56
Research Unit #194
Reporting Period 7/1 - 9/30/76
Number of Pages 4

MORBIDITY AND MORTALITY OF MARINE MAMMALS

Dr. Francis H. Fay
Associate Professor of Marine Science
and Arctic Biology
Institutes of Marine Science and Arctic Biology
University of Alaska
Fairbanks, Alaska 99701

October 1, 1976

Quarterly Report

I. Task Objectives

A. To survey and necropsy stranded dead and moribund marine mammals on the coasts of St. Lawrence Island and Kotzebue Sound.

B. To continue laboratory analysis of materials obtained from necropsies in the previous quarter.

II. Field and Laboratory Activities

A. Field Trip Schedule

St. Lawrence Island survey, 25 June - 15 July (Principal Investigator and Consultant James Leach, DVM).

Kotzebue Sound survey, 12 - 31 July (Associate Investigator Robert Dieterich and Biological Techanician Larry Shults)

B. Laboratory Activities

Bacterial isolates obtained during the field surveys were submitted to the Alaska Department of Health diagnostic laboratory, Fairbanks, for culture and identification. Tissue samples were prepared for histopathological study; teeth were sectioned and osteological samples prepared for age estimation; photographs were processed and examined for confirmation/identification of specimens. Parasitological materials from the *Zagoriany* and *Surveyor* cruises from specimens taken in conjunction with other OCSEAP projects (R.U. #230, 232) were analyzed.

C. Methods

The survey of dead and moribund marine mammals at St. Lawrence Island, comparable to that done in 1975, was unavoidably cancelled, due to the lack of timely receipt of permission from the Native Corporations there to conduct the work.

The coast of Kotzebue Sound was surveyed, from Bering Strait to Point Hope, via supercub aircraft in five transects, as in 1975. Each transect was first surveyed in its entirety, recording each carcass by species and location. Subsequently, beach landings were made wherever feasible, and necropsies performed to determine the cause of death, in accordance with procedures outlined in the project manual.

Bacterial isolates were stored in Amies transport medium at 4-6^{o}C; tissue samples for histopathological study were fixed in buffered formalin and stored at room temperature until embedded in paraffin, sectioned on a rotary microtome, and stained by the hematoxylineosin method; teeth were sectioned on a jeweller's saw and the layering read under reflected light. Parasites were relaxed at room temperature in tap water, fixed in hot formalin, and stained mainly in acetic carmine or menthyl green pyronin for further study.

III. Results

On the 740 km (460 mi.) of coast from Bering Strait to Point Hope, a total of 166 dead marine mammals was sighted, 92 of which were old, weathered remains from previous years. Eighty percent of both the old and the new carcasses were in the 235 km (146 mi.) stretch from Cape Prince of Wales to Cape Espenberg. This distribution was comparable to that found in 1975, though the number of new carcasses was substantially lower (76 vs. 116). As before, about 75 percent of the carcasses were of walruses (*Odobenus rosmarus*), nearly all of which probably had died from gunshot wounds (confirmed in 12/12 necropsies). Seals (*Phocidae*) comprised 21 percent, most of which probably also had died from gunshot wounds (confirmed in 5/5), though at least one had also suffered from a bacterial infection (*beta hemolytic Streptococcus*) of the liver, prior to being shot. One fresh gray whale (*Eschrichtius robustus*) was found (vs. 7 in 1975). It had been killed and partly consumed by killer whales (*Orcinus orca*). The one young harbor porpoise (*Phocoena phocoena*) had suffered an umbilical hernia, with strangulation and necrosis of an intestinal loop. Also found was one belukha (*Delphinapterus leucas*), however beach conditions and weather were such that it was not feasible to land and necropsy this specimen.

Histopathological examination of materials obtained from animals necropsied during the *Zagoriany* and *Surveyor* cruises of the previous quarter (see Quarterly Report, period ending 30 June 1976) disclosed the following:

(a) Dematomycosis: Epidermal lesions, appearing as intensely pigmented areas or concentric rings on walruses and as "hairless" areas on ribbon seals, contained abundant mycelia. In the walruses, these seemed to have invaded only the outer cornified layer of the epidermis, causing some loosening and erosion of the surface and, apparently stimulation of new cell production by the underlying layers. In the ribbon seals, there was invasion deep into the hair follicles, evidently causing some malformation of hairs, resulting in severe erosion and breakage at or near the point of their emergence from the hair canals. In both species of mammals, the resultant lesions appear to be areas pre-conditioned for ease of invasion of other pathogens or of potential chemical irritants, such as petroleum products. Comparable mycotic lesions have been detected in this study also in bearded, ringed, and harbor seals of the Bering and Chukchi Seas and in Steller sea lions of the Bering Sea and North Pacific Ocean.

(b) Hepatic focal necrosis: Minute (< 1 mm) parenchymal lesions of dead cells and concentrations of leucocytes, often associated with thickening of the capsule, were detected in the liver of several larga and harbor seals (*Phoca largha* and *P. richardsi*) and one ribbon seal (*P. fasciata*), each of which except the latter appeared otherwise to be completely normal and healthy. A possible causative agent (*beta hemolytic Streptococcus*, not group A) was isolated from one of the largas and from the ribbon seal. The same agent was isolated from a moribund ringed seal (*P. hispida*) examined in the course of this project, and from several other Bering Sea pinnipeds (larga and ringed seals, and northern fur seals, *Callorhinus ursinus*), in which it caused a lethal bacteremia/toxemia while they were held in captivity in connection with another project at the University of Alaska.

Parasitological investigations of walruses, Steller sea lions, bearded, ribbon, larga, and harbor seals taken during the *Zagoriany* and *Surveyor* cruises in March-April 1976 disclosed three species of anopluran lice, five species of nasal mites, and 12 species of helminths, none of which appeared to have any major pathological consequences in the animals examined. However, the samples were mostly too small for definitive evaluation of such possibilities.

IV. Preliminary Interpretation of Results

The findings thus far suggest that two pathologic conditions, namely dermatomycosis and streptococcosis, occur frequently enough to merit further investigation of their rate of occurrence, present impact, and potential aggravation by the stresses of oil development activities and environmental pollution. Low level infections by agents of both conditions appear to be common in all or most of the pinnipeds inhabiting the Bering and Chukchi Seas, and acute infections occur frequently enough to have been detected even in our presently small samples. It is easily conceivable that a variety of stresses potentially imposed by oil development could have a synergistic effect on both of these conditions.

V. Problems Encountered/Recommended Changes

Failure to obtain timely permission for the St. Lawrence Island survey was a consequence of faulty communications. Notification of the need for permission from the Native Corporations was not received until early June, and the Corporations' response to the principal investigator's immediate request for permission was not received until late June, after the field work was scheduled to have begun. In the meantime, because of other commitments and restraints on both the principal investigator's and co-worker's time, it became necessary to cancel the St. Lawrence Island work and allot the time to other activities. It is likely that this problem could be easily overcome in the future, simply by submitting the request for permission several months in advance of the need.

Given the means to do so, the emphasis of this project in FY '77 will be placed on enlarging the samples of each species for further information on rate of occurrence of pathogens and pathologic conditions, through greater participation in the specimen collection operations of other related projects, utilizing the same logistic support. Some further surveys of stranded dead and moribund animals will be continued in areas where the probability of encountering naturally affected (i.e., not gunshot) animals seems greatest (e.g., the southern and eastern coasts of St. Lawrence Island and the outlying Punuk Islands) and the operation is likely to be most cost-effective. Stranding data will be solicited from other sources for continued monitoring of conditions in areas previously covered by this project, where the number of carcasses per unit of coast seems to be predictably low (Alaska Peninsula, northern Kotzebue Sound) or made up mainly of gunshot animals (southern Kotzebue Sound and northern St. Lawrence Island).

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 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 data 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	submitted			
Kotzebue Sound	7/17/75	7/20/75	submitted			
Kotzebue Sound	7/22/75	7/24/75	submitted			
St. Lawrence Is.	8/8/75	8/22/75	submitted			
Alaska Peninsula	Summer 1976		9/30/76			
Kotzebue Sound	Summer 1976		9/30/76			

Note: 1 Data Management Plan has been approved by M. Pelto; we await approval by the Contract Officer.

* 1976 environmental data will be submitted after receipt and and formal approval of Data Management Plan. Format has been received and approved by all parties.

QUARTERLY REPORT

Contract # 03-5-022-69
Research Unit #229
1 July 1976-30 September 1976
Number of Pages - 6

Biology of the Harbor Seal, *Phoca vitulina richardi*, in the Gulf of Alaska

Principal Investigators

Kenneth Pitcher, Marine Mammals Biologist
Donald Calkins, Marine Mammals Biologist
Alaska Department of Fish and Game .
333 Raspberry Road
Anchorage, Alaska 99502

I. Task Objectives

A. Determination of harbor seal food habits and trophic relationships in different areas of the Gulf of Alaska by season.

B. Investigate population productivity with emphasis on determining age of sexual maturity and age specific reproductive rates.

C. To examine growth rates, development and body conditions.

D. Collection of data concerning seasonal distribution, use of critical habitat, effects of disturbance and population composition.

II. Field and Laboratory Activities

A. Field Activities

1. Field Camp - Tugidak Island - 1 July - 30 September.

B. Laboratory Activities

1. Preparation of tooth sections for age determination 1-15 August.

2. Analysis of female reproductive tracts 20-27 August and 8-20 September.

3. Analysis of male reproductive tracts 8-30 September.

4. Sorting of stomach contents 20-27 August.

B. Scientific Parties

1. Kenneth Pitcher, Alaska Department of Fish and Game, Principal Investigator.

2. Donald Calkins, Alaska Department of Fish and Game, Co-Principal Investigator.

3. Roger Aulabaugh, Alaska Department of Fish and Game, Field and Laboratory Assistant.

4. Francis Palmer, Alaska Department of Fish and Game, Laboratory Specialist.

5. Brian Johnson, Alaska Department of Fish and Game, Field Biologist.

C. Methods

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 of 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.

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.

10. A field camp was established on Tugidak Island. Periodic island censuses were conducted. Instances of disturbance both man-related and natural were recorded. The progression of life history events i.e. birth, lactation, weaning and molting were documented as animals may be particularly sensitive to disturbance during these periods.

D. Sample Localities

During this quarter all field data were collected from Tugidak Island south of Kodiak Island.

E. Data Collected or Analyzed

1. Field work on Tugidak Island has produced considerable data on numbers, seasonal use patterns, effects of disturbance and chronology of life history events. The field party is still on Tugidak so detailed results of this work are not yet available.

2. Microscope slides were prepared for age determination from the canine teeth of 71 harbor seals. Assignment of ages has not been completed.

3. Laboratory analyses were completed for the 43 female and 57 male reproductive tracts.

III. Results

1. Preliminary data from Tugidak Island indicate a late summer buildup of seals approaching 15,000 animals on September 2. The estimates of animals hauling on Tugidak from mid-May through July ranged from 3-6,000 and then progressively increased into September. Pupping began about May 25. The greatest number of pups was observed on June 19. By mid-July few pups remained on the island.

Major disturbance factors observed were aircraft, both fixed wing and helicopter. Detailed reports on disturbance factors and their effects will be presented in the next report.

IV. Preliminary Interpretation of Results

None.

V. Problems Encountered/Recommended Changes

None.

VI. Estimate of Funds Expended

100%

Quarterly Report

Contract # 02-5-022-53
Research Unit #230
Reporting Period: July-September 1976
Number of Pages: 14

The natural history and ecology of the bearded seal (*Erignathus barbatus*) and the ringed seal (*Phoca (Pusa) hispida*)

Principal Investigators:

Thomas J. Eley - ringed seal
Marine Mammals Biologist
Alaska Department of Fish and Game
1300 College Road
Fairbanks, Alaska 99701

John J. Burns - bearded seal
Marine Mammals Biologist
Alaska Department of Fish and Game
1300 College Road
Fairbanks, Alaska 99701

Assisted by: Carol Nielsen, Lynn Vaughan, Lloyd Lowry, Glenn Seaman, Kathryn Frost and David James

30 September 1976

I. Task Objectives

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 Bering, Chukchi and Beaufort Seas.

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 growth rates.

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 condition.

7. Acquisition of additional information on seasonal migrations.

II. Field and Laboratory Activities

A. Schedule

Date	Location	Purpose
July-September	Fairbanks	Analyses of seal specimens and data
July and August	Barrow	Collection of seal specimens
July	Shishmaref	Collection of seal specimens
July	Wainwright	Collection of seal specimens
August	USCGC _Glacier_	Collection of seal specimens
August	OSS _Discoverer_	Collection of seal specimens
August	Barter Island	Collection of seal specimens

B. Scientific Party

Name	Affiliation	Role
John J. Burns	ADF&G	Principal Investigator
Thomas J. Eley	ADF&G	Principal Investigator
David James	ADF&G	Technician
Glenn Seaman	ADF&G	Technician

C. Analytical Methods

From all specimens we endeavor to obtain weights, standard measurements, lower jaws, foreflipper claws, stomachs, reproductive tracts and intestines. We also obtained blubber, tissue, organ and blood samples as the situation permits.

The ages of seals are determined by examination of claw annuli (for animals six years and younger) and dentine or cementum annuli (for animals over six years of age). Growth rates are based on weight and standard measurements correlated with specimen age, sex and date and locality of collection. Species productivity and parasite burden are determined, respectively, through laboratory examinations of reproductive tracts and various organs and correlation of these data with age, sex, and date and locality of collection of each specimen.

Regional differences in seal density and distribution were assessed through aerial surveys following the methods of Burns and Harbo (1972).

Analytical methods are discussed in detail in our Annual Report for FY-1976.

D. Sample Localities

1. Barrow - At sea, within a 22 nautical mile radius of Point Barrow.

2. Wainwright - Specimens obtained from seals killed on sea ice and brought to the village for subsistence purposes. Most seals were killed within a 20 nautical mile radius of the village.

3. Shishmaref - Specimens obtained from seals killed on sea ice and brought to the village for subsistence purposes. Most seals were killed within a 20 nautical mile radius of the village.

4. Barter Island - At sea, within a 20 nautical mile radius of the village.

5. USCGC Glacier - Noon positions are given in Appendix 1.

6. OSS Discoverer - Noon positions are given in Appendix 2.

III-IV. Results and Preliminary Interpretation

A. Specimen Collections

During the July to September, 1976 quarter, our major efforts were devoted to field activities. One hundred and sixty-three ringed seals and 99 bearded seals were obtained from villages, or collected by the Principal Investigators (Table 1). Measurements, jaws, claws, stomachs and reproductive tracks were obtained from most specimens. We also obtained blubber, tissue, organ and blood samples from many specimens. All of these and those obtained in previous years are being processed as rapidly as possible.

Table 1. Specimens obtained between July and September, 1976.

Location	Male	Female	Unknown	Total
Barrow				
Ringed seal	3	2	-	5
Bearded seal	1	-	-	1
Barter Island				
Ringed seal	-	2	1	3
Bearded seal	-	3	-	3
Wainwright				
Ringed seal	5	3	-	8
Bearded seal	8	12	1	21
Shishmaref				
Ringed Seal	59	84	1	144
Bearded seal	31	42	-	73
Glacier				
Ringed seal	1	-	-	1
Discoverer				
Ringed seal	-	2	-	2
Bearded seal	-	1	-	1

B. Parasitology and Pathology

A considerable amount of material for pathological and parasitological examination has been collected by this project. Within the limits of available time and funding, this material has been examined by ADF&G parasitologist Carol Nielsen. Her reports are included in their entirety as Appendix 4 of this report.

C. Food Habits

See Quarterly Report of "Trophic relationships among ice inhabiting phocid seals" (RU #232).

D. Data Management

We have moved rapidly forward with data management throughout this quarter. Measurements, food habits and survey data for bearded and ringed seals have been submitted to NODC. Data from the remainder of the 1975 and 1976 specimens have been formated and await keypunching.

On recent seal surveys and other over-ice flights, several "terrestrial" mammals (wolverine, Arctic fox, wolf, caribou, moose and others) were observed on sea ice. Since ten-digit codes were not available for these animals we could only record them in the remarks spaces. However, for certain species we are obtaining enough sightings to begin computation of seasonal densities and other statistical tests with the aid of a computer. Therefore ten-digit species codes for all the mammal species of Alaska has been prepared (Appendix 3) by Mr. Eley and approved by Mauri Pelto and George Mueller. The ten-digit codes have now been sent to E.D.S. for final approval.

E. Reproduction and Growth

Analysis of reproduction and growth is critically dependent on accurate determination of the age of specimens. The sectioning, staining and mounting of seal teeth has been the full time job of one person for the past five months. Ages and reproductive condition are known for a portion of the ringed seal samples collected, an analysis of which is given below. Additional results will be reported on as age determination and reproductive analysis of the various samples are completed. Analysis of growth rates requires large samples. A sufficient number of measurements have been made, however age data is not yet available from enough individuals to allow meaningful analysis.

The epididymides of 213 male ringed seals (representing all age classes and collected during all months) have been examined for the presence of sperm. Active spermatogenesis has been detected in essentially all males seven years old and older which were collected during the months of March, April, May and June (Table 2). Six of 12 (50%) six year old males collected between March and May had abundant sperm in their epididymides. One five year old male taken in May had a trace of sperm in its epididymides. No geographic variation in spermatogenic activity has been detected thus far, however, our sample size from the Beaufort Sea is small.

The earliest date that sperm was found in male epididymides was mid-March and active spermatogenesis appears to continue until mid-June. Sperm remains on the epididymides of some males until mid-August. Most adult female ringed seals appear to ovulate in April and May therefore the males are physiologically capable of breeding well before and long after most females.

The reproductive tracts of 25 female ringed seals collected during 1976 have been examined and a tabulation of their reproductive status is presented in Table 3. A three year old female and a five year old female had ovulated for the first time but they apparently did not conceive. Five of six females six years old or older had ovulated but it could not be determined whether these females had conceived. A female 13+ years old had cysts on both uterine horns. The cysts caused complete obstruction of the uterine horns and both ovaries had begun to atrophy.

F. Sex and Age Structure of Harvest

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 whenever ice is present and a few animals are taken in ice-free waters.

The sex composition of ringed seals examined thus far is 426 males, 315 females and 18 sex unknown. This is a sex ratio of 1.4 males to 1 female. Grauvogel (unpubl. data) found a sex ratio of 1.3:1 in the ringed seal harvests of 1973 and 1974 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 searchs for females or to defense of a territory, therefore more likely to expose themselves to a hunter. Fedoseev (1965) found no sex selectivity by the Soviet commercial seal harvests.

The age composition of ringed seal populations can be determined only by sampling over a wide area and with a large sample size (Smith 1973; Fedoseev 1965). Sampling from a small area tends to give a biased age composition because of apparent age-specific movements. For example, in Alaska the harvest at Savoonga on St. Lawrence Island is comprised primarily of pups, one and two year old seals while the harvests at Wainwright and Barrow tend to include ringed seals of all ages. The age-sex composition of ringed seals obtained at Barrow, Wainwright and Cape Lisburne are presented in Tables 4, 5 and 6. A detailed analysis of sex-age composition will be covered in our next quarterly report.

Bearded seals comprise about 20 percent of the retrieved kill of seals in the Bering and Chukchi Seas. As a result it is more difficult to obtain samples of adequate size for analysis of age and sex structure. In a sample of 73 bearded seals obtained at Shishmaref in June and July 1976, 42 (57.5%) were females and 31 (42.5%) males. At Wainwright, in July and August 1975, 30 bearded seals were taken. Of these, 18 (60%) were females and 12 (40%) were males. During July and August 1976, 20 bearded seals for which sex could be identified, were examined. Eight (40%) were males and 12 (60%) were females.

The predominance of female bearded seals in the retrieved harvest probably does not reflect the actual sex ratio in the population. Data summarized above indicates a ratio of 58.5 percent females:41.5 percent males. The sex ratio at birth is more nearly equal (Burns 1967). There is a significant change in the sex composition of the harvest which appears to be related to age of the seals. This is evident in three samples indicated above (Wainwright 1975 and 1976, and Shishmaref 1976). This combined sample consists of 72 females and 51 males (58.5% to 41.5%). The ratio in sub-adult animals in this sample (pups through four years old, N=56 for which age was determined) slightly biased toward males; 30 males:26 females. In animals older than four (N=61), the ratio was 19 males:42 females. (Editorial note: the age was determined for fewer animals than was the case with determination of sex. Therefore the different sample sizes.) It appears that physiological condition is an important factor in determining if a bearded seal sinks or floats after being shot in the water. Adult females are in better condition than adult males during the summer months. The retrieval success for adult females is probably much higher than it is for adult males.

Age composition of the samples referred to above (N=117) was as follows:

Age	Males	Females
pup	15	8
1	7	4
2	2	5
3	4	1
4	2	8
5	3	5
6	4	3
6+	12	34
	49	68

Data concerning the age and sex composition of all bearded seals sampled in 1975 and 1976 is currently being analyzed. Results of this analysis will be included in the next quarterly report.

G. Distribution, Density and Habitat

Several aerial surveys of ringed and bearded seals have been conducted in cooperation with RU #231 and RU #248. These include an extensive survey of the Bering Sea ice front in April, a survey of the shorefast ice of the Chukchi Sea and Kotzebue Sound in June and a survey of the shorefast ice of the Beaufort Sea in June. In addition, shipboard surveys and observations were made in the Bering Sea ice front in March and April, in the northern Bering Sea and Chukchi Sea in August and in the Beaufort Sea in August. All data has been computerized, and analysis and interpretation are now being done in conjunction with the above mentioned research units.

Some comments relative to the distribution and density of bearded seals, as determined from coastal hunting sites, are appropriate. Past records indicate that bearded seals winter mainly in the Bering Sea, moving north through Bering Strait as the ice recedes and disintegrates in spring and south as it advances and reforms in autumn. North of Bering Strait the winter distribution of bearded seals is restricted to those areas where winds and ocean currents keep the drifting ice relatively broken up. By comparison, relatively few bearded seals winter in the Chukchi Sea.

Harvest records directly reflect two factors; abundance and availability. However, they also can be used to indicate the timing of animal movements in the vicinity of hunting sites. Bearded seals are a preferred and actively hunted species and are taken by hunters whenever possible.

Harvest records from Point Hope indicate that few if any bearded seals were taken at that location during the months of March through May. Forty-seven seals were sampled from that period by Mr. Glenn Seaman and all were ringed seals.

Sampling records from Shishmaref are both interesting and informative. Shorefast ice persisted rather late near this village, during the summer of 1976. Although the hunters were active, they were restricted to landfast ice, or the lead just off shore of it, until 2 July. Our sample of seals examined in late June and on the first of July included 52 animals, of which all but one (a bearded seal) were ringed seals. The shore ice had broken up sufficiently to permit hunting by boat on July 2. On that date, 14 seals were examined, of which 8 were bearded seals. Thereafter, bearded seals were regularly taken until the intensive hunting ended, about July 12.

Records from Wainwright, for 1975 and 1976, indicate that in both years, bearded seals become numerous at that northern location during the second decade of July, and are present until the ice disappears from that area. Traditionally, bearded seals are most numerous during the last third of July.

V. Problems and Recommendations

None.

VI. Funds Expended (estimated)

100. Salaries and Wages	\$83,000.00
200. Travel	7,522.45
300. Contractual	5,592.17
400. Commodities	4,778.00
500. Equipment	5,351.32
	\$106,243.94

Table 2. Seasonal variation in sperm presence in the epididymides of male ringed seals seven years old and older.

Month	Number Examined	Sperm Presence Abundant (Number)	Trace (Number)	None (Number)
January	3	–	–	3
February	1	–	–	1
March	9	9	–	–
April	15	15	–	–
May	24	23	–	1
June	30	20	4	6
July	5	–	1	4
August	5	–	2	3
September	1	–	–	1
October	2	–	–	2
November	11	–	–	11
December	12	–	–	12

Table 3. Reproductive status of 25 female ringed seals collected during 1976.

Number	Claw Age	Month of Collection	Pregnant Yes-No	Status	Comments
BP-15-76	Pup	July	No	Nulliparous	No follicular activity
SHP-63-76	Pup	June	No	Nulliparous	No follicular activity
SHP-118-76	Pup	July	No	Nulliparous	No follicular activity
SHP-126-76	Pup	July	No	Nulliparous	No follicular activity
SHP-179-76	Pup	July	No	Nulliparous	No follicular activity
SHP-180-76	Pup	July	No	Nulliparous	No follicular activity
SHP-187-76	Pup	July	No	Nulliparous	No follicular activity
SHP-192-76	Pup	July	No	Nulliparous	No follicular activity
SHP-194-76	Pup	July	No	Nulliparous	No follicular activity
SHP-201-76	Pup	July	No	Nulliparous	No follicular activity
SHP-218-76	Pup	July	No	Nulliparous	No follicular activity
SHP-224-76	Pup	July	No	Nulliparous	No follicular activity
SHP-236-76	Pup	July	No	Nulliparous	No follicular activity
SHP-265-76	Pup	July	No	Nulliparous	No follicular activity
SHP-134-76	1	July	No	Nulliparous	No follicular activity
SHP-58-76	3	June	No	Nulliparous	No follicular activity
PHP-41-76	3	May	No	Nulliparous	Ovulated apparently for first time
PHP-40-76	4	May	No	Nulliparous	No follicular activity
SHP-103-76	5	July	No	Nulliparous	Ovulated apparently for first time, degenerate corpus luteum
SHP-190-76	6	July	Unknown	Nulliparous	No corpus albicantia, one corpus luteum
SHP-202-76	7+	July	Unknown	Primiparous	One corpus albicantia, one corpus luteum
BP-7-76	7+	July	Unknown	Multiparous	Two corpus/albicantia, one corpus luteum
SHP-144-76	8	July	Unknown	Multiparous	Two corpora albicantia, one corpus luteum
BP-12-76	11	August	Unknown	Multiparous	Two corpora albicantia, one corpus luteum
NP-1-76	13+	January	No	Multiparous	Uterine cysts sealed both horns of uterus. Ovaries atrophying

Table 4. Sex and ages of ringed seals collected at Barrow, Alaska.

Age	1975 Male	1975 Female	1975 Unknown	1976 Male	1976 Female	1976 Unknown
Pup	–	1	–	2	1	–
1	–	–	–	–	–	–
2	–	–	–	–	–	–
3	1	–	–	–	1	–
4	1	–	–	–	–	1
5	–	–	–	1	–	–
6	1	–	–	1	–	–
6+	–	–	–	–	–	–
7	–	–	–	–	–	–
7+	2	–	–	–	1	–
8	–	–	–	4	–	–
8+	3	–	–	–	–	–
9	–	–	–	–	–	–
9+	–	1	–	–	–	–
10	–	–	–	–	–	–
10+	–	–	–	–	–	–
11	–	–	–	–	1	–
11+	–	–	–	–	–	–
Unknown	–	1	–	2	–	1
Total	8	3	0	10	4	2

Table 5. Sex and ages of ringed seals collected at Wainwright, Alaska.

Age	1975 Male	1975 Female	1975 Unknown	1976 Male	1976 Female	1976 Unknown
Pup	3	3	-	-	-	-
1	-	1	-	-	-	-
2	-	1	-	-	-	-
3	1	-	-	-	1	-
4	-	-	-	2	-	-
5	1	1	-	-	-	-
6	1	3	-	-	-	-
6+	-	-	-	-	-	-
7	3	1	-	1	1	-
7+	-	-	-	-	1	-
8	-	-	-	-	-	-
8+	1	1	-	1	-	-
9	-	-	-	-	-	-
9+	3	-	-	1	-	-
10	-	-	-	-	-	-
10+	3	1	-	-	-	-
11						
11+						
Total	16	12	-	5	3	-

Table 6. Sex and ages of ringed seals killed by polar bears at Cape Lisburne, Alaska, March-April 1976.

Age	Male	Female	Unknown
Pup	–	–	–
1	–	–	–
2	–	–	–
3	1	–	–
4	–	–	–
5	–	–	–
6	1	–	–
6+	–	–	–
7	1	–	–
7+	–	–	–
8	1	–	–
8+	1	–	–
9	1	–	–
9+	1	–	–
10	1	–	–
10+	2	–	–
11	1	–	–
11+	1	–	–
Unknown	–	–	8
Total	12	–	8

VII. Literature Cited.

Burns, J. J. 1967. The Pacific bearded seal. Alaska Department of Fish and Game, Juneau. 66pp.

__________ and S. J. Harbo, Jr. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25:279-290.

Fedoseev, G. A. 1965. Age and sex composition of the kill of the ringed seal (Phoca hispida ochotensis Pall.) as an index of the age structure of the population. Morskie Mlekopitayuschie, Akad. Nauk SSSR, 105-112. Fish. Res. Bd. Can. Trans. Ser. No. 799.

Smith, T. G. 1973. Population dynamics of the ringed seal in the Canadian eastern Arctic. Fish. Res. Bd. Can. Bull. 181:55pp.

APPENDIX 1

APPROXIMATE NOON LOCATIONS OF USCGC *GLACIER*

DATE	LOCATION	
17 August 1976	71°31'N	156°03'W
18 August 1976	71°34'N	155°34'W
19 August 1976	71°34'N	154°42'W
20 August 1976	71°11'N	153°09'W
21 August 1976	70°59'N	149°47'W
22 August 1976	70°40'N	148°26'W
23 August 1976	70°36'N	148°13'W
24 August 1976	70°36'N	148°16'W
25 August 1976	70°37'N	148°13'W
26 August 1976	70°40'N	147°43'W
27 August 1976	70°48'N	149°04'W
28 August 1976	71°07'N	151°01'W
29 August 1976	71°43'N	151°46'W
30 August 1976	71°25'N	152°25'W
31 August 1976	71°18'N	152°32'W
1 September 1976	71°13'N	153°18'W
2 September 1976	71°28'N	154°39'W
3 September 1976	71°34'N	156°02'W

APPENDIX 2

APPROXIMATE NOON LOCATIONS OF R/V *DISCOVERER*

DATE	LOCATION	
19 August 1976	68°08'N	162°00'W
20 August 1976	64°24'N	166°05'W
21 August 1976	64°48'N	167°12'W
22 August 1976	66°25'N	166°25'W
23 August 1976	66°35'N	163°00'W
24 August 1976	69°20'N	170°00'W
25 August 1976	68°50'N	170°55'W
26 August 1976	72°00'N	166°30'W
27 August 1976	72°00'N	166°30'W
28 August 1976	72°00'N	166°30'W
29 August 1976	66°25'N	168°05'W
30 August 1976	63°53'N	171°45'W
31 August 1976	63°00'N	168°40'W
1 September 1976	57°11'N	171°30'W
2 September 1976	52°22'N	176°40'W

APPENDIX 3

TEN-DIGIT SPECIES CODE TO THE MAMMALS OF ALASKA

89	MAMMALIA	
8911	Mysticeti	
891101	Eschrichtiidae	
89110101	Eschrictius	
8911010101	Eschrictius robustus	Grey whale
891102	Balaenopteridae	
89110201	Balaenoptera	
8911020101	Balaenoptera acutorostrata	Minke whale
8911020102	Balaenoptera borealis	Sei whale
8911020103	Balaenoptera physalus	Fin whale
8911020104	Balaenoptera musculus	Blue whale
89110202	Megaptera	
8911020201	Megaptera noraeangliae	Humpback whale
891103	Balaenidae	
89110301	Balaena	
8911030101	Balaena glacialis	Right whale
8911030102	Balaena mysticetus	Bowhead whale
8912	Odontoceti	
891201	Delphinidae	
89120101	Stenella	
8912010101	Stenella caeruleoalba	Striped Dolphin
89120102	Lagenorhynchus	
8912010201	Lagenorhynchus obliquidens	Pacific white-sided dolphin
89120103	Lissodelphis	
8912010301	Lissodelphis borealis	Northern right whale dolphin
89120104	Grampus	
8912010401	Grampus griseus	Gray grampus or Risso's dolphin
89120105	Pseudorca	
8912010501	Pseudorca crassidens	False killer whale
89120106	Globicephala	
8912010601	Globicephala sieboldi	Pilot whale
89120107	Orcinus	
8912010701	Orcinus orca	Killer whale
89120108	Phocoena	
8912010801	Phocoena phocoena	Harbor porpoise
89120109	Phocoenoides	
8912010901	Phocoenoides dalli	Dall's porpoise
891202	Monodontidae	
89120201	Delphinapterus	
8912020101	Delphinapterus leucas	Belukha
89120202	Monodon	
8912020201	Monodon monoceras	Narwhal
891203	Physeteridae	
89120301	Physeter	
8912030101	Physeter catodon	Sperm whale
891204	Ziphiidae	
89120401	Berardius	
8912040101	Berardius bairdi	Giant bottlenose whale

89120402	Ziphius	
8912040201	Ziphius cavirostris	Cuvier's beaked whale
89120403	Mesoplodon	
8912040301	Mesoplodon carlhubbsi	Hubb's beaked whale
8912040302	Mesoplodon stejnergeri	Stejnerger's beaked whale
8913	Carnivora	
891301	Ursidae	
89130101	Ursus	
8913010101	Ursus maritimus	Polar Bear
8913010102	Ursus arctos	Grizzly and Brown Bear
8913010103	Ursus americanus	Black bear
891302	Mustelidae	
89130201	Enhydra	
8913020101	Enhydra lutris	Sea otter
89130202	Lontra	
8913020201	Lontra canadensis	River otter
8913203	Gulo	
8913020301	Gulo gulo	Wolverine
89130204	Mustela	
8913020401	Mustela vison	Mink
8913020402	Mustela nivalis	
8913020403	Mustela erminea	Ermine
89130205	Martes	
8913020501	Martes americana	Marten
8913020502	Martes pennanti	Fisher
89130206	Mephitis	
8913020601	Mephitis mephitis	Striped skunk
891303	Otariidae	
89130301	Zalophus	
8913030101	Zalophus californianus	California sea lion
89130302	Eumetopias	
8913030201	Eumetopias jubatus	Northern or Stellers sea lion
89130303	Callorhinus	
89130301	Callorhinus ursinus	Northern fur seal
891304	Odobenidae	
89130401	Odobenus	
8913040101	Odobenus rosmarus	Walrus
891305	Phocidae	
89130501	Phoca	
8913050101	Phoca largha	Spotted seal
8913050102	Phoca vitulina richardii	Harbor seal
8913050103	Phoca hispida	Ringed seal
8913050104	Phoca fasciata	Ribbon seal
8913050105	Phoca groenlandica	Harp seal
89130502	Erignathus	
8913050201	Erignathus barbatus	Bearded seal
89130503	Cystophora	
8913050301	Cystophora cristata	Hooded seal
89130504	Mirounga	
8913050401	Mirounga angustirostris	Northern elephant seal
891306	Procyonidae	
89130601	Procyon	
8913060101	Procyon lotor	Raccoon
891307	Felidae	
89130701	Lynx	
8913070101	Lynx lynx	Lynx

891308	Canidae	
89130801	Canis	
8913080101	Canis lupus	Wolf
8913080102	Canis lupus	Coyote
89130802	Alopex	
8913080201	Alopex lagopus	Arctic fox
89130803	Vulpes	
8913080301	Vulpes vulpes	Red fox
8914	Artiodactyla	
891401	Cervidae	
89140101	Cervus	
8914010101	Cervus elaphus	Elk or Wapiti
89140102	Odocoileus	
8914010201	Odocoileus hemionus	Black-tail deer
89140103	Rangifer	
8914010301	Rangifer tarandus	Caribou
89140104	Alces	
8914010401	Alces alces	Moose
891402	Bovidae	
89140201	Bison	
8914020101	Bison bison	Bison
89140202	Ovibos	
8914020201	Ovibos moschatus	Muskox
89140203	Ovis	
8914020301	Ovis dalli	Dall sheep
89140204	Oreamnos	
8914020401	Oreamnos americanus	Mountain goat
8915	Insectivora	
891501	Soricidae	
89150101	Sorex	
8915010101	Sorex cinereus	Masked shrew
8915010102	Sorex pribilofensis	Pribilof shrew
8915010103	Sorex jacksoni	St. Lawrence Island shrew
8915010104	Sorex vagrans	Vagrant shrew
8915010105	Sorex palustris	Water shrew
8915010106	Sorex alaskanus	Glacier Bay water shrew
8915010107	Sorex arcticus	Arctic shrew
89150102	Microsorex	
8915010201	Microsorex hoyi	Pygmy shrew
8916	Chiroptera	
891601	Vespertilionidae	
89160101	Myotis	
8916010101	Myotis lucifugus	Little brown bat
8916010102	Myotis keenii	Keen's myotis
8916010103	Myotis volans	Long-legged myotis
8916010104	Myotis californicus	California myotis
8917	Lagomorpha	
891701	Ochotonidae	
89170101	Ochotona	
8917010101	Ochotona collaris	Collared pika
891702	Leporidae	
89170201	Lepus	
8917020101	Lepus americanus	Snowshoe hare
8917020102	Lepus timidus	Northern or tundra hare

8918	Rodentia	
891801	Sciuridae	
89180101	Marmota	
8918010101	Marmota monax	Woodchuck
8918010102	Marmota broweri	Alaska marmot
8918010103	Marmota caligata	Hoary marmot
89180102	Eutamias	
8918010201	Eutamias minimus	Least chipmunk
89180103	Spermophilus	
8918010301	Spermophilus parryii	Arctic ground squirrel
89180104	Tamiasciurus	
8919010401	Tamiasciurus hudsonicus	Red squirrel
89180105	Glaucomys	
8918010501	Glaucomys sabrinus	Northern flying squirrel
891802	Castoridae	
89180201	Castor	
8918020101	Castor canadensis	Beaver
891803	Cricetidae	
89180301	Peromyscus	
8918030101	Peromyscus maniculatus	Deer mouse
8918030102	Permyscus sitkensis	Sitka mouse
89190302	Clethrionomys	
8919030201	Clethrionomys rutilus	Northern red-backed mouse
8918030202	Clethrionomys gapperi	Gapper's red-backed mouse
89180303	Microtus	
8918030301	Microtus pennsylvanicus	Meadow vole
8918030302	Microtus oeconomus	Tundra vole
8918030303	Microtus longicandus	Long-tailed vole
8918030304	Microtus coronarius	Coronation Island vole
8918030305	Microtus xanthognathus	Yellow-cheeked vole
8918030306	Microtus gregalis	Singing vole
8918030307	Microtus abbreviatus	Insular vole
89180304	Ondatra	
8918030401	Ondatra zibethicus	Muskrat
89180305	Lemmus	
8918030501	Lemmus sibiricus	Brown lemming
8918030502	Lemmus nigripes	Black-footed lemming
89180306	Synatomys	
8918030601	Synatomys borealis	Northern bog lemming
89180307	Dicrostonyx	
8918030701	Dicrostonyx torquatus	Collared lemming
891804	Muridae	
89180401	Rattus	
8918040101	Rattus rattus	Black or roof rat
8918040102	Rattus norvegicus	Norway rat
89180402	Mus	
8918040201	Mus musculus	House mouse
891805	Zapodidae	
89180501	Zapus	
8918050101	Zapus hudsonicus	Meadow jumping mouse
8918050102	Zapus princeps	Western jumping mouse
891806	Erethizontidae	
89180601	Erethizon	
8918060101	Erethizon dorsatum	Porcupine

(Draft Report)

Marine Mammal Diseases and Parasites

by

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Appendix 4 to
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(Partial results of examinations of marine mammals obtained in conjunction with RU#230)

APPENDIX 4

CONTENTS

Marine mammal disease and parasites.

1. Recovery of *Trichinella Spiralis* Larvae by Simulated Gastric Digestion

A total of 35 marine mammals, primarily phocids, were examined for the presence of encysted *Trichinella spiralis* larvae using the usual simulated gastric digestion technique with slight modifications as detailed below.

A. Animals and specimens examined.

Specimens were examined from the following animals (see also Table I): 19 *Pusa hispida* (10 M, 6 F, 3 sex unknown), 10 *Erignathus barbatus* (2 M, 8 F), 1 *Phoca vitulina largha* (F), 1 *Odobenus rosmarus* (M), 1 *Phocoena phocoena* (F), 1 *Enhydra lutris* (F), and 2 *Callorhinus ursinus* (2 M), for a total of 35 (15 M, 17 F, 3 sex unknown). The majority of these animals (phocid and odobenid specimens) were collected on the Chukchi Sea coast of Alaska (Barrow, Wainwright and Cape Lisburne), with a single *P. hispida* collected at Nome (Bering Sea). Of the remaining 4 animals, 3 were collected in southeastern Alaska (1 *P. phocoena* at Haines, 2 *C. ursinus* at Pelican), and the single *E. lutris* was collected on Montague Island in Prince William Sound.

Specimens available for examination consisted of pieces of diaphragm and/or tongue which had been stretched, dried, and stored for varying periods (less than 1 year for the phocid and *O. rosmarus* specimens, approximately 14 years for the *P. phocoena, E. lutris* and *C. ursinus* specimens) at room temperature.

Both diaphragm and tongue specimens were available from 3 animals (2 *P. hispida* and 1 *E. barbatus*). Diaphragm specimens only were available for 29 animals (14 *P. hispida,* 9 *E. barbatus,* 1 *P.v. largha*, 1 *O. rosmarus*, 1 *P. phocoena*, 1 *E. lutris* and 2 *C. ursinus*). Tongue specimens only were available for 3 *P. hispida*.

B. Simulated gastric digestion technique.

To simulate normal mammalian gastric digestion, the test specimens were incubated for varying periods of time in an artificial gastric solution at nearly constant temperature (39-41°C). To maintain temperature, the specimens (in separate jars of gastric solution) were suspended in a warm-water bath which did not have a provision for constant agitation. The HCl concentration of this solution varied within a narrow range of 0.7 to 1.0% in the different experiments (see Table II and III), while the concentration of pepsin* was held constant at 0.6%. For digestion of the test specimens 21 to 100 ml of solution was used per dry gram tissue digested (Table III), while from 89 to 970 ml of gastric solution was used per dry gram of "standard" (lynx diaphragm) tissue (Table II).

Groups of 3 to 6 test specimens were digested in 11 separate experiments (exp. #2 through 12). Each group (experiment) shared (1) a common gastric solution composition (including batch number), (2) time,

*Pepsin from Calbiochem (#51643) parcine stomach mucosa, grade B, activity 1:15,000, lot 500309.

temperature and conditions of incubation, and (3) a particular piece of standard tissue digested in the same solution under the same conditions. Incubation times varied from 3 to 24 hours. In many of the experiments undigested chunks of specimen sample tissue were separated out after the initial incubation and reincubated in either the same (exp. #2 and 3) or fresh (exp. #4 through 7) gastric solution so that tissue chunks were dissolved to a size less than 1 mm^2 by the end of the experiment.

C. Standard: source and recovery of trichinae.

A lynx (*Lynx canadensis*) diaphragm recovered from an adult female road-killed animal (Fairbanks area, May 15, 1975) and found to contain a moderate number of encysted *Trichinella spiralis* larvae when examined with a trichiniscope (squash method) was used as a control during the digestion experiments (Table II). In all but one experiment (# 8), different numbers of *T. spiralis* larvae were digested out of this "standard diaphragm" under the same conditions as the marine mammal test specimens (i.e. gastric solution composition, time and temperature of incubation, as described above), with the exception that the volume of gastric solution used per gram of standard was more than that used for the test specimens. It was felt this would not introduce a significant bias because for both standard and test specimens the volumes of solution per gram were far in excess of the usual 10 ml/gm used by most investigators who have the advantage of large test samples. We felt that at least 50 ml per gram tissue was necessary because (1) 10 ml per gram of fresh weight tissue is the recommended and we were dealing with volume per gram dried tissue with only a single known fresh wet, and (2) the fresh weight of diaphragmatic tissue available (for #721A *C. ursinus*) was approximately 5 times the dried weight, thus 10 ml/gm fresh x 5 gm fresh/gm dried = 50 ml/gm dried.

The number of larvae recovered per gram (lpg) of dried lynx diaphragm digested varied between 8 and 133 in the different experiments, averaging 48 lpg (dry) or roughly 20 lpg (fresh), when experiments 1 (solution inadvertantly overheated), and 3a(b) and 3b(b) (inadequate pepsin solution used for digestion) are omitted. This variation seemed to be a function of the physical location in the diaphragm of the muscle sample digested, with the two areas of highest larval density surrounded by areas of lower density (Figure 1). In one case (experiment 8) no larvae at all were apparent in a moderately sized sample area located between the two high-density areas. Gould (1970) had discussed site variation of *Trichinella spiralis* larval encystment, and has indicated that, in man, the portion of the diaphragm near the tendinous insertion is more heavily infected with encysted larvae. Examination of the standard diaphragm in the present investigation did not substantiate such a differential occurrence in the lynx. It should be recalled that such a central tendon is absent in the diaphragms of at least some species of pinnipeds (St. Pierre, 1974), so that this possible factor may not enter in with the pinniped test specimens. Gould (1970) also briefly reviews the possibility that larvae are more abundant in certain muscle area richer in vasculature, which may have influenced the uneven distribution of larvae recovered from the lynx diaphragm.

D. Results of test specimens.

All 35 marine mammal diaphragm and tongue specimens examined for encysted *Trichinella spiralis* larvae were negative. Table III presents the experimental techniques used, together with a listing of the dry weight of muscle effectively examined, the minimal level of infection which could have been detected, and the lower weight limit for detection of minimal infection level (1 larva) for the standard lynx ($\bar{x}$ = 48 lpg dry) diaphragm under the same experimental conditions.

When examining these findings (Table III) and attempting to compare them with those of other investigators, it should be recalled that all results are expressed with regard to dried weight of the tissue. In order to estimate fresh weights we attempted to rehydrate the tissues immediately before digestion, but with apparently limited success (Table IV). We suspect that in all cases the "rehydrated" weights were substantially less than the original weight of the tissue. For the single pinniped specimen (721 A, *Callorhinus ursinus* diaphragm) which was weighed fresh, the weights were: 3.065 g fresh, 0.587 g dried, 1.560 g rehydrated. Thus, while the "rehydration factor" for this specimen was 1.560 g rehydrated/0.587 g dry = 2.7, the true fresh-to-dry ratio was (3.065/0.587=)5.2*. Even rehydrated, then, this diaphragm specimen weighed a little more than half ($\frac{5.2}{2.7}$ = 1.9) its original weight. Length of time of rehydration appeared to have little effect on the rehydration factor (Table IV), but morphology of the specimen had a substantial effect. Thus, flat specimens (such as *Pusa* diaphragms) gained much more weight than thick specimens with less surface area (such as tongues, or *Erignathus* diaphragms), indicating they had dried out more completely.

For comparison with other studies, we can make only rough estimates of the fresh weights of the tissues analyzed. Analyzed *Pusa* diaphragm dry weights (average hydration factor 2.6) can be approximately converted to fresh by a factor of 1.9 x 2.6 = 4.9, to yield estimated effective fresh weights examined of from 0.6 to 12.4 g. *Erignathus* diaphragms can be similarly converted with a factor of 1.9 x 2.0 = 3.8, to yield estimated fresh weights examined from 0.7 to 14.2 g. Estimated fresh weights of *Pusa* and *Erignathus* tongue tissue analyzed are from 4.3 to 11.1 g (factor = 1.6 x 1.9 = 3.0), and of *Odobenus*, *Enhydra* and *Phocoena* diaphragms from 4.6 to 9.7 g (factor = 2.3 x 1.9 = 4.4). Estimated fresh weights of the *Callorhinus* diaphragm specimens not weighed fresh is from 2.7 to 4.5 g (using the 5.2 factor given by the known specimen).

Using the approximated fresh weights of tissue analyzed, the lowest level of *Trichinella* infection we could have found was: *Pusa* diaphragms- 1.7 lpg (fresh), *Erignathus* diaphragms- 1.4 lpg (fresh), *Pusa* and *Erignathus* tongues- 0.2 lpg (fresh), *Callorhinus* diaphragms- 0.4 lpg, and other diaphragms- 0.4 lpg.

*For the standard lynx diaphragm the true fresh-to-dry ratio was $\frac{20.5}{8.5}$ = 2.4.

E. Comparison and discussion.

R. L. Rausch (1970) has discussed the occurrence of *Trichinella spiralis* infection in arctic pinnipeds and cetaceans, pointing out that the intensity and rate of occurrence of such infections is generally low. His review of the findings of various investigators indicate only one (beluga) whale (*Delphinapterus leucas*) of a total of 929 cetaceans examined for encysted *Trichinella* larvae was infected. The infection level for this beluga was 17 larvae in 25 g presumably fresh diaphragm, or 0.6 lpg. Tissue examined from the single beluga in the present study would have only revealed a minimal infection of 4.8 lpg (dry) or approximately 1.1 lpg (fresh).

For *Pusa*, Rausch's (1970) review indicates very low prevalence of encysted *Trichinella* larvae, with 0.1% (3 of 2612) animals infected at levels of (Rausch et al., 1956) 75.0 and 1.2 lpg presumably fresh diaphragm tissue (level of infection of the third Pusa was not available). Tissue examined from the 19 *Pusa* in this study would have revealed a minimal infection of 0.4 to 8.2 lpg dry, or approximately 0.9 to 1.7 lpg fresh.

For *Erignathus*, Rausch's (1970) review also indicates a low prevalence of larvae, with 0.1% (1 of 736) seals infected at an unstated level. For the 10 *Erignathus* examined in this study, the minimal level of detection ranged from 0.3 to 5.5 lpg dry or approximately 0.05 to 1.8 lpg fresh.

Rausch's (1970) review indicates no specific findings for *Phoca vitulina largha*; the present study of a single specimen had a minimum detection level of 4.0 lpg dry, or approximately 0.9 lpg fresh.

Walruses have been most frequently found infected with *Trichinella* larvae of any of the animals examined in this study. Rausch (1970) cites a prevalence of 2.6% (31 of 1206), and elsewhere another group of studies reviewed by Rausch et al. (1956) yielded 2.4% (19 of 792). Fay (1960) found infection levels of 1, 1, 2 and 540 lpg presumably fresh diaphragm in four infected walruses. For the single walrus examined in this study, the minimal level of detection was 4.5 lpg dry, or approximately 1.0 lpg fresh.

In summary, the present study's negative results are not unexpected when the relatively small number of marine mammals examined is considered, in light of the very low occurrence rates of *Trichinella spiralis* larvae encountered by other authors. In most cases, however, the amount of tissue digested would have been sufficient to detect moderately low levels of infection.

TABLE I. MARINE MAMMALS EXAMINED FOR ENCYSTED *TRICHINELLA SPIRALIS* LARVAE.

	AUTOPSY NO.	OCS NO.	SPECIES	SEX	AGE	LOCATION	DATE
1.	4243	WS-19-75	Pusa hispida	F		Wainwright	28-VII-75
2.	4244	WS-20-75	" "	F		"	28-VII-75
3.	4246	WS-23-75	" "	M	pup	"	29-VII-75
4.	4247	WS-24-75	" "	F		"	29-VII-75
5.	4248	WS-25-75	" "	F		"	29-VII-75
6.	4249	WS-26-75	" "	M		"	29-VII-75
7.	4369	N-1-76	" "	F		Nome	23-I-76
8.	4370	BS-2-75	" "	M		Barrow	
9.	4371	B-6-75	" "	F		"	
10.	4372	B-7-75	" "	M		"	
11.	4373	B-8-75	" "	M		"	
12.	4374	B-9-75	" "	M		"	
13.	4375	CL-2-76	" "	M		C. Lisburne	24-III-76
14.	4376	CL-3-76	" "	?		" "	25-III-76
15.	4377	CL-6-76	" "	M		" "	31-III-76
16.	4378	CL-7-76	" "	M		" "	1-IV-76
17.	4379	CL-8-76	" "	?		" "	1-IV-76
18.	4380	CL-11-76	" "	?		" "	10-IV-76
19.	4381	BH-1-76	" "	M		Barrow	23-I-76
20.	4233	WS-1075	Erignathus barbatus	F		Wainwright	23-VII-76
21.	4234	WS-8-75	" "	F		"	24-VII-75
22.	4235	WS-9-75	" "	F		"	24-VII-75
23.	4236	WS-10-75	" "	F		"	24-VII-75

	AUTOPSY NO.	OCS NO.	SPECIES		SEX	AGE	LOCATION	DATE
24.	4237	WS-11-75	Erignathus barbatus		F		Wainwright	24-VII-75
25.	4238	WS-12-75	"	"	M		"	24-VII-75
26.	4239	WS-13-75	"	"	M		"	24-VII-75
27.	4240	WS-14-75	"	"	M		"	24-VII-75
28.	4241	WS-16-75	"	"	F		"	24-VII-75
29.	4382	CL-14-76	"	"	F		C. Lisburne	16-IV-76
30.	4245	WS-21-75	P. vitulina largha		F		Wainwright	29-VII-76
31.	4242	WS-17-75	Odobenus rosmarus		M		"	24-VII-75
32.	1138	-	Phocoena phocoena		F		Haines	23-VII-62
33.	970	-	Enhydra lutris		F		Montague	X-62
34.	721	-	Callorhinus ursinus		M	pup	Pelican	30-XII-61
35.	732	-	"	"	M	pup	"	2-I-62

TABLE II. RECOVERY OF ENCYSTED *TRICHINELLA* LARVAE FROM LYNX #4166 DIAPHRAGM BY SIMULATED GASTRIC DIGESTION: PERFORMANCE OF THE STANDARD.

Exp. no.	Incubation time (hrs)	Incubation °C	Solution & batch	% HCl	g pepsin	ml solution/ g tissue	dry g digested	No. larvae found	redigested ?	Redig. no. larvae	Total larvae found	lpg dry wt.	Min. dry wt. detection	Comments
1	18	35-55	AI	0.7	6.0	?	2.6	ϕ	no	–	ϕ	–	–	overheated
			BI	3.0	7.5	?	2.6	ϕ	no	–	ϕ	–	–	overheated
2	16	40	AI	0.7	6.0	(200)	0.150	8	Di1-AI	ϕ	8	53	0.0189	
			BI	3.0	7.5	(200)	0.156	ϕ	Di1-BI	12	12	77	0.0130	BI too acidic'
3a	18	28	AI	0.7	6.0	181	0.0275	2	no	–	2	73	0.0137	
			BII	(ph2)	7.5	186	0.0268	ϕ	no	–	ϕ	–	–	BII poor dige[illegible]
3b	22	35	AI	0.7	6.0	181	0.0275	1	no	–	1	36	0.0185	
			BII	(ph2)	7.5	186	0.0268	ϕ	AI	ϕ	ϕ	ϕ	0.0278	BII poor dige[illegible]
4a	3	40	AII	0.7	6.0	164	0.1222	1	no	–	1	8	0.1250	
5	4	41	AIII	1.0	6.0	165	0.1820	6	no	–	6	33	0.0303	
6	18	40	AIV	0.9	6.0	89	0.1125	15	no	–	15	133	0.0075	
7	16	40	AIV	0.9	6.0	405	0.1483	4	AV	ϕ	4	27	0.0370	
8	24	39	AV	0.8	6.0	367	0.1357	ϕ	no	–	ϕ	–	–	no larvae here
9	24	39	AVI	0.9	6.0	320	0.1562	3	no	–	3	19	0.0526	
10a	19	39	AVI	0.9	6.0	410	0.0733	4	no	–	4	55	0.0182	
10b	19	39	AVI	0.9	6.0	426	0.0705	2	no	–	2	28	0.0357	

Exp. no.	Incubation time (hrs)	°C	Solution & batch	% HCl	g pepsin	ml solution/ g tissue	dry g digested	No. larvae found	redigested ?	Redig. no. larvae	Total larvae found	lpg dry wt.	Min. dry wt. detection	Comments
11c	18	40	AVII	0.7	6.0	403	0.0745	6	no	–	6	81	0.0124	
11d	18	40	AVII	0.7	6.0	443	0.0679	9	no	–	9	132	0.0076	
12	18	40	AVII	0.7	6.0	970	0.0310	1	no	–	1	32	0.0313	
TOTAL:							6.7888	62	4	12	74			

Minimum detection level = 0.0208 g dry

Total production (omitting Exp. 1, 3a (B) and 3b (B): 1.5352 g dry yielded 74 larvae: 48 lpg dry

Table III. *Trichinella* larvae digestion from marine mammal tissue specimens.

Specimen		Digestion Technique				Tissue Examined					Results			
Autopsy No.	OCS No.	Exp. No.	time (hrs)	% HCl	ml sol per g tissue	Tissue	dry g digested	% exam	Effective dry g exam	% exam redigest	No. larvae recov.	Total effective dry g exam	Minimum level detect. (lpg dry)	Total minimum level detect. (lpg dry)
Pusa hispida														
4243	WS-19-75	3	18	0.7	36	diaphr.	0.8378	50	0.4189	100	0	0.8378	1.2	1.2
4244	WS-20-75	10	19	0.9	54	diaphr.	1.4873	10	0.1487	–	0	0.1487	6.8	6.8
4246	WS-23-75	10	19	0.9	54	diaphr.	1.5828	10	0.1583	–	0	0.1583	6.3	6.3
4247	WS-24-75	8	24	0.8	52	diaphr.	1.9007	10	0.1901	–	0	0.1901	5.3	2.0
		11	18	0.7	100	diaphr.	0.7978	40	0.3191	–	0	0.3191	3.2	
4248	WS-25-75	8	24	0.8	51	diaphr.	1.9680	10	0.1968	–	0	0.1968	5.1	1.9
		11	18	0.7	100	diaphr.	0.7978	40	0.3191	–	0	0.3191	3.2	
4249	WS-26-75	8	24	0.8	48	diaphr.	2.1059	10	0.2106	–	0	0.2106	4.8	1.6
		11	18	0.7	100	diaphr.	1.0322	40	0.4129	–	0	0.4129	2.4	
4369	N-1-76	9	24	0.9	75	diaphr.	2.0024	20	0.3276	100	0	0.6920	1.4	1.4
4370	BS-2-75	4	3	0.7	32	diaphr.	2.5272	100	2.5272	20	0	2.5272	0.4	0.4
		11	18	0.7	112	diaphr.	0.7126	40	0.2850	–	0	0.2850	3.5	
4371	B-6-75	5	4	1.0	75	diaphr.	2.2586	20	0.4517	–	0	0.4517	2.2	2.2
4372	B-7-75	9	24	0.9	49	diaphr.	2.0608	10	0.2061	–	0	0.2061	4.9	4.9
4373	B-8-75	7	16	0.9	41	diaphr.	2.4241	10	0.1746	20	0	0.3102	3.2	3.2
4374	B-9-75	6	18	0.9	27	diaphr.	1.8260	10	0.1826	–	0	0.1826	5.5	5.5
4375	CL-2-76	7	16	0.9	46	diaphr.	2.1847	10	0.1563	20	0	0.2806	3.6	3.6
4376	CL-3-76	6	18	0.9	35	tongue	1.4370	20	0.2874	–	0	0.2874	3.5	3.5
4377	CL-6-76	8	26	0.8	49	diaphr.	2.0483	10	0.2048	–	0	0.2048	4.9	3.1
		10	19	0.9	77	diaphr.	0.6124	20	0.1225	–	0	0.1225	8.2	
4378	CL-7-76	5	4	1.0	69	tongue	1.4600	40	0.5840	–	0	0.5840	1.7	1.7
4379	CL-8-76	4	3	0.7	21	tongue	2.8648	100	2.8648	100	0	2.8648	0.4	0.3
		9	24	0.9	51	diaphr.	1.9465	20	0.3893	–	0	0.3893	2.6	
4380	CL-11-76	6	18	0.9	31	tongue	1.5887	20	0.3177	–	0	0.3177	3.2	3.2
4381	BH-1-76	7	16	0.9	36	tongue	2.7675	20	0.4939	100	0	0.7921	1.3	1.3
		8	26	0.8	47	diaphr.	2.1484	10	0.2148	–	0	0.2148	4.7	0.3
		10	19	0.9	95	diaphr.	0.8389	20	0.1678	–	0	0.1678	6.0	

Erignathus barbatus														
4233	WS-1-75	7	16	0.9	34	diaphr.	2.9512	10	0.0403	20	0	0.5499	1.8	1.8
4234	WS-8-75	5	4	1.0	48	diaphr.	2.2070	20	(0.4414)	10	0	0.4414	2.3	2.3
4235	WS-9-75	4	3	0.7	27	diaphr.	3.7443	100	(3.7443)	10	0	3.7443	0.3	0.2
		11	18	0.7	57	diaphr.	1.4056	20	0.2811	-	0	0.2811	3.6	
4236	WS-10-75	9	24	0.9	55	diaphr.	1.8027	10	0.1803	10	0	0.1803	5.5	5.5
4237	WS-11-75	5	4	1.0	62	diaphr.	1.6247	20	0.3249	-	0	0.3249	3.1	3.1
4238	WS-12-75	7	16	0.9	48	diaphr.	2.0801	10	0.0770	20	0	0.3390	3.0	3.0
4239	WS-13-75	5	4	0.7	26	diaphr.	3.8411	10	(0.3841)	10	0	0.3841	2.6	2.6
4240	WS-14-75	6	18	0.9	42	diaphr.	2.3823	7.5	(0.1787)	20	0	(0.2000)	5.0	5.0
4241	WS-16-75	3	18	0.7	49	diaphr.	2.0276	50	1.0138	100	0	2.0276	0.5	0.5
4382	CL-14-76	4	3	0.7	27	tongue	3.6940	100	(3.6940)	20	0	3.6940	0.3	0.3
		10	19	0.9	65	diaphr.	1.5399	20	0.3080	-	0	0.3080	3.3	
Phoca vitulina largha														
4245	WS-21-75	6	18	0.9	35	diaphr.	1.4440	17.5	0.2527	-	0	0.2527	4.0	4.0
Odobenus rosmarus														
4242 ♂	WS-17-75	5	4	1.0	76	diaphr.	2.2031	10	(0.2203)	10	0	0.2203	4.5	4.5
Phocoena phocoena														
1138	-	12	18	0.7	54	diaphr.	1.0479	20	0.2096	-	0	0.2096	4.8	4.8
Enhydra lutris														
970	-	12	18	0.7	61	diaphr.	1.3107	20	0.2621	-	0	0.2621	3.8	3.8
Callorhinus ursinus														
721	-	12	18	0.7	139	diaphr.	1.1492	10	0.1149	-	0	0.1149	8.7	8.7*
732	-	12	18	0.7	93	diaphr.	0.8575	10	(0.0858)	10	0	0.0858	12.4	5.3**
					156	diaphr.	0.5121	20	0.1024	-	0	0.1024	9.8	

* or 0.2 lpg fresh

** or 0.2 lpg fresh

Table IV. Rehydration weight gain factors.

Autopsy No.	OCS No.	Species	Specimen	Exp. No.	Hydr. time (hrs)	Weight of Tissue dry	Rehydrated	Weight gain factor g rehydr / g dry
4243	WS-19-75	P. hispida	diaphr.	3	1	0.8378	2.0121	2.4
4370	BS-2-75	P. hispida	diaphr.	4	1?	2.5272	6.1054	2.2
4371	B-6-75	P. hispida	diaphr.	5	17.5	2.2586	?	?
4374	B-9-75	P. hispida	diaphr.	6	6	1.8260	6.0882	3.3
4245	WS-21-76	P.v. largha	diaphr.	6	6	1.4400	3.1855	2.2
4373	B-8-75	P. hispida	diaphr.	7	5	2.4241	7.0380	2.9
4375	CL-2-76	P. hispida	diaphr.	7	5	2.1847	5.4356	2.5
4377	CL-6-76	P. hispida	diaphr.	8	26	2.0483	4.1233	2.5
4381	BH-1-76	P. hispida	diaphr.	8	26	2.1484	5.1812	2.4
4247	WS-24-75	P. hispida	diaphr.	8	26	1.9007	5.2463	2.8
4248	WS-25-75	P. hispida	diaphr.	8	26	1.9680	5.0355	2.6
4249	WS-26-75	P. hispida	diaphr.	8	26	2.1059	5.5006	2.6
4369	N-1-76	P. hispida	diaphr.	9	23	2.0024	5.6946	2.6
4372	B-7-75	P. hispida	diaphr.	9	23	2.0608	6.8711	3.3
4379	CL-8-76	P. hispida	diaphr.	9	23	1.9465	6.2122	3.2
4244	WS-20-75	P. hispida	diaphr.	10	5	1.4873	3.1079	2.1
4246	WS-23-75	P. hispida	diaphr.	10	5	1.5828	3.9513	2.5
Repeated Specimens:								
4377	CL-6-76	P. hispida	diaphr.	10	5	0.6124	1.5156	2.5
4381	BH-1-76	P. hispida	diaphr.	10	5	0.8389	1.9229	2.3
4247	WS-24-75	P. hispida	diaphr.	11	4	0.7978	1.9226	2.4
4248	WS-25-75	P. hispida	diaphr.	11	4	0.7978	1.8225	2.3
4249	WS-26-75	P. hispida	diaphr.	11	4	1.0322	2.3385	2.3
4370	BS-2-75	P. hidpida	diaphr.	11	4	0.7126	1.7262	2.4
Average rehydration factor, *P. hispida* (& 1 *P.v. largha*) diaphragms: 2.6								
4241	WS-16-75	E. barbatus	diaphr.	3	18	2.0276	3.4381	1.7
4235	WS-9-75	E. barbatus	diaphr.	4	1?	3.7443	5.4670	1.5
4234	WS-8-75	E. barbatus	diaphr.	5	17.5	2.2070	?	?
4237	WS-11-75	E. barbatus	diaphr.	5	17.5	1.6247	?	?
4239	WS-13-75	E. barbatus	diaphr.	5	17.5	3.8411	?	?
4240	WS-14-75	E. barbatus	diaphr.	6	6	2.3823	4.5789	1.9
4233	WS-1-75	E. barbatus	diaphr.	7	5	2.9512	5.0542	1.7
4238	WS-12-75	E. barbatus	diaphr.	7	5	2.0801	4.1148	2.0
4236	WS-10-75	E. barbatus	diaphr.	9	23	1.8027	4.5289	2.5
4382	CL-14-76	E. barbatus	diaphr.	10	5	1.5399	4.5557	2.9
Repeated Specimen:								
4235	WS-9-75	E. barbatus	diaphr.	11	4	1.4056	2.4478	1.7

Average rehydration factor, E. barbatus diaphragms: 2.0

4379	CL-8-76	P. hispida	tongue	4	1?	2.8648	3.9062	1.4
4378	CL-7-76	P. hispida	tongue	5	17.5	1.4600	2.6426	1.8
4376	CL-3-76	P. hispida	tongue	6	6	1.4370	2.2875	1.6
4381	BH-1-76	P. hispida	tongue	7	5	2.7675	4.0480	1.5
4382	CL-14-76	E. barbatus	tongue	4	1?	3.6940	5.8557	1.6
4380	CL-11-76	E. barbatus	tongue	6	6	1.5887	2.8937	1.8

Average rehydration factor, P. hispida and E. barbatus tongues: 1.6

4242	WS-17-75	O. rosmarus	diaphr.	5	17.5	2.2031	5.3252	2.4
721A	-	C. ursinus	diaphr.	12	3.5	0.5870	1.5600	2.7*
721B	-					0.5622	1.3339	2.4
732A	-	C. ursinus	diaphr.	12	3.5	0.8575	2.0863	2.4
732B	-					0.5121	1.2576	2.5
970	-	E. lutris	diaphr.	12	3.5	1.3107	3.1779	2.4
1138	-	P. phocoena	diaphr.	12	3.5	1.0479	2.2862	2.2

Average rehydration factor, other (above) marine mammal diaphragms: 2.3

*Fresh weight 732A = 3.065 g

2. Phocid Necropsies

At Wainwright, Alaska in late July 1, 1975, a total of 17 seals collected by Eskimo hunters were necropsied and the major organs grossly examined. In all cases the animals were eviscerated and the available organs were presented separate from the carcass. Examined in this manner were 9 *Erignathus barbatus* (2M, 7F), 6 *Pusa hispida* (2M, 4F), 1 *Phoca vitulina largha* (F), and 1 *Odobenus rosmarus* (M).

Most of the organs examined were normal (Table V), and postmortem changes were generally minimal. A small number of samples of normal tissue were taken for histological examination (Table VI A). Small slices of liver tissue were collected from each of the 17 seals and frozen for later chemical analysis. Pieces of diaphragm were collected from each seal and dried for the *Trichinella spiralis* survey study previously described.

Tissue specimens were collected also from the few organs which appeared to be affected by pathologic processes (Table VI B). Most frequently seen were occasional white foci of inapparent etiology on the surface of the liver in 4 of the 6 *P. hispida* and 1 of the 7 *E. barbatus* examined, as well as in the single *P.v. largha* (but not the single *O. rosmarus*) liver examined. In *E. barbatus* the mucosa of the duodenum/anterior small intestine was somewhat inflammed, and in 2 *P. hispida* numerous attached acanthocephalans had eroded a number of small foci in the intestinal mucosa.* A single animal, the *P.v. largha*, had a 5 cm - diameter area of lung tissue in the right diaphragmatic lobe that was firm but not classically consolidated.

*The gastric mucosa of these (and other) seals is considered below, in the parasite section of this report.

Table V. Gross examination of organs: necropsied seals.

	Pusa hispida						*P.v. largha*	*O. rosmarus*
	4243 WS-19-75	4244 WS-20-75	4246 WS-23-75	4247 WS-24-75	4248 WS-25-75	4249 WS-21-75	4245 WS-21-75	4242 WS-17-75
Heart, valves, pericardium	x	x	x	x	x	x	x	x
Pulmonary artery, aorta	x	x	x	x	x	x	x	x
Lungs	x	x	x	x	x	x	Area dense tissue	x
Trachea & bronchi	x	x	x	x	x	x	x	x
Liver	x	x	white foci	white foci	white foci	white foci	white foci	x
Spleen	x	x	x	x	x	x	x	x
Kidneys	x	x	x	x	x	x	x	x
Gall bladder & bile duct	x	x	x	x	x	x	x	x
Esophagus	x	x	x	x	x	x	x	x
Stomach	x	x	x	x	x	x	x	x
Duodenum	x	x	red blotches on serosa	x	x	x	x	x
Small intestine (First 10 ft.)	x	x	x	x	x	x	x	x
Lg. intestine	x	x	x	x	x	x	x	x

x = normal appearance n/a = not available for examination

	Erignathus barbatus								
	4233 WS-1-75	4234 WS-8-75	4235 WS-9-75	4236 WS-10-75	4237 WS-11-75	4238 WS-12-75	4239 WS-13-75	4240 WS-14-75	4241 WS-16-75
Heart, valves, pericardium	n/a	n/a	n/a	x	x	x	x	n/a	n/a
Pulmonary artery, aorta	x	x	x	x	x	x	x	n/a	x
Lungs	x	x	x	x	x	x	x	x	x
Trachea & bronchi	x	x	x	x	x	x	x	x	x
Liver	white foci	n/a	x	x	x	n/a	x	x	x
Spleen	x	x	x	x	x	x	x	x	x
Kidneys	x	n/a	n/a	n/a	n/a	x	n/a	n/a	n/a
Gall bladder & bile duct	x	n/a	x	x	x	x	x	x	x
Esophagus	x	x	x	x	x	x	x	x	x
Stomach	x	x	x	x	x	x	x	x	x
Duodenum	x	x	black foci on mucosa	x	x	x	mucosa red	x	mucosa thickened
Small intestine (First 10 ft.)	x	x	x	x (Post. 3 ft.)	n/a	x	x	x	mucosa thickened
Large intestine	x	x	n/a	x	n/a	x	x	x	x

Table VI A. Tissue specimens to be examined: Normal tissue

	Lung	Thymus	Caecal Lymphoid Tissue	Mucosa Duodenum	Mucosa Sm. Int.	Bile Duct Entrance
P. hispida						
4243 WS-19-75	–	–	–	–	–	–
4244 WS-20-75	–	–	–	–	–	–
4246 WS-23-75	–	–	–	sample	–	–
4247 WS-24-75	–	–	–	–	–	–
4248 WS-25-75	–	–	–	–	–	–
4249 WS-26-75	sample	–	–	–	–	–
	1	Ø	Ø	1	–	Ø
E. barbatus						
4233 WS-1-75	–	–	sample	–	–	samples (2)
4234 WS-8-75	–	–	–	–	–	–
4235 WS-9-75	–	–	–	–	–	–
4236 WS-10-75	–	sample	–	–	sample	–
4237 WS-11-75	–	–	–	–	–	–
4238 WS-12-75	–	–	–	–	–	–
4239 WS-13-75	–	–	–	–	–	–
4240 WS-14-75	–	–	–	–	–	–
4241 WS-16-75	–	–	sample	–	–	–
		1	2	–	1	Ø
P.v. largha						
4245 WS-21-75	–	sample	–	–	–	–
O. rosmarus						
4242 WS-17-75	–	–	–	–	–	–
		1	2	1	1	Ø
TOTAL:	1	2	2	1	1	1

Table VI B. Tissue specimens to be examined: Pathological tissue.

	Lung	Liver	Mucosa of Duodenum	Ant. Sm. Int.	Lg. Int.
P. hispida					
4243 WS-19-75	-	-	-	-	-
4244 WS-20-75	-	-	attached (2) acanth.	acanth. ulcers	attached acanth.
4246 WS-23-75	-	white foci	-	-	-
4247 WS-24-75	-	white foci	-	-	-
4248 WS-25-75	-	white foci	-	-	-
4249 WS-26-75	-	white foci	-	-	attached acanth.
	Ø	4	1	1	2
E. barbatus					
4233 WS-1-75	-	white foci	-	-	-
4234 WS-8-75	-	-	-	-	-
4235 WS-9-75	-	-	black spots	-	-
4236 WS-10-75	-	-	-	-	-
4237 WS-11-75	-	-	-	-	-
4238 WS-12-75	-	-	-	-	-
4239 WS-13-75	-	-	reddened	-	-
4240 WS-14-75	-	-	-	-	-
4241 WS-16-75	-	-	-	congested	-
	Ø	1	2	1	Ø
P.v. largha					
4245 WS-21-75	consolidated area	white foci	3 small dark areas	-	-

	Lung	Liver	Mucosa of Duodenum	Ant. Sm. Int.	Lg. Int.
O. rosmarus					
4242 WS-17-75	–	–	–	–	–
	1	1	Ø	Ø	Ø
TOTAL: 13	1	5	3	2	2

3. Phocid Gastrointestinal Helminths

A. Results.

Gastrointestinal helminth parasites were recovered from 203 phocids. In most cases (189 phocids) only stomachs were available for examination, in conjunction with food habits studies: 70 *Erignathus barbatus*, 98 *Pusa hispida*, 16 *Phoca vitulina largha*, 1 *P.v. richardii* and 4 *Histriophoca fasciata*. In addition, stomachs from 14 of the 17 phocids necropsied at Wainwright in 1975 (see report above) were available for examination: 8 *E. barbatus*, 4 *P. hispida*, 1 *P.v. largha*, and 1 *Odobendus rosmarus*. Intestines, gallbladder and bile ducts were available for helminthological examination only from all of the 17 Wainwright 1975 phocids: 9 *E. barbatus*, 6 *P. hispida*, 1 *P.v. largha* and 1 *O. rosmarus*. Gastrointestinal helminth parasite burdens were evaluated in 4 groups as described below.

Group 1 consists of helminths from the duodenum, anterior small intestine, large intestine - rectum, and gallbladder and bile duct of the 17 phocids necropsied at Wainwright (Table VII). As indicated in Table VII most of the collected helminths represented a percentage of the contents of the organ, since intestinal helminths of phocids, particularly of *E. barbatus*, are exceedingly abundant and voluminous. The entire intestinal contents, from pyloric sphincter to rectum, were collected and examined for a single *E. barbatus*, #4233 (WS175). Table VIII lists the helminths recovered from different segments of the small intestine of this individual. Gastrointestinal helminths of the necropsied Wainwright phocids were recovered within 24 hours of collection by opening the intestines or gallbladder/bile ducts, washing the contents in saline, carefully decanting, and directly examining the washed materials (or given percentage) against a black background using a strong oblique light source. Special attention was directed toward recovering even tiny helminths.

In contrast to group 1 (intestinal and bile duct parasites), groups 2, 3 and 4 were all gastric parasites. Phocid stomachs were preserved by injection with and immersion in 10% formalin shortly after collection. Larger helminths were sorted out when stomach contents were examined for a food habits study. Group 2 consists of gastric helminths recovered from 14 of the 17 necropsied Wainwright phocids, and group 3 consists of gastric helminths recovered from 59 other phocids collected during 1975: 18 *E. barbatus*, 40 *P. hispida*, and 1 *P.v. largha* from a total of 7 locations. In both groups 2 and 3, larger helminths were recovered by sieving total gastric contents (including washing water) through a 60-mesh (opening 0.250 mm) screen and carefully examining the retained particles. For group 2 (Wainwright necropsied phocids), the resultant gastric helminths found are listed in Table IX. Table X lists a summary of similar findings for group 3 (other 1975 seals), while Table XI lists the specific findings for each individual in group 3. As these 3 tables (IX, X, XI) indicate, few small gastric helminths were recovered by sieving, since the primary gastric helminths are robust and easily detectable among the stomach contents.

Group 4 consists of larger helminths recovered from the gastric contents of the remaining 130 phocids without special procedures (sieving) to recover tiny helminths. The animals were collected in 8 different years from 16 Alaskan locations, with findings summarized in Table XII. Table XIII lists the specific findings for each individual in group 4.

B. Discussions.

Examination of the stomach contents of 203 phocids (78 *E. barbatus*, 102 *P. hispida*, 17 *P.v. largha*, 1 *P.v. richardii*, 4 *H. fasciata*, and 1 *O. rosmarus*) indicates that the most frequent and most abundant gastric helminths are nematodes of the family Anisakidae. Encountered with moderate frequency but much less abundance are cestodes of the family Diphyllobothriidae. Rarely encountered (and always only if fine-mesh screens were used to detect them) were acanthocephalans, probably *Corynosoma* spp. These are probably parasites of the gallbladder and bile ducts or intestine which occur only incidentally or accidentally in the stomach.

Although intestinal contents were examined for only 17 phocids (9 *E. barbatus*, 6 *P. hispida*, 1 *P.v. largha* and 1 *O. rosmarus*), it was readily evident that an enormous number of diphyllobothriid cestodes are a feature of the *E. barbatus* lower gastrointestinal tract. Acanthocephala were common and moderately abundant in the *P. hispida*, and the (single) *O. rosmarus* intestines examined, while the almost total lack of intestinal diphyllobothriids was in sharp contrast to the *E. barbatus* situation.

Contrasts were also evident between *E. barbatus* and *P. hispida* in terms of gallbladder - bile duct parasites. Of the 8 *E. barbatus* ducts examined, 7 contained trematodes; also seen were larval cestodes and occasional small anisakids (probably incidental). But none of the 6 *P. hispida* ducts contained helminths of any kind. Also negative was the single *P.v. largha* (only part of the bile duct was available for examination, however). The single *O. rosmarus* harbored 10 trematodes (Campanulidae?) and one larval cestode in the gallbladder and bile duct.

In considering the above findings on gastrointestinal helminths, it should be recalled that collection time of year and food habits are of utmost importance, since the infective larvae of nearly all phocid helminth parasites are ingested with the food. Thus, Delyamure and Popov (1974) have discussed variations in the helminth fauna of *P. hispida* between spring, when crustaceans are the major food item, and autumn, when various fish are eaten in abundance. These two investigators also found difference in these faunal variations of juvenile seals compared to those of adults. Correlations between relative abundance of gastric anasakids and diphyllobothriids, taking into consideration the maturity of these helminths, and the foods present in the host stomach at collection should definitely be made. Correlations of age, sex, location and body condition relative to gastric helminths present are also of potential value. Contrasts should be made between phocids of similar maturity collected at the same location in different years, or at the same time and place but of different species, etc. in relation to gastric helminth burden.

Also remaining to be examined are the slender, small, trichostrongylid-type nematodes recovered from the stomachs of four *P. hispida* and one *P.v. largha*, all collected at Wainwright in 1975. Nematodes such as these have apparently not been previously reported in phocids (Lyster, 1940; Margolis, 1954, 1956; King, 1964; Delyamure, 1968; Dailey and Brownell, 1972; Margolis and Dailey, 1972).

Table VII. Group 1: Helminth parasites from esophagus, lower GI tract and gall bladder - bile duct of seals, Wainwright 1975.*

Autopsy No.	OCS No.	Helminths in Esophagus	Helminths in Duodenum	Helminths in Anterior small intestine	Helminths in large intestine, rectum	Helminths in gall bladder & bile duct
4233	WS-1-75 *E. barbatus*	0	(100% 1st 3ft): 2 diphyll. 1 anisakid 5 trematodes	(100% entire small int.): 10,500 diphyll. 20 acanth. see Table VIII	(100%): 20 diphyll.	2 diphyll. 1 anisakid 30 trematodes
4234	WS-8-75 *E. barbatus*	0	(100% 1st 1ft): modr. diphyll. (mature)	N/A	(10%): some diphyll. (mature, some larval) few anisakids	N/A
4235	WS-9-75 *E. barbatus*	10 anasakids	(100% 1st 3ft): abun. diphyll. (mature, some larval)	(10% entire): abun. diphyll. (mature, some larval)	N/A	15 trematodes
4236	WS-10-75 *E. barbatus*	0	(100% 1st 3ft): modr. diphyll. (mature)	(100% ant. 15ft): abun. diphyll. (mature, some small) (100% post. 3ft): 0	(10%): few diphyll. (fragmented mature)	1 diphyll. 1 trematode
4237	WS-11-75 *E. barbatus*	1 anasakid	(100% 1st 1ft): some diphyll. (mature)	N/A	N/A	15 trematodes
4238	WS-12-75 *E. barbatus*	15 anasakids	(100% 1st 3ft): abun. diphyll. (mature, medium, sm.), few larval diphyll.	(100% ant. 15ft): abun. diphyll. (mature, medium, sm.), modr. larval diphyll.	N/A	2 anisakids 75 trematodes

Table VII (cont.)

Autopsy No.	OCS No.	Helminths in Esophagus	Helminths in Duodenum	Helminths in Anterior small intestine	Helminths in large intestine, rectum	Helminths in gall bladder & bile duct
4239	WS-13-75 E. barbatus	1 anisakid	(100% 1st 3ft): abun. diphyll. (mature, medium, sm.), few larval diphyll.	(10% ant. 4ft): modr. diphyll. (mature)	N/A	5 trematodes
4240	WS-14-75 E. barbatus	0	(100% 1st 3ft): modr. diphyll. (mature & medium)	(10% entire): abun. diphyll. (mature,med., sm.)	(10%): some diphyll (mature, medium)	10 trematodes
4241	WS-16-75 E. barbatus	10 anisakids	(100% 1st 3ft): some diphyll. (mature) some larval diphyll.	(100% ant. 10ft): few diphyll. (mature, med., sm.)	(10%): abun. diphyll. (mature, med., sm.)	3 diphyll. (2 mature, 1 small)
4242	WS-17-75 O. rosmarus	N/A	(100% 1st 3ft): 11 Corynosoma spp.	(100% ant. 15ft): 5 diphyll. (larval) 44 Corynosoma spp.	(100%); 1 Corynosoma sp.	1 diphyll. (larval) 10 trematodes
4243	WS-19-75 P. hispida	0	(100% 1st 2ft): 0	(100% ant. 10ft): 0	(10%):	0
4244	WS-20-75 P. hispida	1 anisakid	(100% 1st 2ft): 10 anisakids (immature) 50 acanth.	(100% ant. 10ft): 30 anisakids (immature)	(10%): 1 anisakid (immature) 50 acanth.	0
4245	WS-21-75 P.v. largha	0	(100% 1st 2ft): 2 anisakids 100 Anophryocephalus spp.	(10% ant. 10ft): 20 Anophyrocephalus spp.	(100%): 25 acanth.	0

Table VII (cont.)

Autopsy No.	OCS No.	Helminths in Esophagus	Helminths in Duodenum	Helminths in Anterior small intestine	Helminths in large intestine, rectum	Helminths in gall bladder & bile duct
4246	WS-23-75 <u>P. hispida</u>	0	(100% 1st 2ft): 0	(100% ant. 10ft): 10 larval diphyll. 5 <u>Anophryocephalus</u> sp.	(100%): 15 acanth.	0
4247	WS-24-75 <u>P. hispida</u>	0	(100% 1st 2ft): 1 <u>Anophryocephalus</u> sp.	(100% ant. 10ft): 5 acanth.	(100%): 40 acanth.	0
4248	WS-25-75 <u>P. hispida</u>	0	(100% 1st 2ft): 0	(100% ant. 10ft): 3 acanth.	(100%): 50 acanth.	0
4249	WS-26-75 <u>P. hispida</u>	0	(100% 1st 2ft): 1 anisakid (immature)	(100% ant. 10ft): 5 anisakids 20 acanth.	(100%): few diphyll. (mature fragments) few anisakids abun. acanth.	0

Anatomical explanations, abbreviations.

1. <u>Esophagus</u>: Between pharynx and cardiac sphincter.

2. <u>Duodenum</u>: First 3 feet of intestine posterior to pyloric sphincter for <u>E. barbatus</u> and <u>O. rosmarus</u>, first 2 feet posterior to pyloric sphincter for <u>P. hispida</u> and <u>P. v. largha</u>.

Table VII (cont.)

3. *Anterior small intestine*: Total length of small intestine beyond pyloric sphincter:
Approx. 63 feet for *E. barbatus*
Approx. 30 feet for *P. hispida* and *P. v. largha*
(*O. rosmarus* intestine length not measured)
Thus usual analyzed portions of duodenum/small intestine was:
   a) 3 + 15 = 18 feet, 18/63 = 1/3.5: less than a third of *E. barbatus* total small intestine length.
   b) 2 + 10 = 12 feet, 12/80 = 1/2.6: more than a third of *P. hispida* and *P. v. largha* total small intestine.

4. *Large intestine, rectum*: Clearly demarcated from small intestine by an incomplete iliocaecal sphincter, length 8 feet in *E. barbatus*, 5 feet in *O. rosmarus*, 2 feet in *P. hispida* and *P. v. largha*.

5. Abundance of helminths rated on score:
   a) abundant (abbreviated abun.)
   b) moderate (abbreviated modr.)
   c) some
   d) few
   e) none (this notation omitted in Table VII)

6. Kinds of helminths found:
   - cestodes
     - diphyllobothriids (abbreviated diphyll.)
     - *Anophryocephalus* sp.
   - nematodes
     - anisakids
   - trematodes
   - acanthocephalans (abbreviated acanth.)

7. Other abbreviations in Table VII:
   - ant. = anterior
   - post. = posterior
   - sm. = small

Table VIII. _Erignathus barbatus_ #4233 (WS-1-75): helminth parasites of entire small intestine, analyzed in five segments.

Segment 1 (from 0 to 14 feet beyond duodenum)
1262 diphyllobothriids (nearly all mature)
6 trematodes
1 anisakid (immature)

Segment 2 (from 14 to 28 feet beyond duodenum)
approx. 7500 diphyllobothriids (mature, medium, small and larval)
approx. 20 acanthocephalans

Segment 3 (from 28 to 42 feet beyond duodenum)
approx. 1000 diphyllobothriids (medium, small)

Segment 4 (from 42 to 56 feet beyond duodenum)
approx. 500 diphyllobothriids (medium, small, larval)

Segment 5 (distal 6 feet, from 56 to 62 feet beyond duodenum)
approx. 200 diphyllobothriids (most fragmented, in poor condition)

Total contents of small intestine:
approx. 10,500 diphyllobothriids
approx. 20 acanthocephalans
few anisakids
few trematodes

Table IX. Gastric Parasites, Group 2: Wainwright 1975
Necropsied Phocids

topsy No.	OCS No.	Species	Anisakids Med. (M)	Large (F)	Small (Imm)	Total	Diphyllobothriids	Other
33	WS-1-75	*E. barbatus*	Ø	3	11	14	Ø	–
34	WS-8-75	"	202	131	91	424	Ø	–
35	WS-9-75	"	100	200	200	500	24	–
36	WS-10-75	"	11	21	14	46	Ø	–
37	WS-11-75	"	37	100	40	177	1	5 Cestode frag.
38	WS-12-75	"	46	97	276	419	31	–
39	WS-13-75	"	This stomach not available					
40	WS-14-75	"	52	51	268	371	55	1 Imm. Cestode
41	WS-16-75	"	67	87	302	459	1	–
42	WS-17-75	*O. rosmarus*	31	48	38	117	Ø	–
43	WS-19-75	*P. hispida*	This stomach not available					
44	WS-20-75	"	Ø	Ø	14	14	Ø	–
45	WS-21-75	*P.v. largha*	Ø	Ø	1	1	Ø	1 Trichostrongy.
46	WS-23-75	*P. hispida*	This stomach not available					
47	WS-24-75	"	Ø	Ø	3	3	Ø	–
48	WS-25-75	"	Ø	Ø	1	1	Ø	–
49	WS-26-75	"	Ø	Ø	38	38	Ø	–

tal: 8 *E. barbatus*
4 *P. hispida*
1 *P.v. largha*
1 *O. rosmarus*

Contents of this stomach not filtered

= Male
= Female
= Immature

Table X. Group 3: Summary of Gastric Parasites Collected.

Location	Year	Host Species E.b.	Host Species P.h.	Host Species Other	Total Seals	Gastric Parasites: Anisakids Abundant	Anisakids Moderate	Anisakids Some	Anisakids Few	Anisakids None	Diphyllobothtriids Abundant	Diphyllobothtriids Moderate	Diphyllobothtriids Some	Diphyllobothtriids Few	Diphyllobothtriids None	Other
Barrow	1975	-	8	-	8	Ø	Ø	Ø	4	4	Ø	Ø	Ø	Ø	8	-
Diomede	1975	-	13	-	13	Ø	Ø	Ø	4	9	Ø	Ø	Ø	Ø	13	-
Gambell	1975	2	1	-	3	1	Ø	1	1	Ø	Ø	Ø	Ø	1	2	1-acanth
Mekoryuk	1975	-	1	-	1	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	1	Ø	1-acanth
Nome	1975	-	1	-	1	Ø	Ø	Ø	1	Ø	Ø	Ø	1	Ø	Ø	1-acanth
Savoonga	1975	1	2	-	3	Ø	2	Ø	1	Ø	Ø	Ø	1	1	1	2-acanth
Wainwright	1975	15	14	1P.v.l.	30	Ø	6	5	14	5	Ø	1	8	6	15	4-trich. 1-acanth
TOTAL: 7 locations,	1975	18	40	1P.v.l.	59	1	8	7	25	18	Ø	1	10	9	39	

Table XI. Group 3: Marine Mammal Stomach Parasites, 1975.

	Seal			Gastric Parasites										
				Anisakids					Diphyllobothriids					Other
OCS No.	E. barbatus	P. hispida	Other	Abundant	Moderate	Some	Few	None	Abundant	Moderate	Some	Few	None	
BS-1-75		X						X					X	
BS-2-75		X						X					X	
BS-3-75		X					X						X	
BS-4-75		X					X						X	
BS-5-75		X						X					X	
BS-7-75		X					X						X	
BS-8-75		X						X					X	
BS-9-75		X					X						X	
Barrow Total: 8 *Pusa hispida*														
DS-6-75		X					X						X	
DS-12-75		X						X					X	
DS-13-75		X					X						X	1 acanth.
DS-14-75		X						X					X	
DS-18-75		X						X					X	
DS-19-75		X						X					X	
DS-21-75		X						X					X	
DS-22-75		X						X					X	
DS-27-75		X					X						X	
DS-32-75		X						X					X	
DS-34-75		X						X					X	
DS-50-75		X					X						X	
DS-51-75		X						X					X	
Diomede Total: 13 *P. hispida*														
GAM-19-75	X			X								X		
GAM-21-75		X					X						X	
GAM-40-75	X					X							X	2 acanth.
Gambell Total: 2 *Erignathus barbatus*, 1 *P. hispida*														
KK-2-75		X				X						X		15 acanth.
Mekoryuk Total: 1 *P. hispida*														
N-1-76		X					X				X			6 acanth.
Nome Total: 1 *P. hispida*														

	Seal			Gastric Parasites										
				Anisakids					Diphyllobothriids					Other
OCS No.	E. barbatus	P. hispida	Other	Abundant	Moderate	Some	Few	None	Abundant	Moderate	Some	Few	None	
SS-190-75	X				X						X			20 acanth.
SS-204-75		X					X						X	
SS-206-75	X				X							X		42 acanth.
Savoonga	Total:	1 *E. barbatus*, 2 *P. hispida*												
WS-27-75		X					X						X	
WS-28-75		X					X						X	
WS-29-75		X					X						X	2 trichost.
WS-31-75		X					X					X		
WS-32-75	X				X							X		
WS-33-75	X				X						X			
WS-34-75		X					X						X	
WS-35-75	X					X							X	
WS-36-75	X				X								X	
WS-37-75	X					X					X			
WS-38-75	X							X			X			
WS-39-75		X					X						X	
WS-41-75	X						X					X		
WS-42-75	X						X				X			
WS-43-75		X					X						X	
WS-45-75	X					X				X				
WS-46-75		X						X					X	
WS-47-75		X						X					X	
WS-48-75		X					X						X	
WS-49-75			P.v.l.					X					X	1 trichost.
WS-50-75	X					X					X			
WS-51-75	X					X							X	Several acanth.
WS-53-75	X						X						X	
WS-54-75	X				X						X			
WS-55-75		X					X					X		
WS-58-75	X				X						X			
WS-59-75	X				X						X			
WS-60-75		X						X					X	
WS-61-75		X					X					X		50 trichost.
WS-62-75		X					X					X		5 trichost.
Wainwright	Total:	15 *E. barbatus*, 14 *P. hispida*, 1 *P. v. largha*												

Acanth. = Acanthocephalans
Trichost. = Trichostrongylids

Table XII. Group 4: Summary of Gastric Parasites Collected.

Location	Collection Year	Host Species E.b.	Host Species P.h.	Host Species Other	Total Seals	Gastric Parasites: Anisakids Abundant	Anisakids Moderate	Anisakids Some	Anisakids Few	Anisakids None	Diphyllobothtriids Abundant	Diphyllobothtriids Moderate	Diphyllobothtriids Some	Diphyllobothtriids Few	Diphyllobothtriids None	Diphyllobothtriids Other
CRUISES:																
1. Alpha-Helix	1973	6	Ø	Ø	6	Ø	Ø	1	1	4	Ø	Ø	3	3	Ø	–
2. Glacier	1971	1	Ø	Ø	1	Ø	Ø	Ø	1	Ø	Ø	Ø	Ø	1	Ø	–
3. Surveyor	1976	Ø	Ø	4. H.f.	4	Ø	Ø	Ø	4	Ø	Ø	Ø	Ø	Ø	4	–
VILLIAGES:																
4 Barter Island	1976	3	Ø	Ø	3	Ø	1	Ø	2	Ø	Ø	Ø	Ø	Ø	3	–
5. Barrow	1969	Ø	5	Ø	5	Ø	Ø	1	4	Ø	Ø	Ø	Ø	Ø	5	–
Barrow	1975	Ø	1	Ø	1	Ø	Ø	Ø	Ø	1	Ø	Ø	Ø	1	Ø	–
6. Cape Lisburne	1976	Ø	2	Ø	2	Ø	Ø	Ø	2	Ø	Ø	Ø	Ø	Ø	2	–
7. Diomede	1970	1	13	Ø	14	1	Ø	Ø	13	Ø	Ø	Ø	Ø	11	3	–
Diomede	1975	5	Ø	Ø	5	Ø	1	4	Ø	Ø	Ø	Ø	2	1	2	–
8. Gambell	1970	Ø	2	Ø	2	Ø	Ø	Ø	2	Ø	Ø	Ø	Ø	1	1	–
Gambell	1975	2	Ø	Ø	2	Ø	Ø	2	Ø	Ø	Ø	Ø	Ø	Ø	2	–
Gambell	1976	2	1	Ø	3	Ø	1	1	1	Ø	Ø	Ø	Ø	1	2	–
9. King Is.	1973	1	Ø	Ø	1	Ø	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	1	–
10. Mekoryuk	1975	11	5	7P.v.l.	23	Ø	2	4	16	1	Ø	1	3	7	12	–

Location		Collection Year	Host Species E.b.	Host Species P.h.	Host Species Other	Total Seals	Gastric Parasites: Anisakids Abundant	Anisakids Moderate	Anisakids Some	Anisakids Few	Anisakids None	Diphyllobothtriids Abundant	Diphyllobothtriids Moderate	Diphyllobothtriids Some	Diphyllobothtriids Few	Diphyllobothtriids None	Other
11.	Nanvak Bay	196?	Ø	Ø	1P.v.r.	1	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1	-
12.	Nome	1969	1	Ø	Ø	1	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1	-
	Nome	1970	3	1	Ø	4	2	1	Ø	1	Ø	Ø	1	1	1	1	-
	Nome	1971	Ø	3	1P.v.l.	4	Ø	Ø	Ø	4	Ø	Ø	Ø	Ø	Ø	4	-
	Nome	1972	Ø	Ø	4P.v.l.	4	Ø	Ø	2	2	Ø	Ø	Ø	Ø	2	2	-
	Nome	1974	Ø	1	1P.v.l.	2	1	Ø	Ø	1	Ø	Ø	Ø	Ø	1	1	-
	Nome	1975	1	1	Ø	2	Ø	1	Ø	1	Ø	Ø	Ø	Ø	Ø	2	-
13.	Point Hope	1975	Ø	20	Ø	20	Ø	Ø	1	19	Ø	Ø	Ø	Ø	1	19	-
14.	Savoonga	1975	7	3	Ø	10	2	4	Ø	4	Ø	Ø	Ø	Ø	Ø	10	-
15.	Shishmaref	1976	4	Ø	Ø	4	Ø	2	1	1	Ø	Ø	1	1	1	1	-
16.	Teller	1970	Ø	Ø	2P.v.l.	2	Ø	Ø	1	1	Ø	Ø	Ø	Ø	Ø	2	-
Total: 16 Locations, 8yrs.			52	58	4 H.f. 1 P.v.r. 15 P.v.l.	130	7	14	22	81	6	Ø	3	10	34	83	-

Table XIII. Group 4: Gastric Parasites of Individual Phocids.

A. Cruise Collections

OCS No.	Seal: *E. barbatus*	Seal: *P. hispida*	Seal: Other	Gastric Parasites — Anisakids: Abundant	Anisakids: Moderate	Anisakids: Some	Anisakids: Few	Anisakids: None	Diphyllobothriids: Abundant	Diphyllobothriids: Moderate	Diphyllobothriids: Some	Diphyllobothriids: Few	Diphyllobothriids: None	Other
AH-70-73	X					X					X			
AH-72-73	X							X				X		
AH-73-73	X							X			X			
AH-74-73	X							X			X			
AH-75-73	X						X					X		
AH-76-73	X							X				X		
Alpha-Helix 1973 Total = 6 *Erignathus barbatus*														
GLA-4-71	X						X					X		
Glacier 1971 Total = 1 *E. barbatus*														
SUV-23-76			*H.f.*				X						X	
SUV-24-76			*H.f.*				X						X	
SUV-27-76			*H.f.*				X						X	
SUV-28-76			*H.f.*				X						X	
Surveyor 1976 Total = 4 *Histriophoca fasciata*														

B. Village Collections

OCS No.	Seal: *E. barbatus*	Seal: *P. hispida*	Seal: Other	Gastric Parasites — Anisakids: Abundant	Anisakids: Moderate	Anisakids: Some	Anisakids: Few	Anisakids: None	Diphyllobothriids: Abundant	Diphyllobothriids: Moderate	Diphyllobothriids: Some	Diphyllobothriids: Few	Diphyllobothriids: None	Other
BIE-1-76	X						X						X	
BIE-2-76	X				X								X	
BIE-5-76	X						X						X	
Barter Island 1976 Total = 3 *E. barbatus*														
L-1-69		X					X						X	
L-2-69		X					X						X	
L-4-69		X				X							X	
L-7-69		X					X						X	
L-8-69		X					X						X	
Barrow 1969 Total = 5 *Pusa hispida*														
B-10-75		X						X				X		
Barrow 1975 Total = 1 *P. hispida*														
CLP-2-76		X					X						X	
CLP-8-76		X					X						X	
Cape Lisburne 1976 Total = 2 *P. hispida*														

OCS No.	Seal: *E. barbatus*	Seal: *P. hispida*	Seal: Other	Gastric Parasites – Anisakids: Abundant	Anisakids: Moderate	Anisakids: Some	Anisakids: Few	Anisakids: None	Diphyllobothriids: Abundant	Diphyllobothriids: Moderate	Diphyllobothriids: Some	Diphyllobothriids: Few	Diphyllobothriids: None	Other
DS-2-70	X			X									X	
DS-4-70		X					X					X		
DS-5-70		X					X					X		
DS-6-70		X					X					X		
DS-7-70		X					X					X		
DS-8-70		X					X					X		
DS-10-70		X					X					X		
DS-11-70		X					X					X		
DS-12-70		X					X					X		
DS-14-70		X					X					X		
DS-15-70		X					X						X	
DS-18-70		X					X					X		
DS-19-70		X					X					X		
DS-70		X					X						X	
Diomede 1970	Total = 1 *E. barbatus*, 13 *P. hispida*													
DS-2-75	X				X						X			
DS-3-75	X					X						X		
DS-4-75	X					X							X	
DS-66-75	X					X					X			
DS-70-75	X					X							X	
Diomede 1975	Total = 5 *E. barbatus*													
GS-4-70		X					X						X	
GS-5-70		X					X					X		
Gambell 1970	Total = 2 *P. hispida*													
GAM-20-75	X					X							X	
GAM-40-75	X					X							X	
Gambell 1975	Total = 2 *E. barbatus*													
GE-004-76	X				X								X	
GP-6-76		X					X						X	
G-7-76	X					X						X		
Gambell 1976	Total = 2 *E. barbatus*, 1 *P. hispida*													

OCS No.	Seal: E. barbatus	P. hispida	Other	Gastric Parasites — Anisakids: Abundant	Moderate	Some	Few	None	Diphyllobothriids: Abundant	Moderate	Some	Few	None	Other
KI-1-73	X						X						X	
King Island 1973 Total = 1 *E. barbatus*														
KK-5-75	X					X					X			
KK-8-75			Pvl			X							X	
KK-10-75			Pvl					X				X		
KK-15-75	X				X						X			
KK-18-75			Pvl				X						X	
KK-19-75			Pvl			X							X	
KK-21-75		X					X						X	
KK-23-75		X					X					X		
KK-24-75	X						X						X	
KK-25-75	X						X					X		
KK-27-75	X						X					X		
KK-28-75	X						X						X	
KK-29-75	X				X						X			
KK-31-75			Pvl			X						X		
KK-34-75	X						X						X	
KK-36-75		X					X						X	
KK-37-75		X					X						X	
KK-41-75	X						X					X		
KK-44-75	X						X						X	
KK-45-75	X						X						X	
MEKS-48-75			Pvl				X						X	
KK-49-75			Pvl				X					X		
KK-68-75		X					X			X				
Mekoryuk 1975 Total = 11 *E. barbatus*, 5 *P. hispida*, 7 *Phoca vitulina largha*														
NAN-3-?			Pvr.		X								X	
Nanvak Bay Total = 1 *P.v. richardi*														
N-31-69	X			X									X	
Nome 1969 Total = 1 *E. barbatus*														
N-13-70		X					X					X		
N-1001-70	X			X							X			
N-1002-70	X			X									X	
N-1003-70	X				X					X				
Nome 1970 Total = 3 *E. barbatus*, 1 *P. hispida*														

	Seal			Gastric Parasites										
				Anisakids					Diphyllobothriids					Other
OCS No.	E. barbatus	P. hispida	Other	Abundant	Moderate	Some	Few	None	Abundant	Moderate	Some	Few	None	
N-1-71		X					X						X	
N-2-71		X					X						X	
N-3-71		X					X						X	
N-71-71			Pvl				X						X	
Nome 1971	Total = 3 *P. hispida*, 1 *P.v. largha*													
NM-40-72			Pvl			X						X		
NMS-57-72			Pvl			X							X	
NM-59-72			Pvl				X						X	
NMS-74-72			Pvl				X					X		
Nome 1972	Total = 4 *P.v. largha*													
N-1-74		X					X					X		
N-19-74			Pvl.	X									X	
Nome 1974	Total = 1 *P. hispida*, 1 *P.v. largha*													
N-2-75		X					X						X	
NS-7-75	X				X								X	
Nome 1975	Total = 1 *E. barbatus*, 1 *P. hispida*													
NE-2-76	X					X						X		
NE-5-76	X					X							X	
NM-8-76	X					X							X	
NE-9-76	X					X						X		
Nome 1976	Total = 4 *E. barbatus*													
PHS-6-76		X					X						X	
PHS-7-76		X					X						X	
PHS-8-76		X					X						X	
PHS-11-76		X					X						X	
PHS-15-76		X					X						X	
PHS-19-76		X					X						X	
PHS-21-76		X					X						X	
PHS-23-76		X					X						X	
PHS-25-76		X				X							X	
PHS-29-76		X					X						X	
PHS-31-76		X					X						X	
PHS-34-76		X					X					X		
PHS-35-76		X					X						X	
PHS-36-76		X					X						X	

	Seal			Gastric Parasites										
				Anisakids					Diphyllobothriids					Other
OCS No.	*E. barbatus*	*P. hispida*	Other	Abundant	Moderate	Some	Few	None	Abundant	Moderate	Some	Few	None	
PHS-39-76		X					X						X	
PHS-40-76		X					X						X	
PHS-41-76		X					X						X	
PHS-43-76		X					X						X	
PHS-45-76		X					X						X	
PHS-46-76		X					X						X	
Point Hope 1975 Total = 20 *P. hispida*														
SS-185-75		X					X						X	
SS-189-75	X				X								X	
SS-191-75	X				X								X	
SS-192-75		X					X						X	
SS-193-75		X					X						X	
SS-200-75	X			X									X	
SS-201-75	X			X									X	
SS-202-75	X						X						X	
SS-203-75	X				X								X	
SS-207-75	X				X								X	
Savoonga 1975 Total = 8 *E. barbatus*, 2 *P. hispida*														
SHS-116-76	X						X			X				
SHS-140-76	X				X						X			
SHE-196-76	X					X						X		
SHS-198-76	X				X								X	
Shishmaref 1976 Total = 4 *E. barbatus*														
Teller-2-70			Pvl			X							X	
Teller 24-70			Pvl				X						X	
Teller 1970 Total = 2 *P.v. largha*														

4. Mucosal Lesions Associated With Marine Mammal Gastric Parasites

A. Occurrence of gastric lesions.

The gastric mucosae of 85 marine mammals (nearly all phocids) were examined for evidence of gastric lesions. Ulcers and mucosal erosions have been frequently reported from these animals in association with nematode parasites of the family Anisakidae, and these nematodes had been recovered frequently from the animals examined (see report 3). The entire gastric mucosae of 82 phocids collected during the spring and summer of 1975 and of two animals collected in the summer of 1976 were available after the stomach contents were removed for food habits studies as previously described (report 3). The stomachs of these animals were injected with and stored whole in 10 percent formalin until the food habits examination, when they were opened with a longitudinal incision from cardia to pylorus. Contents were removed and studied, with parasitological evaluations available for 78 of the 82 phocids, and the emptied incised organ was returned to 10 percent formalin for storage prior to further examination for lesions. The results of the examinations are listed in Table XIV, part A.

Three additional specimens were available from earlier collections. The entire unopened stomach of an adult male *Enhydra lutris* collected off Amchitka Island in February, 1962 (KWK 62-138) was incised and examined. Although a moderate number of anisakids were found among the contents, no mucosal lesions were evident. The second specimen consisted of two samples of gastric mucosa (precise location not noted) with embedded anisakids from a male *Delphinapterus leucas* collected on the Kvichak River in May, 1960 (KAN-20) and examined by Kenneth A. Neiland. Mr. Neiland noted that many smelt were present in the animal's stomach and that numerous anisakids were evident both in the smelt and free in the gastric lumen. The third specimen also consisted of two samples of gastric mucosa (precise location not noted) with embedded anisakids from a male *Eumetopias jubata* collected at Juneau in December 1960. Although several free anisakids accompanied the mucosal samples, no observation on the total amount of anisakids (or other parasites) present in the stomach was available. These results are listed in Table XIV, part B.

Table XV summarizes the information obtained from the examination of the gastric mucosae of the 85 marine mammals. Of the 82 phocids collected during 1975 and 1976, 13 (16%) displayed lesions of the gastric mucosa. This percentage occurrence is probably higher than the actual frequency in the population since (a) if there is any debility associated with these lesions, animals may be more lethargic and thus more readily collected, and (b) personnel involved in the food habits study were probably slightly biased toward saving stomachs with apparent gastric lesions in comparison with other stomachs.

There was no clear association between relative abundance of anisakids (or other helminth parasites) encountered in the gastric lumen and mucosal lesions. Of the 13, phocids with lesions or abnormalities

(8 *Erignathus barbatus*, 4 *Pusa hispida* and 1 *Phoca vitulina largha*), 4 had few anisakids (less than 20), 4 had some (20-50), 3 had a moderate number (50-150), and 2 had abundant anisakids (150-1000). In a few cases the lesions were evident because the anisakids were still attached to the mucosal lesion area. But in most cases the preserved anisakids had apparently been washed from the lesions when the stomach contents were removed, so that it was no longer possible to associate specific individual parasites with lesions they caused.

B. Character of the gastric mucosal lesions.

In nearly all stomachs containing anisakid parasites, a few widely scattered individuals were attached with their anterior ends embedded in the mucosa. The tiny mucosal pits thus formed were not considered to be "lesions" in this report. There is a generally unresolved question of definition as to when the size or depth of this pit, or the density of individual pits in a small area, can be considered a lesion. Here, "lesion" will refer to (1) raised crater-like ulcers larger than 2 mm diameter which appeared macroscopically to penetrate the submucosa, (2) focal mucosal erosions in the form of depressions or slits which were readily evident but did not appear to penetrate the submucosa, and (3) small focal pits as described for individual anisakids but occurring in an unusual local density. Also defined as a "lesion" for the purpose of this report was the single case of thickened pyloric muscularis (see below).

Gastric lesions, as defined above, were encountered in 15 of the 85 marine mammal stomachs examined: 8 of 33 (24%) *E. barbatus*, 4 of 46 (12%) *P. hispida*, 1 of 3 *P.v. largha* and also the 1 *Eum. jubata*, and 1 *Delph. leucas*. In severity the lesions ranged from a perforation (1 stomach), through crater-like ulcers (5), erosions (6), to densely situated focal pits (2).

The most serious lesion encountered was a perforated ulcer, with an opening 8 by 20 mm through the serosa. The ulcer was situated in the fundus near the greater curvature 15 cm posterior to the cardia. Rugae were continuous with the (20 mm wide) rolled serosal margins. No marked thickening or inflammatory phenomena were macoscopically evident. A large clump of anisakids were found plugging the ulcer, with heads through the serosa and tails within the gastric lumen. Unfortunately, no necropsy history was available concerning the patency of this lesion at the time of collection, observations of nematodes or stomach contents in the mesenteries or abdominal cavity, possible peritonitis, etc. The remainder of the gastric mucosa was normal. The animal involved was an adult female *E. barbatus* (SS-206-75) collected June 13, 1975 at Savoonga. Rausch (1953) has discussed intestinal perforations of apparently similar etiology in *En. lutris*.

Crater-like ulcer formations appeared to be the next most serious lesion, encountered in 5 stomachs. They ranged in numbers from 2 to 4 per stomach, with sizes from 8 to 15 mm in diameter, protruding into the

OCS No.	Species: E. barbatus	P. hispida	Other	Anisakids Present	Mucosal Lesions: Total	Location	Description
SS-190-75	X			Modr.	Ø		
SS-206-75	X			Modr.	1	Fundus	Perforation 5 x 20 mm
Savoonga 1975	Total:	2 *E. barbatus*					
WS-1-75	X			Few	Ø	(Blood)	
WS-8-75	X			Abun.	Ø		
WS-9-75	X			Abun.	Ø		
WS-10-75	X			Some	Ø		
WS-71-75	X			Modr.	Ø	(Blood)	
WS-12-75	X			Abun.	Ø		
WS-13-75	X			N/A	Ø	(Blood)	
WS-14-75	X			Abun.	Some	Cardiac	Tiny pits in mucos
WS-16-75	X			Abun.	Ø		
WS-19-75		X		N/A	Ø		
WS-20-75		X		Few	Ø		
WS-21-75			P.v.l.	Few	3	Fundus	Punctiform shallow 3-mm erosions
WS-23-75		X		N/A	Ø		
WS-24-75		X		Few	Ø		
WS-25-75		X		Few	Ø		
WS-26-75		X		Some	Ø		
WS-27-75		X		Few	Ø		
WS-29-75		X		Few	Ø		
WS-30-75		X		N/A	Ø		
WS-31-75		X		Few	Ø		
WS-32-75	X			Modr.	Ø		
WS-33-75	X			Modr.	Some	Fundus	Scattered small sh depressions
WS-34-75		X		Few	Ø		
WS-35-75	X			Some	Ø		
WS-36-75	X			Modr.	Ø	(Blood)	
WS-37-75	X			Some	3(?)	Cardiac	Small shallow depressions
WS-38-75	X			None	Some	Cardiac	Small shallow depressions
WS-39-75		X		Few	Ø		
WS-41-75	X			Few	Ø	(Blood)	
WS-42-75	X			Few	Ø		
WS-43-75		X		Few	2	Fundus	Craters 8 mm dia.
WS-45-75	X			Some	(Ø)	(Blood)	Pyloric wall thick
WS-46-75		X		None	Ø		
WS-47-75		X		None	Ø		
WS-48-75		X		Few	Ø		
WS-49-75			P.v.l.	None	Ø		
WS-50-75	X			Some	Ø		
WS-51-75	X			Some	Ø		
WS-52-75	X			N/A	Ø		
WS-53-75	X			Few	Ø		

Table XIV. Gastric Mucosal Lesions.

A. Phocids, Collected 1975 & 1976.

OCS No.	Species: E. barbatus	Species: P. hispida	Species: Other	Anisakids Present	Mucosal Lesions: Total	Mucosal Lesions: Location	Mucosal Lesions: Description
BS-1-75		X		None	Ø	–	–
BS-2-75		X		None	Ø	(Blood)	
BS-3-75		X		Few	4	Fundus	Craters 12-15 mm dia.
BS-4-75		X		Few	Ø		
BS-5-75		X		None	Ø		
BS-6-75		X		N/A	Ø		
BS-7-75		X		Few	Ø		
BS-8-75		X		None	Ø	(Blood)	
BS-9-75		X		Few	Ø	(Blood)	
Barrow 1975 Total: 9 *P. hispida*							
DS-06-75		X		Few	Ø		
DS-12-75		X		None	Ø		
DS-13-75		X		Few	Ø		
DS-14-75		X		None	Ø		
DS-18-75		X		None	Ø		
DS-19-75		X		None	Ø		
DS-21-75		X		None	Ø		
DS-22-75		X		None	Ø		
DS-27-75		X		Few	Ø		
DS-28-75		X		N/A	Ø		
DS-32-75		X		None	Ø		
DS-34-75		X		None	Ø		
DS-50-75		X		Few	Ø		
DS-51-75		X		None	Ø		
Diomede 1975 Total: 14 *P. hispida*							
GAM-19-75	X			Abun.	Ø		
GAM-21-75		X		Few	Ø		
GAM-40-75	X			Some	Ø		
Gambell 1975 Total: 2 *E. barbatus*, 1 *P. hispida*							
KK-2-75		X		Some	Ø		
KK-24-75	X			Few	Ø		
KK-27-75	X			Few	Ø		
KK-36-75	X			Few	Ø		
KK-41-75	X			Few	Ø		
Mekoryuk 1975 Total: 4 *E. barbatus*, 1 *P. hispida*							
PHS-15-76		X		Few	4	Cardiac	Craters 10-15 mm dia.
PHS-25-76		X		Some	3	Cardiac & Fundus	Craters 8 & 15 mm dia.
Point Hope 1976 Total: 2 *P. hispida*							

(exsheathing fluids, etc., see Dobson, 1972) and that adult forms cause no specific response, hence no lesions. Rausch (1953) has discussed the pathogenicity of the different stages of *Porrocaecum (Terranova) decipiens* in the gastrointestinal tract of *En. lutris*. Clearly precise correlations should be made between host age and condition, faunal variations of gastric parasites, and character of mucosal lesions in future studies.

Finally, the exclusive localization of gastric lesions in the cardiac and anterior fundic areas of the stomach is interesting. Although it is possible the cardiac mucous glands are more favorable for anisakid colonization, two facts made this unlikely: (1) the nematodes rarely if ever were found embedded in the pyloric mucous glands, and (2) anisakids were found in the anterior fundus, an area of gastric glands. Young and Lowe's (1969) suggestion that the anterior stomach is more heavily affected because this is where the intermediate host is first macerated and the larval anisakids it contains are first exposed to thermal and chemical stimuli is worthy of note. It is also possible local differences in immunological response are responsible.

which appeared to be contracted to such an extent that the pyloric rugae, usually small and sparse, were large and abundant in this individual. Perhaps this was an artifact of preservation during rigor, or perhaps pyloric spasms associated with parasitism or pathologic processes were involved (Jubb and Kennedy, 1970). The gastric mucosa of this animal was otherwise unremarkable, and both anisakids (some) and diphyllobothriids (moderate) were found in the stomach.

C. Discussion.

P. C. Young and D. Lowe (1969) have presented an excellent review of observations of gastric lesions in marine mammals and their possible implications. The high frequency and abundance of anisakids in the stomachs of marine mammals throughout the world makes it rather surprising that these parasites can and apparently often do cause serious harm in their hosts. Although the regenerative capacity of the gastric mucosa is remarkable, the frequency with which lesions are encountered in even adult animals implies that anisakids could be a constant debilitating factor throughout the life of the mammal. The host can mount an inflammatory response to the embedded anisakid, as evinced by the character of the crater-like lesions, and there is evidence that an immunologic response is attempted as well (Young and Lowe, 1969; Wilson and Stockdale, 1970; Lui and Edward, 1971) but it is difficult to effectively deal with a parasite of this size. Feltz (1967) has suggested a unique method whereby the mammal may rid itself of anisakids by direct regurgitation and expulsion, although it is hard to imagine how anisakids with their heads embedded in the mucosa (which are often immature forms) might be expelled in this way. However, it is very possible that heavy anisakid infestations and their associated lesions are only periodic phenomena occurring at certain times of the year when particular intermediate hosts constitute the primary food source (Delyamure and Popov, 1974; see also report 3). It seems unlikely that severe ulcerative lesions and perforations are more than a rare occurrence in marine mammals, but the problem clearly should be more thoroughly investigated.

Also remaining to be investigated is the generic identity and maturity of the individual anisakids apparently causing the lesions. In a study of *Halichoreus grypus* and *Phocoena phocoena*, Young and Lowe (1970) made a number of interesting observations concerning both the gastric lesions and the anisakids found in them. First, they observed that anisakids of either the genus *Anisakis* or the genus *Contracaecum*, but never both together, were clumped at lesion sites. Second, although both genera caused similar crater-like lesions, *Anisakis* did so only in juvenile hosts. Pathological differences were also noted in laboratory rats infected with larvae of these marine mammal anisakids. Third, clumps of embedded parasites (hence lesions?) nearly always consisted of immature anisakids, while adult anisakids were invariably found embedded singly anywhere on the gastric mucosa (a situation noted also in this report and excluded from the definition of "lesions") or lying free in the lumen. It is even possible that the crater-like lesions are the result of an inflammatory or immunologic response to the immature forms lumen with a height at or somewhat above that of the normal rugae. Anisakids were initially found with their anterior ends embedded in the crater summit in two of the four lesions, however nearly all had become detached upon later examination. When the nematodes were not obstructing the summit, it became evident that a depression (ranging from shallow and irregular erosions to a deep, narrow pits or slits) was situated there at the central summit of the crater. The craters seen in this study are macroscopically identical to those described by previous workers (Vik, 1964; Young and Lowe, 1969; Wilson and Stockdale, 1970; Lui and Edward, 1971). In all cases the crater-like lesions were located within 5 to 19 cm of the cardia (i.e. within the anterior third of the stomach), an area with abundant rugae and epithelium of the fundic type (Simpson and Garder, 1972; Eastman and Coalson, 1974). These crater-like lesions were encountered in the stomachs of 1 *E. barbatus* and 4 *P. hispida* (see Table XV).

Third in apparent seriousness were medium and small slits, depressions, or erosions in the mucosa. These were similar in central appearance to the crater-like ulcers described above, but did not seem to penetrate the submucosa. Although in nearly all cases the erosions occurred on the tops of rugae (or perhaps they were only more noticeable when located there?) there was not the marked hemispherical swelling associated with these erosive lesions as with the crater-like ulcerative lesions. Perhaps the erosions are merely an earlier less inflammatory stage of the crater lesions. Like the craters, the erosions occurred exclusively in the cardiac or anterior fundic parts of the stomach.* Numbers of erosions per stomach ranged from 1 to 15, usually widely scattered. Although probably initially present in all of the erosions, from 4 to 50 anisakids were found with anterior ends clumped together in the erosions in the only 2 of the 6 stomachs which were not washed out in the course of the food habits study: the *Eum. jubata* (CJL-54-60) and the *D. leucas* (KAN-20). The remaining 4 animals with erosions were 3 *E. barbatus* and 1 *P.v. largha* (see Table XV).

The fourth and least in apparent seriousness of the gastric lesions were unusual densities of the (commonly occurring) small focal pits associated with individual anisakids. In these two cases, both *E. barbatus* stomachs (GAM-19-75 and WS-14-75), approximately 30 of 50 of these tiny pits were scattered together in the cardiac area (i.e. approximately 50 cm^2) with a local density not encountered in other stomachs (see Table XV).

In another unusual case, the wall of the pyloric canal of an adult female *E. barbatus* (WS-45-75) was markedly thickened or contracted. While the pyloric wall thickness of other preserved *E. barbatus* stomachs ranged from 10 to 15 mm (mucosa: 3-5 mm, submucosa and muscularis: 7 to 10 mm), in this individual it was 22 mm (mucosa: 5 mm, submucosa and muscularis: 17 mm). Most of the thickness involved the muscularis,

*Precise locations not known for the *Eum. jubata* (CJL-54-60) and *Delph. leucas* (KAN-20) lesions, as described previously.

OCS No.	Species E. barbatus	P. hispida	Other	Anisakids Present	Mucosal Lesions Total	Location	Description
WS-54-75	X			Modr.	Ø		
WS-55-75		X		Few	Ø		
WS-58-75	X			Modr.	Ø		
WS-59-75	X			Modr.	3	Cardiac	Small craters 5 mm dia.
WS-60-75		X		None	Ø		
WS-61-75		X		Few	Ø		
WS-62-75			P.v.l.	Few	Ø		

Wainwright 1975 Total: 25 *E. barbatus*, 19 *P. hispida*, 3 *P.v. largha*

B. Marine Mammals, Collected 1960 & 1962.

KWK-138	*Enhydra lutris*	Modr.	Ø		
Amchitka 1962					
CJL-54	*Eum. jubata*	(Some)	3	?	Small lesions where anisakids attached in clumps
Juneau 1960					
KAN-20	*Delph. leucas*	Abun.	2	?	Small lesions where anisakids attached in clumps
Kvichak Rvr. 1960					

Table XV. Summary of gastric mucosal lesions.

Collection Location	Animals Examined: Species* E.b.	P.h.	P.v.l.	Total Seals	Seals With	Animals With Lesions: OCS No.	Affected Individual Species E.b.	P.h.	P.v.l.	Gastric Anisakids	Lesion: Total No.	Diameter (mm)	Description & Distance From Cardia
A. *Phocids*, 1975 & 1976													
Barrow	-	9	-	9	1	BS-3-75		X		Few	4	12-15	Crater 13 to 19 cm post
Diomede	-	14	-	14	∅	-							
Gambell	2	1	-	3	1	GAM-19-75	X			Abun.	50	1-2	Tiny pits throughout cardiac area.
Mekoryuk	4	1	-	5	∅	-							
Point Hope	-	2	-	2	2	PHS-15-76		X		Few	4	10-15	Craters 6 to 12 cm post
						PHS-25-76		X		Some	3	8-15	Craters 7, 9 & 15 cm posterior.
Savoonga	2	-	-	2	1	SS-206-75	X			Modr.	1	8x20	Perforation 15 cm post.
Wainwright	25	19	3	47	8	WS-14-75	X			Abun.	30	1-2	Tiny pits throughout cardiac area.
						WS-21-75			X	Few	3	3	Punctiform depressions cardiac area.
						WS-33-75	X			Modr.	5	3	Small slit erosions 9-15 cm posterior.
						WS-37-75	X			Some	2	3	Small slit erosions cardiac area.
						WS-38-75	X			None	3	2	Small depressions in cardiac - fundus.
						WS-43-75		X		Few	2	8	Craters 11 & 13 cm post
						WS-45-75	X			Some	-	-	Pyloric muscularis thickened.
						WS-49-75	X			Modr.	3	5	Small craters 5 cm post
Subtotal:	33	46	3	82	13	-	8	4	1				
B. Other Marine Mammals 1960 & 1962													
Amchitka	*En. lutris*			1	∅	KWK62-138							
Juneau	*Eum. jubata*			1	1	CJL54-60				?	3	3,10	Erosions with clumped anisakids
Kvichak R.	*D. leucas*			1	1	KAN-20				Abun.	2	8,15	Erosions with clumped anisakids

Total: 85 Examined 15 with gastric mucosal lesions.

*Species examined: *E.b.* = *Erignathus barbatus* *P.v.l.* = *Phoca vitulina largha* *P.h.* = *Pusa hispida*

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Quarterly Report

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Research Unit #231
Reporting Period - 1 July 1976-
30 Sept. 1976

Number of pages: 1

An Aerial Census of Spotted Seals, *Phoca vitulina largha*

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30 September 1976

I. Task Objectives

This project is primarily addressed to OCSEAP Task A-2; Determination of the seasonal density and distribution of spotted seals, Phoca vitulina largha, in the ice front of eastern Bering Sea. During late winter and early spring, this seal occurs in considerable numbers, within the proposed Bristol Bay, St. George Basin and Navarin Basin lease areas.

Task A-1 is also an integral part of this project. This task is the summarization and evaluation of existing literature and unpublished data on distribution and abundance of spotted seals.

II. Field and Laboratory Activities

All of the field activities required for the completion of this project were conducted during March and April. Since that time, we have completed transcription and keypunching of all data in preparation for analysis and final report submission. A description of methods used and data collected were given in our previous quarterly report.

III and IV. Results and Interpretation

All data collected have been transcribed from field record forms to computer forms. These forms have been keypunched and verified. Due to unavoidable delays in the computer system we have been using, printouts of analyzed data are only now becoming available. We anticipate that all data will be analyzed and the final report prepared and submitted by 1 December 1976.

V. Problems Encountered

Delay in computer processing of data has prevented compilation and interpretation of results and will preclude the final report for this project being submitted by the scheduled date. This problem has been rectified and we are proceeding with data analysis and interpretation as rapidly as possible.

VI. Estimate of Funds Expended to Date

Science*	-	$ 8,000.00
Logistics	-	$35,000.00
Total	-	$43,000.00

*Does not include salaries.

Quarterly Report

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Trophic Relationships Among Ice Inhabiting Phocid Seals

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30 September 1976

I. Task Objectives

The investigation of trophic relationships among ice inhabiting phocids is addressed to the following task objectives:

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 seal species being studied throughout their geographic range and during all times of year. The contents of seal stomachs are 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 involves 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.

With the understanding thus obtained of the trophic interrelationships of ice inhabiting phocids in the Bering-Chukchi and Beaufort marine systems, we will 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 influence on populations of competitors for food resources.

II. Field and Laboratory Activities

Late spring and early summer is one of the most active periods of hunting in Alaskan coastal villages. Consequently, it is also a time of extensive field collection of specimen materials.

During the sixth quarter collection efforts were made at the coastal villages of Nome, Shishmaref, Wainwright, Barter Island and Barrow. The OSS DISCOVERER was utilized for acquisition of seal stomach samples and invertebrate and fish reference material in Norton and Kotzebue Sounds, the northern Bering Sea and the Chukchi Sea. A similar collection attempt was undertaken from the USCGC GLACIER in the Beaufort Sea. See Figure 1 for location of field collection sites.

Sixth quarter laboratory activities focused on continued processing of stomach samples. Considerable effort was expended on the development of reference collections of otoliths, skeletal parts and preopercular bones from fishes of the family Cottidae.

Data management progressed without major problems. Upon completion of laboratory analysis of specimens, data was transcribed, keypunched and transferred to magnetic tape for submission to NODC.

Table 1 provides a listing of field and laboratory activities for the sixth quarter. Dates and personnel are included.

Methods

Field collection procedures at coastal hunting villages and methods for laboratory analyses of specimen material are described in the annual and fifth quarterly reports for RU #232. Seals were collected from the OSS DISCOVERER and the USCGC GLACIER, and otter trawls for fish and invertebrates conducted as described below.

The DISCOVERER and GLACIER cruises were utilized to collect seals for investigation of food habits, parasitology and natural history (RU #s 230, 232 and 194). Hunting was done in the ice from small boats. Animals were shot in the water, taken to the ship and processed as described in previous reports.

Bottom sampling of fishes and invertebrates was done on both cruises. Trawls were conducted with 19 foot Marinovich otter trawls (3/4" stretch mesh, 1/4" mesh cod end liner) for 10 to 20 minutes duration at a ships speed of 2-4 knots. Contents of each trawl were identified, enumerated and representative specimens of organisms retained. Examples of selected invertebrate species were measured and weighed to provide an index of length/weight ratios that could be applied to partially digested food items found in seal stomachs. Fishes from trawl samples were measured and weighed. Otoliths were removed and measured for correlations of otolith size to the size of fishes from which they were obtained. Some fishes were preserved as reference specimens and some were frozen to provide skeletal parts for comparative identification purposes.

Data Collected or Analyzed

Table 2 summarizes the results of our collection efforts from 15 June to 20 September 1976. A total of 195 stomachs was collected. Five of these were from Norton Sound, 173 from the Hope Basin, 10 from the northern Chukchi Sea and 7 from the Beaufort Sea. Ringed seals from

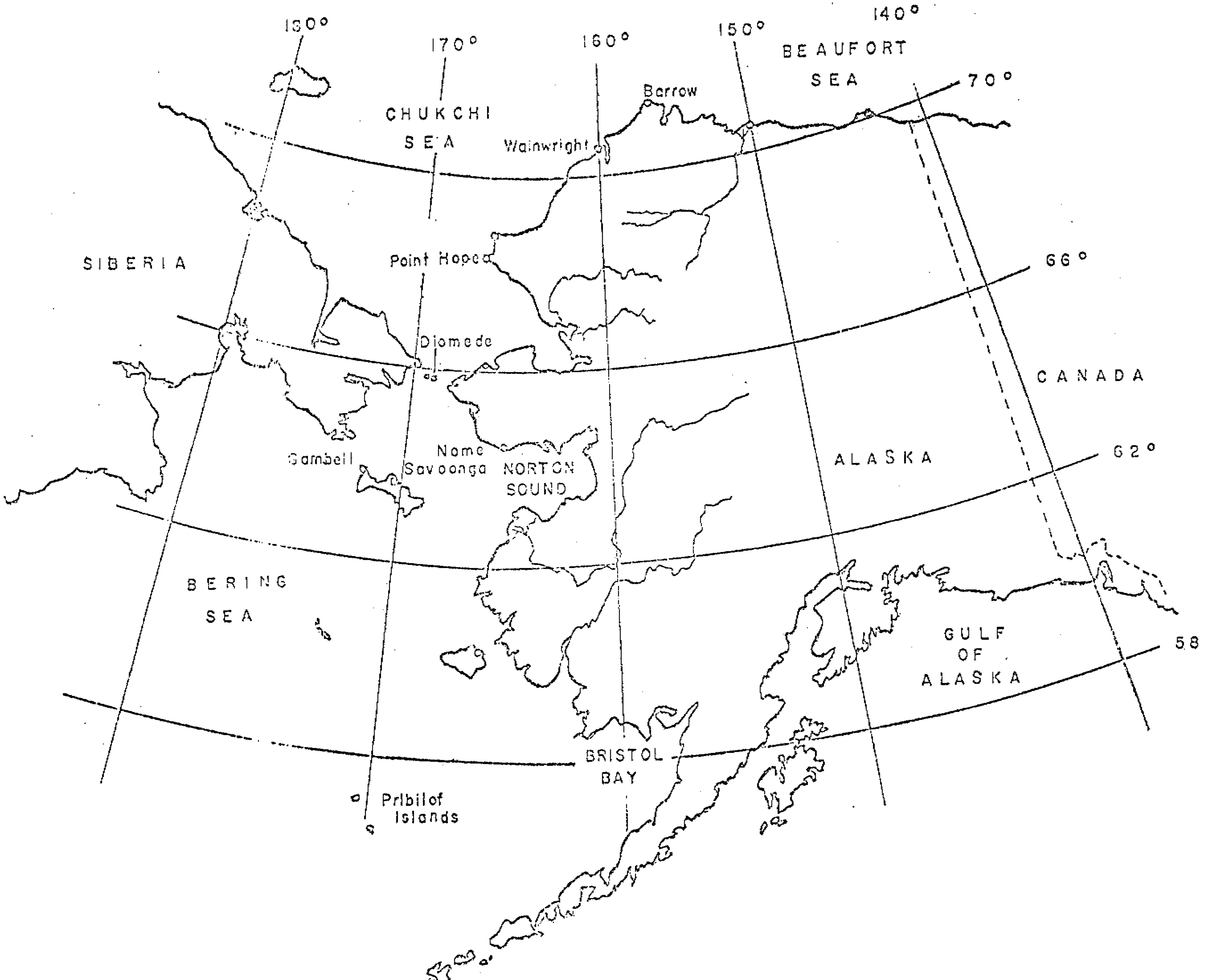
180°
170°
160°
150°
140°
BEAUFORT
SEA
70°
Barrow
CHUKCHI
SEA
Wainwright
SIBERIA
Point Hope
66°
Diomede
CANADA
Gambell
Nome
Savoonga
NORTON
SOUND
ALASKA
62°
BERING
SEA
GULF
OF
ALASKA
58°
BRISTOL
BAY
Pribilof
Islands

Table 1. Field and laboratory activities from 15 June - 30 September 1976.

Activity	Dates	Personnel
Specimen collection at Nome, Norton Sound	11-21 June	L. Lowry, K. Frost
Specimen collection at Shishmaref	22 June-15 July	G. Seaman
Specimen collection at Wainwright	22 July-1 August	J. Burns
Specimen collection at Barter Island	20 July-3 August	G. Seaman
Specimen collection at Barrow	2-10 August	L. Lowry, T. Eley
Bering Sea/Chukchi Sea cruise on NOAA OSS DISCOVERER - collection of seal specimen material at ice edge in Chukchi Sea and otter trawls for invertebrate and fish reference material and assessment of food availability	17 August-3 Sept.	K. Frost, D. James
Beaufort Sea cruise on USCGC GLACIER-collection of seal specimen material and otter trawls	17 August - 3 Sept.	L. Lowry, G. Seaman
Laboratory processing of specimen material - seal stomachs, invertebrate and fish material identifications, reference collections	Intermittent	K. Frost, L. Lowry, G. Seaman
Data management - transcription keypunching and taping of data	Continuous	L. Vaughan, K. Frost
Compilation and analysis of data	Intermittent	L. Lowry, K. Frost
Preparation of Quarterly Report	23 August-15 Sept.	L. Lowry, K. Frost, J. Burns

Shishmaref (in the Hope Basin) made up the largest sample of 124 stomachs. An additional 7 ringed seals were taken in the Beaufort and Chukchi Seas. The largest bearded seal sample, 44 stomachs, was also from Shishmaref. Five bearded seals were taken in Norton Sound, 8 in the northern Chukchi Sea and 2 in the Beaufort Sea.

Table 2. Seal stomachs collected during the period 15 June to 20 September 1976. Not all stomachs contained food.

Location	Phoca (Pusa) hispida	Erignathus barbatus	Phoca vitulina largha
Nome	-	5	-
Shishmaref	124	44	5
Barter Island	1	1	-
Wainwright	-	7	-
Barrow	3	1	-
Northern Chukchi Sea (OSS DISCOVERER)	2	1	-
Beaufort Sea (USCGC GLACIER)	1	-	-
Totals	131	59	5

A total of 22 otter trawls were conducted during the sixth quarter. Five of these were in Norton Sound, 4 around St. Lawrence Island, 4 in the Hope Basin area, 7 in the northern Chukchi Sea and 2 in the Beaufort Sea. Representatives of over 60 invertebrate species and 30 fish species were identified. Otoliths were collected from 18 species of fishes.

In addition to the extensive field work of the sixth quarter, 50 stomach samples were processed in the laboratory. The entire sample of ringed seals obtained at Pt. Hope in May 1976 was analyzed. Miscellaneous ringed and bearded seal specimens from Nome, Gambell and Savoonga were also processed.

III. Results

Results of the analysis of food habits of ringed and bearded seals from Barrow, Barter Island and the USCGC GLACIER cruise in the Beaufort Sea will appear in a separate final report of Beaufort Sea activities.

Bearded Seals

Two small collections of bearded seal stomachs were examined; 4 from Gambell and 5 from Nome (Table 3). Food items from the two areas were similar, but relative importance of items in the diet differed greatly.

Table 3. Food items identified from 9 bearded seal stomachs taken at Gambell and Nome. Data are expressed in part A as the percent of the total volume of contents comprised of each species or group and frequency of occurrence. Part B indicates the species composition of fishes expressed as a percentage of total number of fishes identified and the frequency of occurrence.

Food Species	Gambell May 14 - 28, 1976 N = 4 % Vol/#	Gambell % Freq	Nome June 3 - 19, 1976 N = 5 % Vol/#	Nome % Freq
A. Amphipods Total	1.5	100	*	20
Shrimp Total	31.3	100	10.2	100
Sclerocrangon boreas	15.2	50	*	20
Argis crassa	8.6	50		
A. lar	6.5	100	7.3	80
Crangon dalli			2.1	80
Other shrimp	1.0	50	0.7	100
Brachyuran Crabs Total	24.3	100	*	40
Hyas coarctatus	22.4	100		
Chionocetes sp.	1.8	50	*	20
Bivalve Molluscs Total	6.3	50	87.2	80
Serripes sp.	6.1	25	86.5	80
Other bivalves	0.2	50	*	20
Other Invertebrates Total	17.6	100	1.2	40
Invertebrates Total	81.0	100	98.6	100
Fishes Total	17.9	50	1.3	60
B. *Eleginus gracilus*			28.5	20
Enophrys diceraus	68.4	25	57.1	40
Gymnocanthus sp.	7.9	25		
Myoxocephalus sp.	18.4	50		
Artediellus sp.	2.6	25		
Family Cottidae			14.2	20
Family Cryptocanthodidae	2.6	25		
Total number of individual fishes identified	38		7	
Mean volume contents (ml)	280.3		852.5	

* Indicates food species which constitute less than 1% of the total volume

[1] Frequency of occurrence = $\frac{\text{number of times taxon found}}{\text{number of stomachs examined}} \times 100$

Bearded seals from Gambell fed largely on decapod crustaceans. Shrimps, primarily Sclerocrangon boreas, Argis lar and Argis crassa, comprised over 30 percent of the food material, and brachyuran crabs, mostly Hyas coarctatus, 24 percent. Serripes groenlandicus, a bivalve mollusc, accounted for just over 6 percent of the food volume. Fish also were eaten in substantial quantities. Eighteen percent of the total food volume was comprised of four species of cottids and a cryptocanthodid. Enophrys diceraus, Myoxocephalus sp. and Gymnocanthus sp. were the fish species most commonly eaten.

Bearded seals from Nome exhibited a very different diet. Fish made up less than 2 percent of the total food volume. Of the 98.6 percent invertebrate material, 86.5 percent was the bivalve Serripes groenlandicus. Shrimp, primarily Argis lar and Crangon dalli, made up the remaining 10.2 percent. Fish species represented were the gadid Eleginus gracilus and the cottid Enophrys diceraus. The mean volume of contents (852.5 ml) was the highest of all the samples we have analyzed to date.

Ringed Seals

Four different locations were represented in the ringed seal collections examined during the past quarter (Table 4). The collection from Point Hope was the largest, consisting of 33 stomachs. Forty-four percent of the identified contents was invertebrates, primarily crustaceans. Amphipods (mainly Ampelisca spp.) accounted for 20.3 percent of the total volume, shrimp (Pandalus goniurus, Eualus gaimardii, Argis lar and Sclerocrangon boreas) comprised 13.2 percent and euphausiids (Thysanoessa spp.) 3.2 percent. Fish made up the remaining 55.6 percent of the stomach contents. One hundred and fifty-three individual fishes were identified. Boreogadus saida was by far the most common; 63.4 percent of the total number. Next in importance were Ammodytes hexapterus (22.2%) and members of the family cottidae (7.9%).

The 2 stomachs examined from Nome contained 15.8 percent invertebrates and 84.1 percent fishes. The invertebrates were mostly the shrimps Pandalus goniurus and Pandalus hypsinotus. Of the fishes, Pungitius pungitius, a stickleback present in both stomachs, made up 94.2 percent of total volume of fishes. In addition a cottid and several Eleginus were identified.

At Gambell and Savoonga, on St. Lawrence Island, virtually 100 percent of the volume of ringed seal stomach contents was invertebrates. At Savoonga mysids (Mysis litoralis) were the most prevalent prey item, comprising 78.7 percent of the total contents. In addition amphipods (mostly Parathemisto libellula) and shrimp (Lebbeus polaris) were found in notable amounts (13.4% and 7.8%, respectively). A single ringed seal from Gambell had eaten the amphipods Anonyx nugax (86.4%), Ampelisca spp. (5%) and Acanthostepheia sp. (4.1%). A small amount (3.6%) of the shrimp Eualus gaimardii had also been eaten.

Table 4. Food items identified from 40 ringed seal stomachs taken at four locations. Data are expressed in the same manner as in Table 3.

Food Species	Nome May 1975 N = 2		Savoonga Feb29-Mar27'76 N = 4		Gambell May 14'76 N = 1		Point Hope Mar7-May27'76 N = 33	
	%Vol/#	%Freq	%Vol/#	%Freq	%Vol/#	%Freq	%Vol/#	%Freq
A. Amphipods Total			13.4	100	96.4	100	20.3	57.6
<u>Parathemisto libellula</u>			11.3	75				
<u>Anonyx nugax</u>			*	100	86.4	100	*	27.3
<u>Ampelisca</u> spp.			*	50	5.0	100	20.0	48.5
<u>Acanthostepheia</u> sp.					4.1	100		
Other amphipods			*	25	*	100	*	12.1
Euphausiids Total							3.2	30.3
<u>Thysanoessa</u> spp.							3.1	24.2
Mysids Total	1.0	100	78.7	100			*	42.4
<u>Mysis litoralis</u>			78.7	100			*	12.1
<u>Neomysis rayi</u>	1.0	100					*	30.3
Shrimp Total	13.7	100	7.8	75	3.6	100	13.2	57.6
<u>Pandalus goniurus</u>	3.8	50					1.2	12.1
<u>P. hypsinotus</u>	9.2	50						
<u>Eualus gaimardii</u>					3.6	100	1.0	27.3
<u>Lebbeus polaris</u>			7.1	25				
<u>Argis lar</u>	*	50					5.3	45.4
<u>Sclerocrangon boreas</u>							2.0	21.2
Other shrimp	*	50	0.7	50			3.7	24.2
Echiuroids Total	1.2	50					1.8	3.0
<u>Echiurus echiurus</u>	1.2	50					1.8	3.0
Other Invertebrates							5.9	21.2
Invertebrates Total	15.8	100			100	100	44.4	93.9
Fishes Total	84.1	100	*	25			55.6	72.7
B. <u>Pungitius pungitius</u>	94.2	100						
<u>Eleginus gracilus</u>	5.0	50					4.6	6.1
<u>Boreogadus saida</u>							63.4	33.3
<u>Ammodytes hexapterus</u>							22.2	30.3
<u>Lumpenus</u> sp.							1.3	3.0
Family Cottidae	0.8	50					7.9	21.2
Total number fishes identified	121		0		0		153	
Mean volume contents (ml)	184.4		71.8		44.0		57.7	

IV. Discussion of Results

Bearded Seals

Analyses of the stomach contents of bearded seals collected at both Gambell and Nome reiterated results of earlier analyses of bearded seal collections from various locations. These seals appear to be mainly dependent on a benthic food web. They feed extensively on sedentary benthos, epibenthic crustaceans and demersal fishes.

Bearded seals collected near Gambell in May 1976 had consumed large volumes of crustaceans, primarily crangonid shrimps and the spider crab *Hyas coarctatus*. Few molluscs had been eaten. A substantial amount of fish, 18 percent of the total volume of stomach contents, was eaten. These fish were all members of the bottom dwelling family Cottidae. Genera represented were *Enophrys*, *Gymnocanthus*, *Myoxocephalus* and *Artediellus*.

Results of the analyses of four seals taken at this location in May 1976 compare closely with those from two seals obtained at the same location in May 1975. In these earlier specimens crustaceans, primarily crangonid shrimps and *Hyas*, also made up a large proportion (almost 80%) of the total food volume. Fishes also accounted for about 20 percent of the food volume. *Gymnocanthus* and *Myoxocephalus* were the two genera represented.

Stomachs from bearded seals taken near Savoonga and previously reported upon (annual and fifth quarterly reports for RU #232) reflect the same general pattern of prey selection. Crustaceans comprise almost 70 percent of the total diet, the bivalve *Serripes* 10 percent, and fishes, primarily cottids, about 15 percent.

Bearded seals taken near Nome in June 1976 differed substantially from Gambell and Savoonga specimens. Whereas seals taken near Gambell and Savoonga consumed about 80 percent crustaceans and 20 percent fish, seals in the Nome area (Norton Sound) consumed only 10 percent shrimp and less than 2 percent fish. However, the bivalve *Serripes groenlandicus* was consumed in large quantities (86.5%). In almost all cases only the foot portion of the clam was eaten. Occasionally siphons and pieces of mantle were found.

A collection of bearded seals from Nome taken during May-June 1970-75 (reported in the fifth quarterly report) showed the same general trend: a diet of bivalves, mostly *Serripes*, and lesser amounts of epibenthic crustaceans, mostly the shrimp *Argis lar*. However, among these 5 seals, *Serripes* accounted for only 39 percent of the food volume and the proportion of shrimp was 22 percent. In addition, some hermit crabs (5% of volume of the stomach contents) were consumed. Such differences may be attributable to different collection sites with different bottom conditions, and therefore different local abundance of bivalves and shrimps.

Stomach contents of two other bearded seals from Nome, taken in November 1969, were analyzed. They provide the only fall data from this area. Prey species were almost exclusively crustaceans (98%). Shrimps, both crangonids and pandalids, comprised the largest volume (85%) and an anomuran crab Haplogaster grebnitzkii most of the remainder (13%).

Calculation of mean volume of stomach contents for all Nome stomachs suggests that seals feeding on clams consume larger volumes of food than do those eating other items. Six of the 12 stomachs contained clams (48%-96%); the mean volume of total contents for those 6 was 842 ml. Mean volume for the stomachs that did not contain clams was 121 ml.

Clams, when they occur in an area, are probably present in concentrated beds providing a large supply of readily available food to the seals. In the absence of these clam beds there is very probably much more picking and choosing occurring; selection for shrimps and crabs occurs amidst sponges, tunicates, anemones and other less frequently eaten benthos.

The variety of benthic and epibenthic organisms occurring in the diet and the apparent spatial variability in relative importance of major food items might lead to the conclusion that bearded seals are non-selective feeders. However, comparison of bottom trawls conducted in the St. Lawrence Island area during August 1976 with a list of prey items from bearded seals taken off Gambell and Savoonga suggests selectivity for food types. The predominant species collected in the trawls were sponges, the solitary tunicate Boltenia, other colonial tunicates, and echinoderms (urchins, sand dollars, sea stars and brittle stars). Spider crabs, Hyas coarctatus and Chionoecetes opilio, shrimps (especially Argis lar, Eualus spp. and Lebbeus spp.) and fishes (stichaeids, cottids, zoarcids and liparids) were found in smaller amounts and numbers. These latter groups comprise most of the diet of seals collected in the area. Selection of crustaceans and bivalves in lieu of more common species is perhaps due to their high food value and to the low food value of sponges, tunicates and echinoderms. Sponges and tunicates are occasionally eaten in more than incidental amounts, but this is not a common occurrence.

Trawls in the Nome/Norton Sound area produced large numbers of sea urchins, sea stars and ophiuroids. In addition crangonid shrimps, spider crabs, gastropods and fish (cottids, pleuronectids and stichaeids) were caught. Once again, bearded seals in the area appeared to be feeding selectively not on the echinoderms, but on the apparently less abundant shrimps and on bivalves, the latter not sampled at all by trawls.

Alton (1974) pointed out the importance of considering benthos utilized as food as opposed to total benthos when evaluating the availability of food to demersal fish populations. Such a distinction is also relevant to availability of food to bearded seals. Although the Chirikov Basin (largely included in the proposed Norton Basin lease area) has the highest biomass of benthos of the entire Bering Sea platform (Alton loc. cit.), most of the organisms appear to be unsuitable food for bearded seals. In evaluating critical feeding areas it will be necessary to know the standing stock of suitable foods available. It appears that two faunal assemblages may be important; patches of the clams Serripes groenlandicus and Clinocardium ciliatum and areas of concentrated shrimp and crab populations. The discreteness (if any) and spatial extent of these faunal groupings merit study.

Ringed Seals

Ringed seals from the Nome area follow the general pattern apparent at other locations; they feed on nektonic and benthic crustaceans, especially pandalid shrimps, and various fishes.

Results from four stomachs obtained in May 1975 (2 analyzed this quarter and 2 the previous quarter) show an "average" diet of 37 percent pandalid shrimps and 58 percent fishes. There was, however, great variability among individuals. Two seals ate entirely fishes: one the fresh or brackish water stickleback Pungitius pungitius (not previously recorded from ringed seal stomachs) and the other Eleginus and Osmerus. A third seal ate a mixture of 80 percent shrimps and 20 percent cottids and the fourth consumed 50 percent shrimp in combination with Pungitius and Eleginus. One additional seal also collected in May (1971) fed entirely upon pandalid shrimps.

Ringed seals collected during mid-winter had a much different diet. The contents of 4 stomachs obtained during February (1971 and 1972) consisted entirely of polar cod (Boreogadus saida). Additional winter stomach specimens and more information regarding the seasonal distribution of Boreogadus in Norton Sound is needed to evaluate the significance of this difference.

Only 2 stomachs from Gambell ringed seals have been examined. Both were collected in May, one in 1975 and the other in 1976. Neither stomach contained notable quantities of fish. Instead the diet of both seals was comprised of crustaceans. Species composition of the two was, however, quite different. The May 1976 specimen contained almost entirely amphipods, primarily Anonyx nugax (86.4%), whereas the May 1975 specimen included over 70 percent shrimp, Spirontocaris spp. and Argis lar, and 20 percent amphipods, mostly Rhachotropis sp.

Four specimens from Savoonga collected in late February and March of 1976 were also examined. Crustaceans comprised 100 percent of the diet. In this case Mysis litoralis was the dominant food item (78.7%). The hyperiid amphipod Parathemisto libellula and the shrimp Lebbeus polaris were also important (11.3% and 7.1% respectively). As evidenced in the Nome sample, there was considerable variation among the Savoonga specimens. Two animals had fed almost entirely on Mysis, the third on Parathemisto and the fourth on Lebbeus.

Crustaceans appear to be a preferred food item among ringed seals, but the particular species eaten at any one time is probably entirely dependent on local distribution and abundance.

The spring sample of ringed seals from Pt. Hope is interesting for a number of reasons: it is one of the largest samples of ringed seal stomachs analyzed by us to date, and the food habits of seals from this area have been previously reported on by Johnson et al. (1966) and thus some basis for comparison of results exists.

If the entire March-May collection is treated as a single sample it appears that the seals eat an almost equal mixture of crustaceans and fishes. The predominant crustaceans were amphipods (primarily Ampelisca spp.) and a combination of shrimps, especially the crangonids Argis lar and Sclerocrangon boreas. Boreogadus was the species of fish most commonly eaten. Ammodytes hexapterus (sandlance) was also common. Eleginus was found in only small numbers as were members of the family Cottidae.

If this sample is broken down by month a somewhat different pattern is evident. Thirteen stomachs were collected during April. Seventy-five percent of the contents was fish, mostly Boreogadus (78% of the individuals identified), with smaller amounts of Ammodytes, Eleginus and cottids present. Most of the importance of fish, however, was attributable to a single stomach containing 850 ml of Boreogadus. Without this stomach, the percent of fish in the remaining 11 stomachs drops to 34 percent, a figure comparable to that reported by Johnson et al. for the month of April 1961 (40%, n=119). Their investigations found that in general, the stomachs of animals feeding on cod contained larger volumes than those of animals feeding on invertebrates. This also appears to be the case for our sample; the one stomach which contained large numbers of Boreogadus had a contents volume of 850 ml whereas the average volume for the remaining 12 stomachs was 43 ml.

The invertebrate fraction of our April sample was made up mostly of Ampelisca. In addition, shrimps were present in notable amounts, as was Echiurus. Johnson et al. reported similar findings for April 1961. Amphipods, once again Ampelisca, were important, as were shrimps. Echiurus was found in trace amounts.

May ringed seals from Pt. Hope show a predominance of crustaceans in their diet. The 19 stomachs we collected during May contained 94.5 percent invertebrates, 32 percent of which was Ampelisca and another 41 percent shrimp. Most of the shrimp belonged to the family Crangonidae. In addition, euphausiids made up about 11 percent of the food volume and mysids 3 percent. Many of the stomachs contained very small volumes of food - mean volume for the 19 stomachs was 27.9 ml.

Once again Johnson et al. reported similar results. Invertebrates accounted for 84 percent of the total diet of the 100 seals they examined from May 1961. Crangonid shrimps, mysids, amphipods and euphausiids, in that order of abundance, were the predominant food items. Echiurus was present in small amounts (4.5%). The principal difference in the two samples appears to be the abundance of mysids in the 1961 stomachs. Year to year differences in climate, ice conditions, etc. may well affect local abundance of such species, and thus their availability as seal food.

Fish made up a minor portion of the diets of seals from the Point Hope area during both May samples. Only 30 fishes were identified from 19 stomachs in the 1976 sample. Most of these were Ammodytes hexapterus, a species which Johnson et al. found to be present throughout the year, but of greater importance in the spring. Fish identified in the 1961 stomachs were mostly cottids.

Potential Effects of Petroleum Development

The potential effects of petroleum development on seal populations are multiple. This project is primarily concerned with effects which might be mediated through the trophic structure of the areas under consideration. The following general considerations are involved:

1. Incorporation and potential accumulation of petrochemicals in food webs and the direct effects of ingestion of the compounds by seals.
2. Effects of petrochemicals on availability and suitability of various food items in light of observed importance in the diet.
3. Resultant effects of 1 and 2 above on the physiological conditions of animals and their ability to respond to normal and abnormal environmental stresses.

A detailed evaluation of these potential effects would be premature at this point. However, it seems appropriate to mention some pertinent results of recent studies.

Conover (1971) has demonstrated that copepods ingest oil particles. Most of the oil apparently passed through the animals with little effect. However, it could remain in the food chain both by direct passage to planktivores and ingestion of feces by detritus feeders. Scarratt and Zitko (1972) noted that bunker C oil persisted in sediments and benthic organisms with little reduction in concentration for over two years after an initial spill. They found no evidence for concentration in the food chain. Smith and Geraci (1975) investigated short-term effects of oil ingestion both on ringed seals in the laboratory and harp seals in the field. Results indicated minor damage to kidneys and liver. Longer term studies are obviously needed.

The effect of hydrocarbon pollution on prey species utilized by seals is a major and difficult question. An excellent discussion of the problem is given in Percy and Mullin (1975). In dealing with invertebrates and fishes, it is crucial to evaluate the tolerance limits of the most sensitive life history stage. Larval stages of bivalves and crustaceans appear quite sensitive to water soluble fractions of crude oils (Wells and Sprague 1975, Renzoni 1975). Some recent documentation is available which indicates that oil pollution may cause reduced survival and productivity of bivalves (Dow 1975) and impairment of molting in crabs (Karinen and Rice 1974). Struhsaker et al. (1974) noted some reduction in survival of eggs and larvae of anchovy and herring exposed to benzene and Percy and Mullin (1975) found fry of *Myoxocephalus quadricornis* to be extremely sensitive to crude oil dispersions. The tendency for suppression of larval stages in arctic and subarctic invertebrates (Thorson 1936) and fishes (Marshall 1953) may function to reduce exposure of sensitive life history stages, however this may be more than compensated for by difficulty of recolonization (Chia 1970) and low productivity (Dunbar 1970).

In an evaluation of the effects of crude oil on ringed seals, Smith and Geraci (1975) noted that seals exposed to oil in the laboratory perished very rapidly while animals similarly treated in the field showed relatively little discomfort. They hypothesized that the additional stress imposed on laboratory animals may have compounded the effects of the oil. A reduction in availability or suitability of preferred food could potentially stress animals in the field and aggravate direct effects of oil in the natural environment. Thus, it is most important to know not only what prey items are most important to seals, but also, as exactly as possible, what the effects of oil development may be on these species.

V. Problems Encountered/Recommended Changes

As expected, we were quite successful in obtaining specimen material from coastal villages during the past quarter. Field collection attempts in the Beaufort Sea continued to be largely unproductive due to lack of hunting activity in villages and poor weather. A considerable expenditure of time and money would be necessary to adequately sample this area. Due to funding limitations, laboratory personnel have been required to spend substantial amounts of time in the field. As a result of the exceptionally large collection of material from Shishmaref, a considerable backlog of specimen material is now on hand. We anticipate continuing extensive field activities throughout the next year, therefore it seems reasonable to expect that backlog of laboratory processing will increase.

Every report written by this research unit has contained a request for timely distribution of the reports of other projects. The fact that six months after submission the annual reports have still not been distributed is unacceptable. Certainly more extensive interpretation of results would be possible by all projects if rapid distribution of reports could be accomplished.

We have also repeatedly suggested several species which, by virtue of their importance in the trophic structure in various areas, appear to merit further study. To reiterate, the following species seem exceptionally important.

Invertebrates
- *Thysanoessa inermis* - euphausiid
- *Anonyx nugax* - amphipod
- *Pandalus goniurus* - shrimp
- *Sclerocrangon boreas* - shrimp
- *Serripes groenlandicus* - clam

Fishes
- *Theragra chalcogramma* - Alaska pollock
- *Boreogadus saida* - Arctic cod
- *Myoxocephalus scorpius* - sculpin

VI. Estimate of Funds Expended

As of August 31 we have expended approximately the following amounts:

Salaries and benefits	-	$51,000
Travel and per diem	-	7,000
Contractual services	-	5,500
Commodities	-	5,200
Total Expenditures		$68,700

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RU# 240

NO REPORT WAS RECEIVED

A final report is expected next quarter

RU# 241

NO REPORT WAS RECEIVED

A final report is expected next quarter

QUARTERLY REPORT

Contract # 03-5-022-69
Research Unit #243
Reporting Period-July 1 thru Sept. 30
Number of Pages - 12

Population Assessment, Ecology and Trophic Relationships of Steller Sea Lions in the Gulf of Alaska

Principal Investigators:

Donald G. Calkins, Alaska Department of Fish and Game
Kenneth W. Pitcher, Alaska Department of Fish and Game

September 30, 1976

I. Task Objectives

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 birth rates, duration of reproductive activity and survival rates for various sex and age classes.

To determine food habits of Steller sea lions in the Gulf of Alaska with emphasis on variation with season and habitat type. An effort will be made to relate food habits with prey abundance and distribution. Effects of sea lion predation on prey populations will be examined.

To incidentally collect information on pathology, environmental contaminant loads, critical habitat and fishery depredations.

II. Field or Laboratory Activities

A. No field activities were scheduled during this quarter. Laboratory activities consisted of the following:

1. Completion of photo counts for March and June surveys.
2. Tentative ageing of all sea lions collected to date.

3. Preparation of and submission to EDS all survey data accumulated to date.

B. Methods

1. The method of photo censusing sea lions involves taking the photos with a hand held 35mm motor driven camera using high speed ektachrome film. From the developed slides a mosaic is constructed whereby each individual sea lion which has been photographed is counted.

2. Sea lion ages are estimated by counting cementum annuli which is deposited on the roots of the teeth. This method is still in the experimental stage and all ages are tentative.

C. Data Analyzed

1. Counts have been made of a total of 97 sea lion rookeries and hauling areas in March and 100 in June.

2. Tentative ages for 60 sea lions have been established.

III. Results

A. Table 1 shows the results of the photo surveys for March and June.

B. Table 2 shows tentative ages of all sea lions collected.

Table 1. Sea lion photo counts.

Hauling Area or Rookery	March Count	June Count
Venisa Pt.	0	0
Harbor Pt.	5	0
Cape Fairweather	258	0
Sitkagi Bluff	199	20
Cape St. Elias	435	1,628
Middleton Is.	92	2,901
Fish Is.	861	878
Seal Pks. (PWS)	2,500*	1,709
Porpoise Rk.	0	0
Fox Pt.	0	0
Knowles Hd.	0	0
Glacier I.	197	0
Perry I.	308	0
Pt. Eleanor	222	0
The Needle	666	537
Latouche I.	0	0
Danger I.	0	0
Pt. Elrington	2,014	725
Cape Puget	0	89
Cape Junken	0	0
Barwell I.	0	0
Rugged I.	0	0
Hive I.	0	0
Chat I.	0	0
Chiswell I.	2,076	1,106

continued

Table 1. (continued) Sea lion photo counts.

Hauling Area or Rookery	March Count	June Count
Seal Rks. (KEN)	630	320
Outer I.	1,528	3,847
Nuka Pt.	0	0
Gore Pt.	200*	535
E. Chugach I.	0	0
Perl I.	8	33
Nagahut Rks.	68	344
Cape Elizabeth	68	124
Flat I.	0	0
Sugarloaf I.	301	5,226
Sud I.	0	2
Rk. S.W. Sud	87	670
Rk. S.W. Ushagat	819	902
Rk. N.W. Ushagat	0	106
Rk. Between Amatulis	0	57
Latax Rk.	322	1,164
Sea Otter I.	51	541
Tonki Cape	0	1
Sea Lion Rk.	127	432
Marmot I.	3,655	9,862
Long I.	62	0
Cape Chiniak	883	365
Ugak I.	0	0
Gull Pt.	28	145
Cape Barnabas	120	364

continued

Table 1. (continued) Sea lion photo counts.

Hauling Area or Rookery	March Count	June Count
Two Headed I.	1,636	1,615
Sundstrom I.	0	0
Cape Sitkinak	257	120
Chirikof I.	3,870	2,391
Nagai Rks.	1,401	657
Bert Pt.	0	0
Cape Hepburn	0	0
Cape Alitak	0	1
Outer Seal Rk.	0	3
Tombstone Rk.	0	8
Cape Ikolik	1,913	0
Middle Cape	0	374
Sturgeon Head	25	0
Cape Ugat	222	0
Ugaiushak	0	125
Cape Nukshak	0	0
Cape Ugyak	0	0
Pt. South of Cape Gull	0	207
Cape Kuliak	0	4
Takli I. Rk.	1,014	1,877
Puale Bay	1,704	3,166
Foggy Cape	0	0
Sutwik I.	40	6
Kumlik I.	0	0
Kak I.	0	0

continued

Table 1. (continued) Sea lion photo counts.

Hauling Area or Rookery	March Count	June Count
Atkulik I.	0	0
Seal Cape	0	0
Mitrofania I.	0	0
Spitz I.	0	25
Kupreanof	0	0
Whaleback I.	0	0
Haystacks	0	0
Chowiet I.	865 (incomplete)	Not Surveyed
Castle Rk.	189	401
Atkins I.	1,211	2,726
Simeonof I.	0	0
Chernabura I.	1,667	1,437
Twins	0	0
Nagai I.	233	405
Sea Lion Rk.	187	243
Unga Cape	0	0
Jude I.	0	302
Wosnesenski I.	0	0
Pinnacle Rk.	141	1,745
Clubbing Rk.	0	1,217
Cherni I.	0	0
Rk. South of Sanak I.	972	1,004
Bird I.	Not Surveyed	112
Cape Lazaref	Not Surveyed	0
Rock I.	Not Surveyed	54

continued

Table 1. (continued) Sea lion photo counts.

Hauling Area or Rookery	March Count	June Count
Cape Lutke	Not Surveyed	0
Total	36,332	54,895

* These areas were surveyed but photographs were not satisfactory. Number given is a visual estimate.

Table 2. Tentative age of all sea lions collected under RU#243.

Field Number	Sex	Age	Field No.	Sex	Age
SL-1-75	F	3	SL-12-76	F	1
SL-2-75	F	7	SL-13-76	F	2
SL-3-75	F	6-7	SL-14-76	M	1
SL-4-75	M	1-2	SL-15-76	F	1
SL-5-75	M	3-4	SL-16-76	M	1
SL-6-75	M	3	SL-17-76	F	3
SL-7-75	M	2-3	SL-18-76	F	3
SL-8-75	M	2-4	SL-19-76	F	8
SL-9-75	M	3-4	SL-20-76	M	2-3
SL-10-75	M	3-4	SL-21-76	M	1
SL-11-75	M	3-4	SL-22-76	F	1
SL-12-75	M	2	SL-23-76	F	2
SL-13-75	M	3-4	SL-24-76	M	2-3
SL-14-75	M	2	SL-25-76	M	2
SL-15-75	M	4-5	SL-26-76	M	1-2
			SL-27-76	M	4-5
SL-1-76	F	13-14	SL-28-76	M	7-8
SL-2-76	F	15-16	SL-29-76	M	1-2
SL-3-76	F	3-4	SL-30-76	F	3
SL-4-76	M	2-3	SL-31-76	M	1
SL-5-76	M	1	SL-32-76	F	10
SL-6-76	F	3	SL-33-76	M	13-14
SL-7-76	M	4	SL-34-76	F	8-9
SL-8-76	M	3-4	SL-35-76	F	11
SL-9-76	F	1			
SL-10-76	F	1			
SL-11-76	F	3-4			

continued

Table 2. (continued) Tentative age of all sea lions collected under RU#243.

Field Number	Sex	Age
SL-36-76	F	1
SL-37-76	F	4
SL-38-76	M	1
SL-39-76	F	1
SL-40-76	F	3
SL-41-76	F	12
SL-42-76	F	24
SL-43-76	M	3-4
SL-44-76	M	2-3
SL-45-76	F	1

IV. Preliminary Interpretation of Results

A total of 32 locations which have been listed in various publications as hauling areas were found to have no sea lions on both the March and June surveys. In some cases this lack of sea lions represents inadequate surveys but more than likely many of those areas are not true hauling areas. They are probably not used on a regular basis. Many of them are probably not even used on a seasonal basis but are more likely used infrequently and irregularly during peak local abundance of food.

It is interesting to note the significant change in numbers of sea lions at Sugarloaf Island. Sugarloaf Island in the Barren Islands has one of the largest breeding rookeries of Steller sea lions in the Gulf of Alaska. Apparently this population leaves the area in winter. Branded animals born on this rookery have been sighted as far away as the Kenai Peninsula and Cape St. Elias on the southeast side of Prince William Sound. It is likely that these animals travel great distances away from their birth place and probably return to breed and pup. Marmot Island, which is another of the largest breeding rookeries in the Gulf of Alaska also shows a significant reduction in numbers in the winter. Intensive work is planned for the next contract period to discover the pattern of dispersal of these animals.

The ages shown in Table 1 of all sea lions collected in this project are cementum annuli counts of upper premolar teeth. The counts are made from stained sections of the teeth which have been decalsified and sectioned on a freeze microtome. Exact chronological age has not been determined but is presumed to be within one year of the cementum counts presented.

V. Problems Encountered.

None.

VI. Estimate of Funds Expended.

All funds have been expended.

Quarterly Report

Contract #
Research Unit 248/249
Report Period: 1 July-30 September 1976
Number of Pages: 3

The Relationships of Marine Mammal Distributions, Densities and Activities to Sea Ice Conditions

Co-Principal Investigators

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20 October 1976

I. Task Objectives:

The concurrent investigation of sea ice conditions and marine mammal distributions, densities and activities includes the following task objectives:

1. Summarization and evaluation of existing literature and available unpublished data concerning relationships of marine mammals to sea ice conditions in the study areas;

2. Development of a classification of sea ice conditions which is meaningful in terms of marine mammal habitat and can be determined directly from satellite imagery;

3. Evaluation of the physical and environmental factors prevailing in the Bering and Chukchi seas which influence the annual occurrence, dynamics and extent of these habitats;

4. Correlation of the temporal and spatial distribution of marine mammals in the study areas to sea ice conditions.

II. Field and Laboratory Activities:

Both field and laboratory activities occurred during this quarter. Laboratory activities mainly involved the formating, keypunching and verification of a large volume of data obtained during the course of previous field work, the summarization and plotting of unpublished data concerning distribution of marine mammals, particularly walrus, and the examination of NOAA and LANDSAT imagery. Field activities which contributed to the data base incorporated into this study are indicated in section III (below).

III. Results:

A. Data regarding observations of mammal occurrences, obtained through 30 June have been organized, put into approved formats and, for the most part, keypunched. These data include information acquired from cruises, aerial surveys and work from shore based sites, conducted during 1976. A program which can be used to plot the survey data on a transverse mercator projection, at a scale of 1:1,000,000, has been written. Preparation of mammal distribution maps will begin shortly. The results will provide some of the surface and near surface verification required for interpretation of the satellite imagery.

Cursory examination of pertinent NOAA and LANDSAT imagery is continuing. Detailed analyses of this imagery is planned for the winter quarter.

List of Cruises and Surveys

Location and Transport	Date	Ice
St. George Basin/Bristol Bay (Surveyor)	March-April 1976	Ice Front

Bering Sea Ice Front (P2V)	April 1976	Ice Front
Eastern Bering Sea (Zagoriahy)	March-April 1976	Ice Front
Cape Lisburne/Chukchi Sea (helicopter and Cessna 180)	March-April 1976	Fast Ice and Drifting Pack
Kotzebue Sound to Barrow (Cessna 180)	June 1976	Fast Ice
Barrow to Barter Island (Cessna 180)	June 1976	Fast Ice
Chukchi and Beaufort Seas (Twin Otter)	June 1976	Fast Ice and Drifting Pack
Chukchi Sea (Discoverer)	August 1976	Drifting Pack
Beaufort Sea (Glacier)	August 1976	Drifting Pack
Beaufort Sea (Natchek)	September 1976	Drifting Pack

B. Compilation of data from old field notes was continued, and is nearing completion. Much of the data has not been plotted.

C. All NOAA 2/3 satellite pictures from March 1974 to date have been examined as part of the study of the persistence of major ice features in the study area. The results are presently being keypunched in preparation for computer analysis of correlations between the occurrence of these features and mammal distributions. In addition, available LANDSAT imagery has been inventoried to indicate days for which good data are available from both satellites.

IV. Preliminary Interpretation:
None

V. Problems Encountered/Recommended Changes:

None. However, we may be faced with a serious problem concerning timely availability of computer services.

VI. Estimated Funds Expended:

Approximately $30,000 this quarter.

MARINE BIRDS

MARINE BIRDS

MARINE BIRDS

MARINE BIRDS

QUARTERLY REPORT

Contract #03-5-022-69

Research Unit #3/4

Reporting Period July 1, 1976-

Sept. 30, 1976

Pages - 27

Identification, Documentation and Delineation of Coastal Migratory Bird Habitat in Alaska.

Paul D. Arneson

Alaska Department of Fish and Game

September 30, 1976

I. Task Objectives

1. Summarize and evaluate existing literature and unpublished data on the distribution, abundance, behavior, and food dependencies of birds associated with littoral and estuarine habitat in the Gulf of Alaska, Bristol Bay, Beaufort Sea and Chukchi Sea, and on barrier islands in the Beaufort Sea.

2. Determine seasonal density distribution, critical habitats, migratory routes, and breeding locales for principal bird species in littoral and estuarine habitat in the Gulf of Alaska, Bristol Bay, Beaufort Sea and Chukchi Sea; and on barrier islands in the Beaufort Sea. Identify critical species particularly in regard to possible effects of oil and gas development.

3. Describe dynamics and trophic relationships of selected species at coastal study sites on the Beaufort Sea.

III. Field Activities

The report of activities in the Beaufort and Chukchi Seas will be completed by George Divoky, Alaska Department of Fish and Game, Fairbanks.

A. Schedule

1. Not reported in the June 30, 1976 Quarterly Report were bird surveys conducted from June 21-25, 1976 in Lower Cook Inlet. This included a complete shoreline count and a pelagic survey on eight transects. A DeHavilland Beaver and Travel Air were used for the shoreline survey and a State of Alaska Grumman Goose for the pelagic survey.

2. Bird colonies were mapped from June 26-July 8 in Kachemak Bay and the Iniskin Bay vicinity from a Boston Whaler and Avon raft.

3. From July 24-26 habitat mapping and a partial bird survey were conducted from Cape Fairweather to Valdez Arm using a Gulf Air Cessna 180 and a Chitina Air Cessna 185 and Beaver.

4. Pelagic bird observations were made on July 30-31 in southern Bristol Bay from the Office of Aircraft Services "Super Goose".

5. On August 24 and 31 habitat mapping flights were made from Montague Island to Gore Point in a PA-18 from Charlie Allen's Flying Service.

6. Habitat mapping was done from August 28-31 on Kodiak Island in a Flirite Bellanca Scout.

B. Scientific Party

1. Bird observers for the Lower Cook Inlet surveys from June 21-July 8 were David Erikson, ADFG, Homer and Paul Arneson, ADFG, Anchorage.

2. Habitat mapping in Lower Cook Inlet on June 21-25, in NEGOA and Prince William Sound on July 24-26 and in Kodiak on August 28-31 was done by David Kurhajec, ADFG, Anchorage. He also conducted a bird survey on July 24 in NEGOA.

3. Bird surveys in southern Bristol Bay on July 30-31 and habitat mapping on August 24 and 31 were conducted by Paul Arneson, ADFG, Anchorage.

C. Methods

As in past reports, the technique used for shoreline bird surveys was flying in single-engine, high wing aircraft at an altitude of approximately 30-45 meters and speed of 160 kilometers per hour. Observers were used on both sides of the aircraft with the shoreside observer covering the area to the high tide line and the oceanside observer enumerated all birds within 200 meters of the aircraft. In estuarine habitat and where upland vegetation was inundated by storm tides, a total count of birds was attempted. These methods were used in the June 21-25 Lower Cook Inlet survey.

On July 24, 1976 from Cape Fairweather to Cape Suckling on the outer beach only, a survey was conducted using one observer on the shoreside of the aircraft. The area being surveyed was variable, since the distance from the aircraft to which the observer enumerated birds was not fixed.

In southern Bristol Bay on July 30-31 the bird survey was conducted in conjunction with marine mammal surveys and only one bird observer was aboard. Transects were flown out to approximate outer limits of sea otter habitat and at higher altitudes (61 meters) and faster speeds (222 kilometers/hour) than normal bird surveys. Therefore, the distance out to which birds were enumerated was only 100 meters.

All observations were recorded on cassette-type tape recorders. Information recorded was: bird identification to lowest taxa possible (order, family, genus, species); bird numbers, habitat type in which the bird was found and other information including activities, sex, color phase, etc., as outlined in the data processing format. Weather observations were recorded at the start of each flight and a coded survey conditions number was noted as often as conditions change. Time was recorded each time a new station was started and ended.

During the colony survey of Kachemak Bay and the Iniskin Bay vicinity, all known colonies were visited by skiff or raft. Nests and/or burrows were either counted or sampled depending on the size of the colony. The coastline was searched by boat for colonies not previously known and for nesting birds not associated with a colony. Bird use of the nearshore area other than for nesting was also noted at that time.

Habitat mapping was conducted from single-engine aircraft while flying at 90-120 meters along the coastline. Information was color-coded onto USGS 1:63,360 maps.

D. Localities

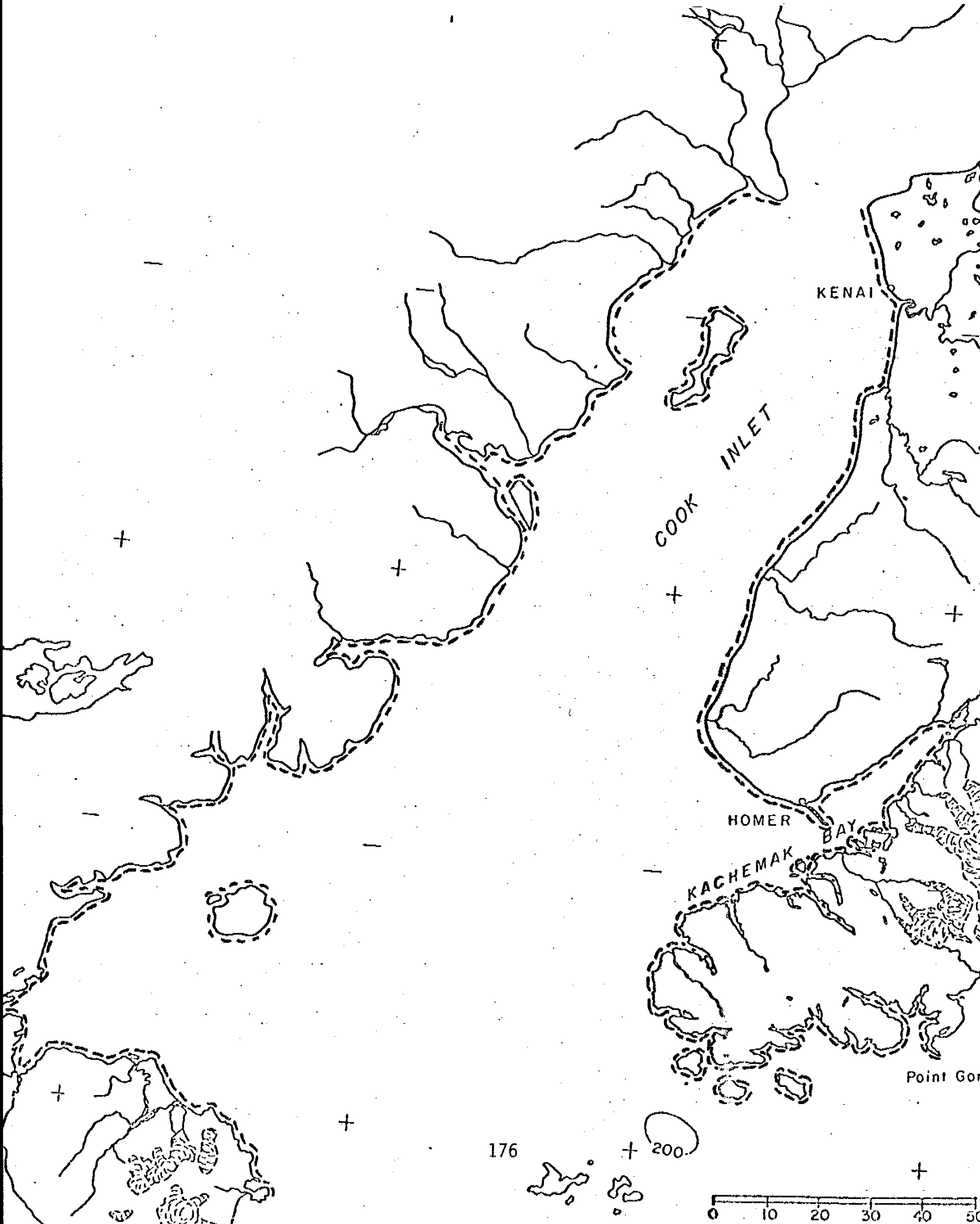
See attached maps (Figures 1-10).

E. Data Collected

During the June aerial survey of Lower Cook Inlet, approximately 1300 kilometers of shoreline were covered. In all, 182 stations were surveyed with 1270 parameters recorded. During the boat survey over 80 km of shoreline were searched for nesting birds. The pelagic bird surveys of Lower Cook Inlet totaled 464 kilometers with a breakdown as follows:

Transect	Length (km)
A	16
B	52
C	50
D	64
E	114
F	56
G	86
H	26

Figure 1. Trackline of aerial shoreline bird survey of Lower Cook Inlet, June 21-23, & 25, 1976 ADFG.



re 2. Aerial pelagic bird transects, June 24, 1976, Lower Cook Inlet, ADFG.

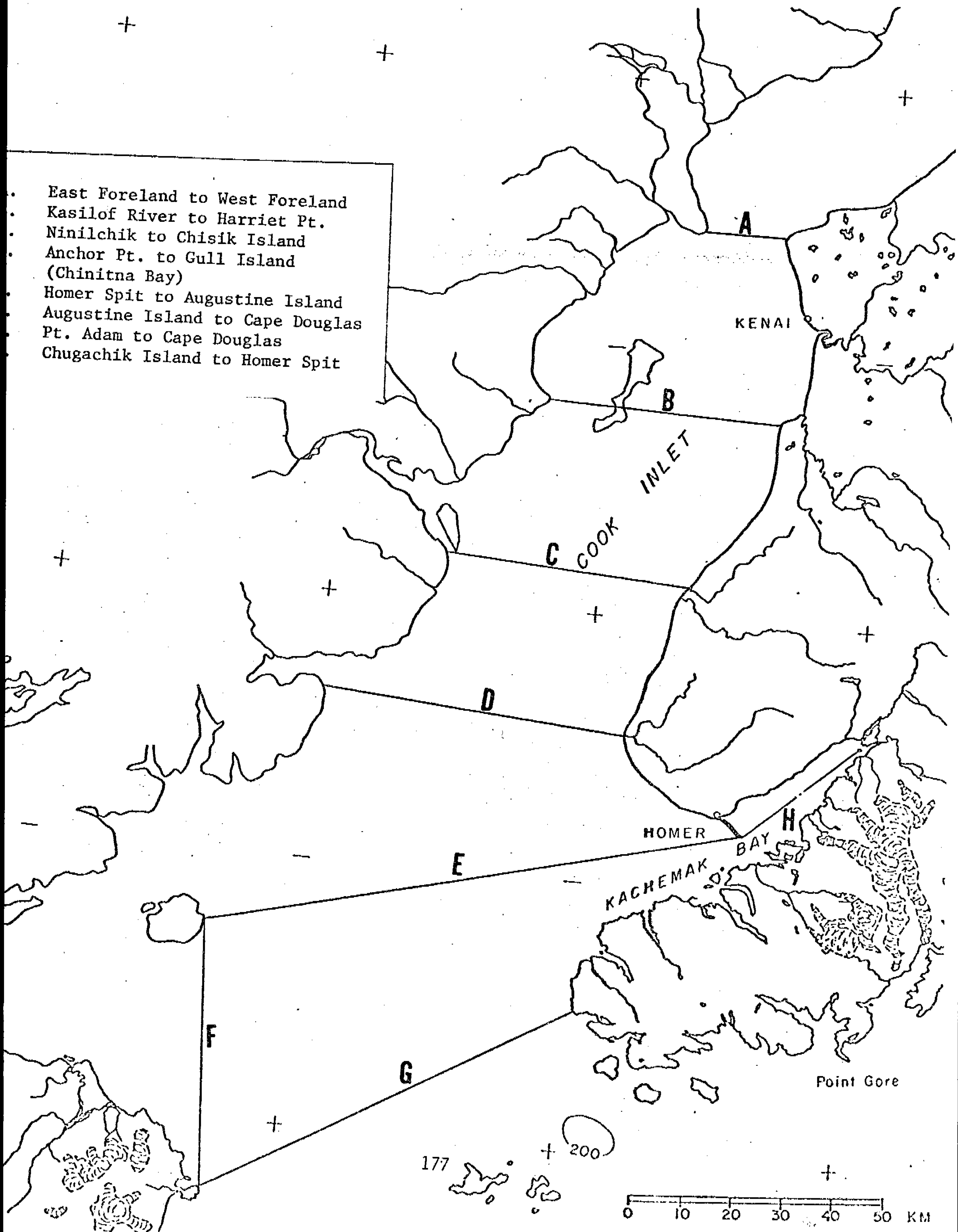


Figure 3. Trackline of colony mapping in Lower Cook Inlet by boat, June 26-July 8, 1976, ADFG.

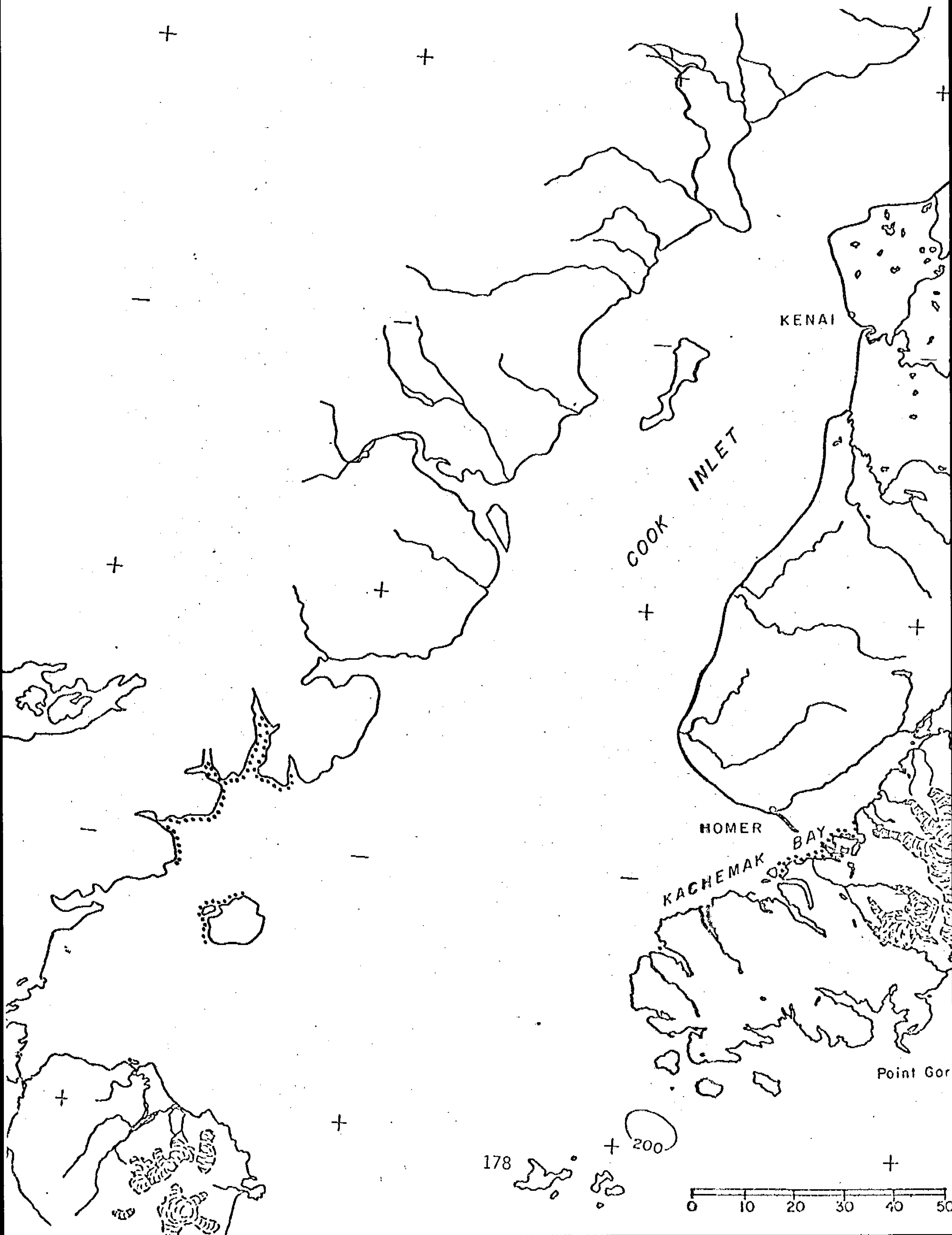


Figure 4. Trackline of aerial bird surveys in NEGOA, July 24, 1976, ADFG.

Figure 5. Trackline of habitat mapping flight on July 24-25, 1976 in NEGOA, ADFG.

gure 6. Trackline of habitat mapping flight in Prince William Sound on July 26, 1976, ADFG.

Figure 7. Aerial transects for marine mammal/bird survey, southern Bristol Bay, July 30-31, 1[9]
ADFG.

gure 8. Trackline of habitat mapping flight, Prince William Sound, August 24, 1976, ADFG.

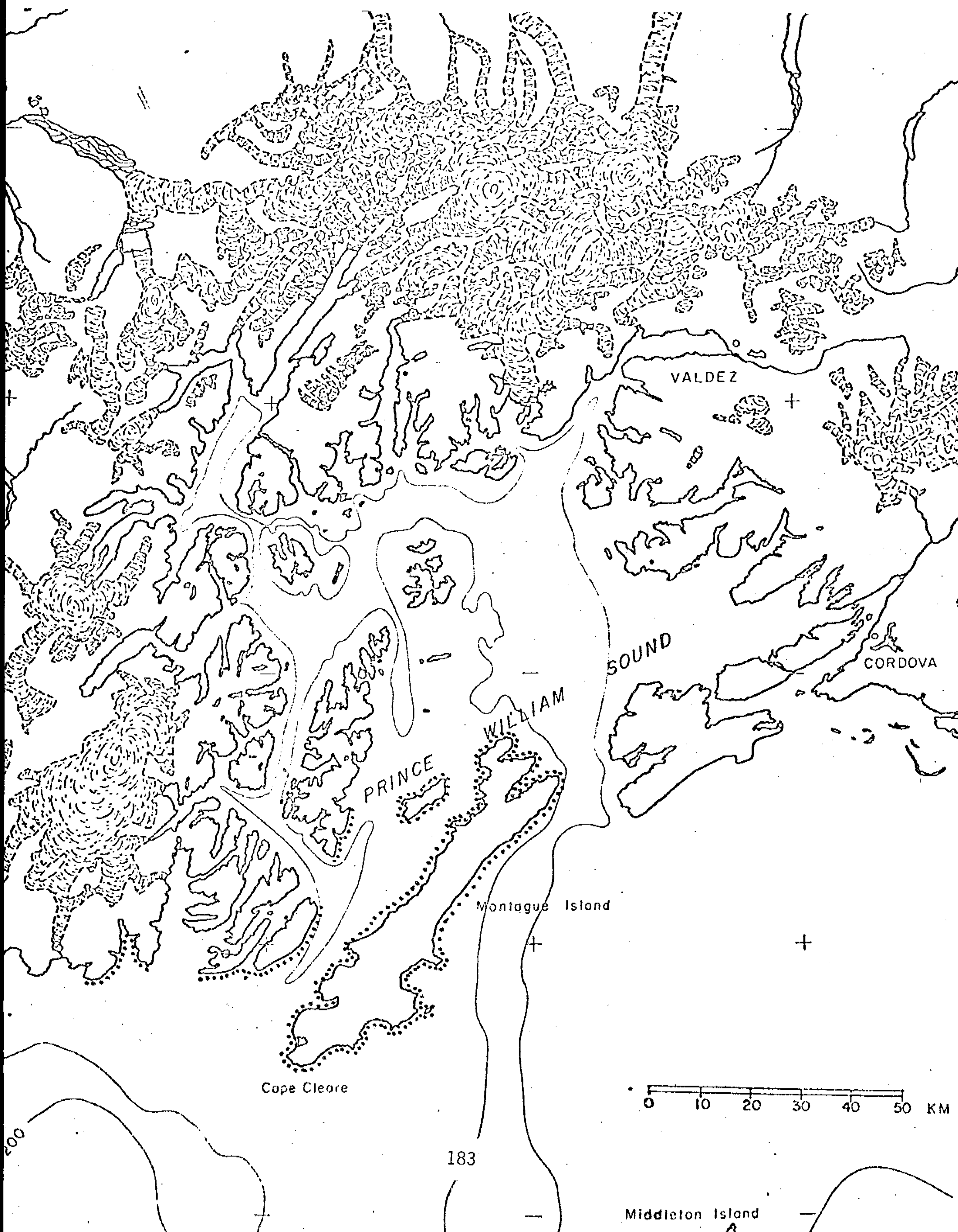
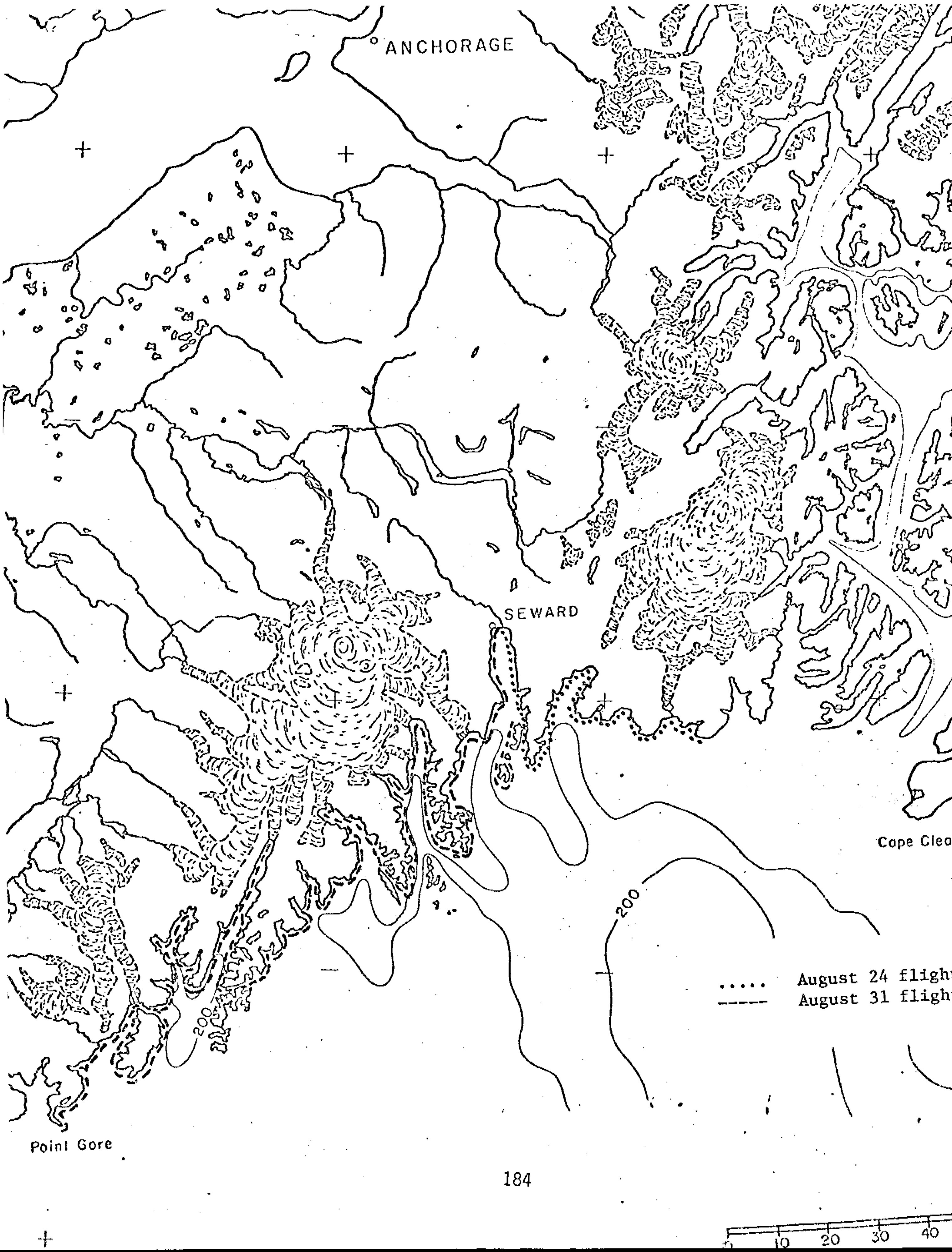
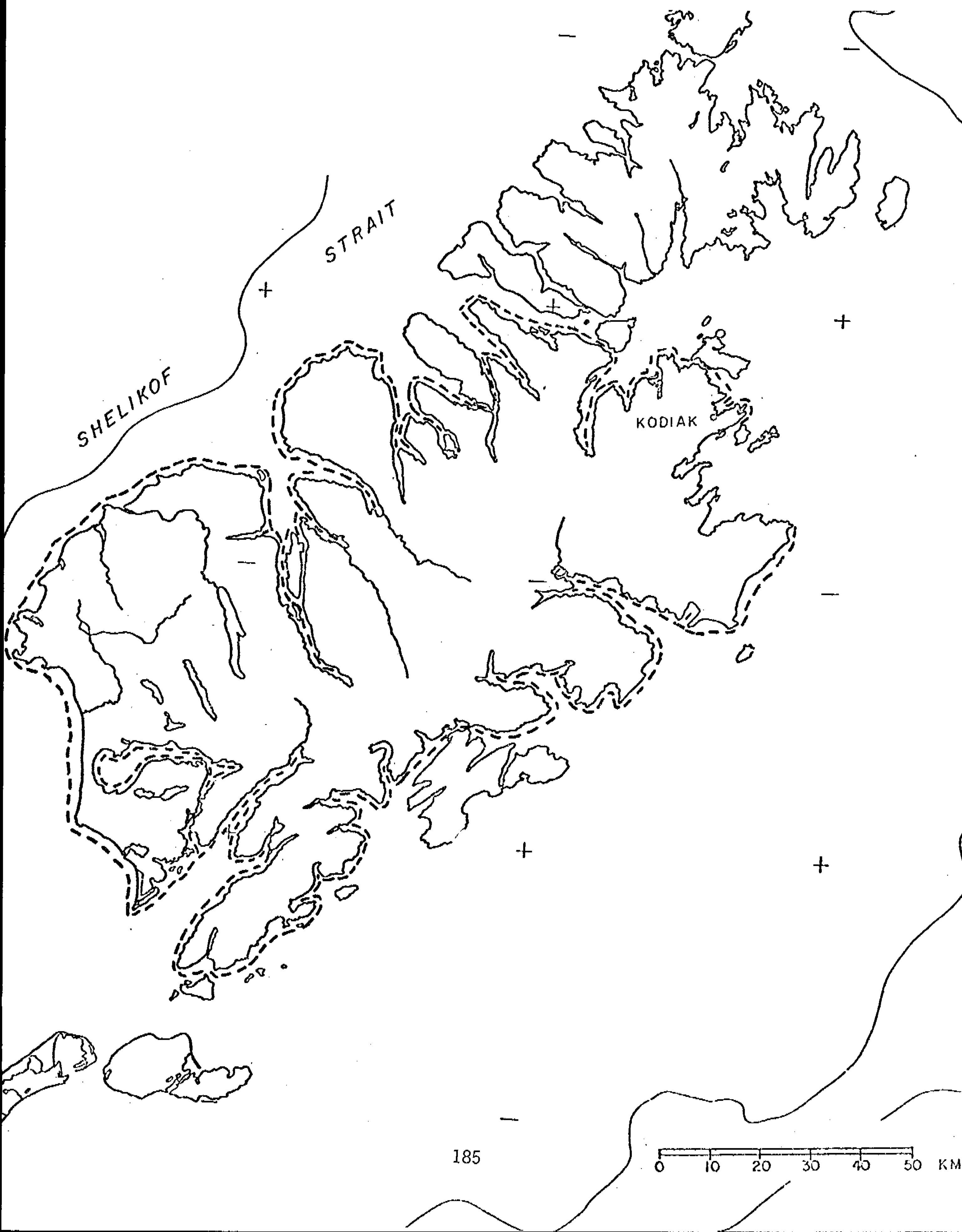


Figure 9. Trackline of habitat mapping flight, Blying Sound, August 24 & 31, 1976, ADFG.



ure 10. Trackline of habitat mapping flight, Kodiak Island, August 28-31, 1976, ADFG.



Aerial bird surveys in NEGOA on July 24, 1976 covered 324 kilometers with 26 stations surveyed and 308 parameters recorded. During the same period 912 kilometers of shoreline were mapped for the various habitat types. Also, approximately 470 kilometers of eastern Prince William Sound were mapped.

A total of 1401 km were surveyed in the 39 transects from Cape Sarichef to Port Moller. Seventeen species of birds were observed and 313 parameters recorded.

On August 24, 1976 375 kilometers of shoreline were mapped from Montague Island to Seward and on August 31 approximately 415 kilometers were mapped from Seward to Gore Point.

From August 28-31, 1976 about 1130 kilometers of shoreline were mapped on the mainland of Kodiak Island.

III. Results

The final format for data processing was accepted by NOOC/EDS during this report period. A transcribing form was designed to facilitate transcribing directly from cassette tapes to a key-punchable format. Nine of ten surveys were transcribed and submitted for keypunching. A backlog of data turned in simultaneously for keypunching caused a delay in verification of the data. All data should be keypunched, verified and finalized in October and analysis begun.

An ADFG programmer has been contacted and a computer program is being written for data analysis. The analysis will stress bird distribution and densities by habitat type but will include distribution in relation to tide height, activity, age, sex and weather where possible.

A preliminary analysis of the pelagic survey in southern Bristol Bay has been completed. Table 1 lists the number of transects, area of transects, approximate area covered by the survey and mean number of birds per transect. The Unimak-Izembek region was sufficiently different from the Port Moller region to be analyzed separately. Table 2 shows the total number of birds observed and their percent occurrence in the transects by region. Shearwaters made up almost 95 percent of the total with murres (2.5%) and kittiwakes (1.3%) a distant second and third, respectively. Together with the three previously mentioned specious, glaucous-winged gulls were the most ubiquitous being observed in 87 percent or more of the transects. Fifteen species or groups were observed in the Unimak-Izembek region and eight species in in the Port Moller region. Two species of scoters (white-winged and surf) were seen in Port Moller but were combined for the analysis. Scoters were not seen in the Unimak-Izembek area.

Transects either began or ended on shore so different species occurred in nearshore waters versus the pelagic areas some distance from shore. No attempt has yet been made to analyze the birds' distribution in relation to distance from shore but, in general, terns, most gulls, cormorants and seaducks occurred closest to shore. Shearwaters did not

Table 1. Transect number and area, approximate area covered, and mean number of birds observed on a pelagic bird survey in the Unimak-Izembek and Port Moller regions of Bristol Bay, July 30-31, 1976.

	No. of Transects	Area of Transects-Km^2	Approx. area Surveyed-Km^2	$\bar{x}$ No. Birds per Transect
U-I	34	126.2	10,045	2160
PM	5	13.9	1,555	148
Total	39	140.1	11,600	1903

Table 2. Total number of birds by species and percent occurrence in transects in pelagic bird surveys of the Unimak-Izembek and Port Moller regions of Birstol Bay, July 30-31, 1976.

Species	Part A Total No. of Birds Observed U-I	PM	Total	Percent of Total Birds	Part B % Occurrence in Transects U-I	PM	Total
ShWa	70,000	341	70,341	94.8	94	40	87
Murr	1,697	178	1,875	2.5	94	80	92
Kitt	926	70	996	1.3	88	100	90
GWGu	460	73	533	0.7	91	80	90
SmAl	193	3	196	0.3	44	20	41
Scot	0	70	70	0.1	0	40	5
Corm	63	0	63	0.1	9	0	8
TuPu	34	0	34	Tr	44	0	38
Phal	28	0	28	Tr	15	0	13
Tern	19	7	26	Tr	38	40	38
SaGu	8	0	8	Tr	15	0	13
Jaeg	6	0	6	Tr	4	0	10
GlGu	3	0	3	Tr	2	0	5
Petr	3	0	3	Tr	2	0	5
RTLo	2	0	2	Tr	2	0	5
PaEi	1	0	1	Tr	1	0	3
Total	73,443	742	74,185	99.8			

show up in transects until some distance from shore and were still abundant when transects ended. Murres and kittiwakes could be found in most parts of a transect. The shortest transect was 13 kilometers and the longest 57.4 kilometers.

Shearwaters were about 40 times more dense than the next most abundant species (murres) and only five species had more than one bird per square kilometer (Table 3). After expanding the population by multiplying the density of bird species in each region by the approximate area in the region (found in Table 1), the importance of southern Bristol Bay to summering populations of shearwaters and other seabirds is strongly indicated. Over 6 million birds were estimated for the 11,600 km^2 surveyed and only a small portion of the Bering Sea was covered in the survey.

Habitat types mapped in Prince William Sound/Blying Sound, east side of Lower Cook Inlet, and west side of Lower Cook Inlet are summarized in Tables 4, 5 and 6 respectively. An atlas of all habitat information collected this past fiscal year has been completed on 1:63,360 USGS maps in color-coded form and is on file in the Anchorage ADFG office. Arrangements are being made to transfer the information onto a black and white format of 1:250,000 maps for distribution.

le 3. Densities and expanded population size of sixteen species of birds observed on pelagic bird surveys in the Unimak-Izembek and Port Moller regions of Bristol Bay July 30-31, 1976.

	Part A Density: Birds/Km^2 *			Part B Expanded Population Size: Est. No. Birds**		
cies	U-I	PM	Total	U-I	PM	Total
Ja	554.6	24.6	502.1	5,570,957	38,253	5,824,360
r	13.4	12.8	13.4	134,603	19,904	155,440
t	7.3	5.0	7.1	73,329	7,775	82,360
u	3.6	5.3	3.8	36,162	8,242	44,080
l	1.5	0.2	1.4	15,068	311	16,240
t	0	5.0	0.5	0	7,775	5,800
m	0.5	0	0.4	5,023	0	4,640
u	0.3	0	0.2	3,014	0	2,320
l	0.2	0	0.2	2,009	0	2,320
n	0.2	0.5	0.2	2,009	778	2,320
u	0.1	0	0.1	1,005	0	1,160
g	Tr	0	Tr	1,193	0	1,379
u	Tr	0	Tr	1,193	0	1,379
r	Tr	0	Tr	1,193	0	1,379
o	Tr	0	Tr	1,193	0	1,379
i	Tr	0	Tr	1,193	0	1,379
bined	581.9	53.4	529.5	5,845,185	83,037	6,142,200

Based on actual area and bird numbers observed.

Based on approximate area covered by survey and the calculated densities of Part A.

Table 4. Substitute of shoreline in Prince William Sound and Blying Sound from Cordova to Entrance Point and Montague Island to Gore Point, Summer 1976.

	Shoreline in Kilometers						
	Mud	Sand	Gravel	Rock	Sand & Gravel	Sand & Rock	Rock & Gravel
Cordova to Entrance Point	6.8	2.1	94.0	326.4	0	0	78.4
Hawkins Island	4.0	0	27.5	52.0	0	0	18.0
Hinchinbrook Is.	18.0	13.7	80.3	70.8	1.4	3.2	20.9
Montague Island	0	62.4	109.0	51.8	23.2	0	65.0
Green Island	0	2.4	37.8	4.3	0	0	3.7
Cape Puget to Seward	0	20.4	28.3	149.7	15.4	0	13.7
Seward to Gore Point	0	10.9	149.7	571.3	32.5	0.3	26.4

Table 5. Quantity of various habitat types on the shoreline from Gore Point to East Foreland in Lower Cook Inlet, summer 1976.

	Shoreline in Kilometers								Area in Square Kilometers			
	Mud	Mud & Sand	Sand	Gravel	Rock	Sand & Rock	Gravel & Rock	Sand & Gravel	Mud Flats	Sand Flats	Mixed Forbs	Eelgrass
Gore Point to Chugach Bay	0	0	1.8	25.3	28.3	0	20.4	0	0	0	4.4	0
Elizabeth, Perl & E. Chugach Is.	0	2.7	1.1	3.2	35.4	0.3	3.1	3.4	0	0	0	0
Chugach Bay to Point Adam	0	0	0.3	22.0	23.0	0	18.0	0.8	0	0	0.5	2.3
Point Adam to Sadie Cove	0	0	0.6	66.9	87.1	0	24.1	2.4	5.4	0	1.0	0
Sadie Cove to Homer Spit	16.6	1.6	1.9	57.9	70.2	0	7.2	25.3	62.9	0	29.0	0
Homer Spit to Ninilchik	0	0	0.5	33.6	0.6	3.1	12.2	10.5	0	2.8	1.0	0
Ninilchik to East Foreland	21.6	0	2.7	27.5	0	0	1.0	50.9	0	6.2	11.9	0

Table 6. Quantity of various habitat types on the shoreline from West Foreland to Cape Douglas, Lower Cook Inlet, summer 1976.

	Shoreline in Kilometers									Area in Square Kilometers				
	Mud	Mud & Sand	Sand	Gravel	Rock	Sand & Rock	Gravel & Rock	Sand & Gravel	Sand Gravel & Rock	Mud Flats	Sand Flats	Mud & Sand Flats	Mixed Forbs	Elymus
West Foreland to S. end Chisik Is.	28.5	36.7	21.6	13.7	49.9	0.6	23.3	29.3	7.9	28.0	10.4	112.9	99.2	0
S. end Chisid Is. to Ursus Head	10.9	0	7.2	46.5	104.9	1.4	20.3	24.0	1.0	63.2	7.0	0	27.5	0
Ursus Head to Contact Point	0	0	0	38.6	32.5	0	19.2	2.4	0	0	0	0	4.4	0
Contact Point to Kamishak River	10.0	0	0.2	29.3	17.5	0	22.4	0	0	21.8	0	0	4.9	6.5
Kamishak River to Cape Douglas	3.2	0	27.4	26.7	23.2	0	5.6	0	0	2.8	49.7	0	7.3	5.7
Kalgin Island	0	0	0	4.2	8.5	0	19.0	20.3	7.7	0	3.9	0	6.7	0
Augustine Island	0	0	6.4	0	5.8	18.0	0	0.6	1.6	0	0	0	0	0

IV. Interpretation of Results

Quite obviously, southern Bristol Bay is a very important summering area for birds. The regions surveyed containing an estimated 6 million birds represent only a small portion of the southern Bering Sea area. With large colonies in the Pribilofs, the Cape Newenham/Cape Peirce vicinity, the Walrus Islands, and Aleutian Islands, densities of birds are likely quite large in a much more extensive area. It is extremely productive in both birds and their food organisms. Past surveys have also indicated heavy use of this area for migrating birds both in spring and fall. For these reasons oil development (in particular an oil spill) in this region could be quite damaging to large populations of birds directly, or indirectly by affecting their food source.

Interpretation of data from other surveys awaits final development of a computer program for data retrieval. General observations indicate that the nearshore waters and beaches of the portions of the Gulf of Alaska surveyed during this report period do not support large densities of summering birds except in the vicinity of colonies. Larids and non-breeding and molting scoters were likely the most abundant species (not associated with breeding colonies) that were encountered during the summer's surveys. Final analysis of bird densities and distribution will be available when the computer program is completed.

V. Problems - nothing noteworthy.

VI. Estimate of funds expended

Salaries	14,588
Per diem/travel	475
Logistics (air charter, etc.)	6,170
Commodities	260
Equipment	0
Total	$21,493

Quarterly Report

Contract #
Research Unit #3/4 and 196
Report Period: 1 July-30 September
Number of Pages: 19

Identification, Documentation, and Delineation of Coastal Migratory Bird Habitat in Alaska

and

The Distribution, Abundance and Feeding Ecology of Birds Associated with Pack Ice

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Principal Investigator

and

Robert J. Boekelheide
Kate P. Darling
Doug Forsell
A. Edward Good
Thomas E. Harvey
Katherine V. Hirsch
Steve D. MacDonald
Karen L. Oakley
Kenneth L. Wilson
Douglas A. Woodby

Co-Investigators

Alaska Department of Fish and Game
1300 College Road
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October 1, 1976

I. Task Objectives

Task A-5--Determine the seasonal density distribution, critical habitats, migratory routes, and breeding locales for principal marine bird species in the study areas. Identify critical species particularly in regard to possible effects of oil and gas development.

Task A-6--Describe dynamics and trophic relationships of selected species at offshore and coastal study sites.

Task A-31--Determine the relationship of living resources to the ice environment (including the edge of drifting ice, land fast ice and inner pack ice) on a seasonal basis in the Bering, Chukchi and Beaufort Seas.

A. Ship and field trip schedule and scientific parties.

Date	Location	Type of Study	Personnel
14 Mar-2 Apr	Southern Bering Sea, SURVEYOR	Ice edge-pelagic densities	George Divoky Doug Woodby
12 Apr-1 May	Southern Bering Sea, SURVEYOR	Ice edge-pelagic densities	Doug Woodby
6 May-3 June	Barrow Whale Camp	Migration watch	Doug Woodby
15 May	Barrow to Icy Cape and return	Aerial census	Doug Woodby
19 May	Barrow to Pt. Hope	Aerial census	Doug Woodby
4 June	Northeast of Barrow	Aerial census	Kate Darling Tom Harvey Doug Woodby
4-7 June	Wales	Migration & habitat census	Steve MacDonald
5 June	Barrow to Wainwright and return	Aerial census	Kate Darling Tom Harvey
7-15 June	Oliktok & vicinity	Habitat census, foot	Kate Darling Tom Harvey
9-13 June	Pt. Hope	Migration & habitat census	Steve MacDonald
10 June	Barrow to Icy Cape and return	Aerial census	Beth Chiodo Ken Wilson Doug Woodby
11 June	Chukchi Sea	Aerial census	Bob Boekelheide

12 June	Barrow to Halkett and return	Aerial census	Katie Hirsch Ken Wilson
12-18 June	Wales	Migration watch	Dan Gibson
18-19 June	Wales to Pt. Lay	Aerial census	Dan Gibson
16 June	Cooper Island Beaufort Sea	Breeding bird, habitat census, migration	Bob Boekelheide Beth Chiodo to 15 July Katie Hirsch to 2 September Tom Harvey to 10 September
17-21 June	Peard Bay and vicinity	Habitat census, foot	Kate Darling Ken Wilson
17 June	Barrow to Pt. Lay and return	Aerial census	George Divoky Katie Hirsch
17 June	Barrow to Pt. McIntyre and return	Aerial census	Tom Harvey Doug Woodby
19 June	Barrow to Lisburne and return	Aerial census	Doug Woodby
21 June	Barrow to Icy Cape	Aerial census	Tom Harvey Katie Hirsch
21-29 June	Icy Cape and vicinity	Habitat census, foot	Tom Harvey Katie Hirsch
21 June-15 July	Prudhoe Bay and vicinity	Breeding bird census	Karen Oakley Doug Woodby
22-23 June	Barter Island	Habitat census, foot	George Divoky Ed Good
23-28 June	Kasegaluk Lagoon (Pt. Lay - s)	Habitat and breeding bird census	Dan Gibson Steve MacDonald
23 June-3 July	Beaufort Lagoon to Demarcation Bay and return	Habitat and breeding bird census	George Divoky Ed Good
25-28 June	Cape Lisburne and vicinity	Habitat census	Kate Darling Ken Wilson
28 June-6 July	Wainwright and vicinity	Habitat census	Kate Darling Ken Wilson
1 July	Barrow to Barter Island and return	Aerial census	Tom Harvey

6-20 July	Kasegaluk Lagoon (Pt. Lay to Icy Cape)	Habitat and breeding bird census	Brina Kessel Dan Gibson Steve MacDonald
6 July	Barrow to Wainwright and return	Aerial census	Tom Harvey
7 July	Barrow to Prudhoe Bay and return	Aerial census	Ed Good Tom Harvey
8 July	Barrow to Pt. Lay and return	Aerial census	Ed Good Tom Harvey Ken Wilson
8-12 July	Pitt Point and vicinity	Habitat census, foot	Kate Darling Doug Woodby
12-16 July	Southern Kasegaluk Lagoon to Cape Beaufort	Habitat census, foot	George Divoky Ed Good
13-15 July	Colville Delta	Habitat census, foot	Kate Darling Ken Wilson
15 July	Barrow to Barter Island and return	Aerial census	Tom Harvey Doug Woodby
16 July	Barrow to Cape Beaufort and return	Aerial census	Tom Harvey Karen Oakley
16-19 July	Oliktok & vicinity	Habitat census	Kate Darling Ken Wilson
18-19 July	Barrow to Walakpa Bay	Habitat census, foot	Beth Chiodo Karen Oakley
20 July	Barrow to Demarcation Point and return	Aerial census	Ed Good Karen Oakley
20-26 July	Bullen to Brownlow	Habitat census, foot	Kate Darling Ken Wilson
22-28 July	Chukchi Sea, BURTON ISLAND	Pelagic census	Doug Woodby
22-29 July	Icy Cape to Wainwright	Habitat and breeding bird survey	Dan Gibson Steve MacDonald Karen Oakley
25 July	Barrow to Icy Cape	Aerial Census	Tom Harvey Ed Good
25-26 July	Islands next to Utukok Pass	Breeding bird and habitat census	George Divoky Ed Good

28 July	Barrow to Demarcation Point and return	Aerial census	George Divoky Ed Good Tom Harvey
30 July	Barrow to Lonely	Aerial census	Tom Harvey Doug Woodby
30 July- 6 August	Wainwright to Peard Bay	Habitat census	Kate Darling Ken Wilson
30 July- 6 August	Peard Bay	Habitat census	Ed Good
31 July- 5 August	Plover Island	Breeding bird census	Tom Harvey Katie Hirsch
6 August	Barrow to Cape Lisburne and return	Aerial census	Tom Harvey Katie Hirsch Doug Woodby
6 August- 3 September	Chukchi and Beaufort Seas, CGC GLACIER	Pelagic censusing	Mark Phillips Doug Woodby
6-16 August	Icy Cape	Migrant watch	Dan Gibson
7-13 August	Icy Cape and vicinity	Habitat census, foot	Kate Darling Ken Wilson
12 August	Barrow to Demarcation Point and return	Aerial census	Doug Forsell Ed Good Tom Harvey Karen Oakley
12-19 August	Pingok to Bullen	General survey, boat	Tom Harvey Karen Oakley
13-20 August	Cape Lisburne and vicinity	Habitat census, foot	Kate Darling Ken Wilson
19 August	Bullen to Barrow	Aerial census	Tom Harvey Karen Oakley
19-31 August	Barrow to Barter Island, R.V. ALUMIAC	Pelagic censusing	Doug Forsell Ed Good
20 August	Barrow to Cape Lisburne	Aerial census	Tom Harvey Karen Oakley
30 August- 1 September	Pitt Point and vicinity	Habitat census	Kate Darling Ken Wilson

31 August- 8 September	Barter Island	Land and boat survey	George Divoky Ed Good
4-7 September	Oliktok	Habitat census, foot	Kate Darling Ken Wilson
5 September	Beaufort Sea, CGC GLACIER	Pelagic census	Doug Forsell
7 September	Beaufort	Aerial census	George Divoky Karen Oakley Doug Woodby Katie Hirsch
9 September	Icy Cape	Habitat census, foot	Kate Darling
10 September	Chukchi Sea, DISCOVERER	Pelagic census	Doug Woodby
9-12 September	Icy Cape	Habitat census	Kate Darling
11 September	Barrow to Cape Lisburne and return	Aerial census	Karen Oakley Katie Hirsch Ken Wilson
13-15 September	Peard Bay	Habitat census	Kate Darling
13-14 September	Wainwright and vicinity	Habitat census	Ken Wilson
various dates throughout	Barrow	Migration watch	--
summer	Prudhoe Bay	Habitat census	--

C. Methods

Aerial censusing - Aerial censusing was the primary means of obtaining information on bird use of coastal waters. Observations were made from both sides of a Twin Otter flying at 150 feet. In general, flights were over the barrier islands for the first half of the flight and mid-lagoon or mainland beach on the return. Information on ice and habitat was mapped during the flight. The species, number, activity and habitat of all birds seen were noted. Birds were mapped on U. S. Coast and Geodetic Charts after each flight.

Habitat censusing (foot) - Transects along the coast were walked in order to determine numbers and activities of species using inshore waters, adjacent beach and tundra. Information on breeding birds was obtained whenever possible. Birds per distance walked in each habitat were computed. Most areas were visited three times during the summer in order to obtain information on breeding, post breeding and fall migration densities. At the same time, information was gathered on the species and numbers of migrating birds in each area.

Shipboard observations - Observations are made from the flying bridge while the ship is underway. All birds within a 300 m wide transect are counted. Observations are made in 15 minute intervals. At the end of each interval all birds following the ship are counted. Densities (birds per km^2) are computed for each transect. Migrants are counted on a birds per unit line basis. Ship followers are counted at the end of each transect. Detailed ice observations are made during each transect and the activities of birds in relation to ice are noted.

Migration watches - In addition to migration data gathered during the course of other work some stationary migration watches were conducted at appropriate points on the coast. This provided information on the number of birds passing per unit time.

Breeding birds - Whenever nests were encountered information on clutch size, stage of nesting and habitat was recorded.

Specimen collecting - Specimens were collected during the course of a number of field trips in order to obtain information on food items and fat and molt condition of the birds. Whenever possible plankton tows were conducted when birds were collected.

D&E. Data Collected

Numbers given in parentheses after locality refer to sections of coast studied. See Figure 1 for sections.

Bering Sea Cruise - SURVEYOR - Leg I

14 March - 2 April

Transect time	2400 min.
Station observations	240 min.
Specimens collected:	
Common Murre	17
Ivory Gull	6
Glaucous-winged Gull	6
Thick-billed Murre	3
Black Guillemot	2
Thayer's Gull	1
Crested Auklet	1
7 species	36

Bering Sea Cruise - SURVEYOR - Leg II

12 April - 1 May

Transect time	1500 min.
Station observations	35 min.
Specimens collected:	
Common Murre	14
Thick-billed Murre	10

Black-legged Kittiwake	5
Ivory Gull	4
Northern Fulmar	3
Glaucous Gull	3
Black Guillemot	2
7 species	41

Barrow Whale Camp (8)
6 May - 3 June
Migration watch 7860 min.
Specimens collected:
King Eider 2

Aerial Survey - Barrow to Icy Cape and return (4-7)
15 May
Aerial observations 199 min.
Trackline 224 nm (415 km)

Aerial Survey - Barrow to Pt. Hope (1-7)
19 May
Aerial observations 113 min.
Trackline 217 nm (402 km)

Aerial Survey - East of Barrow
4 June
Aerial observations 133 min.
Trackline 210 nm (389 km)

Migration and Habitat Census - Wales
4-7 June
Observations 474 min.

Aerial Survey - Barrow to Wainwright and return (5-7)
5 June
Aerial observations 160 min.
Trackline 312 nm (578 km)

Habitat Census (foot) - Oliktok and vicinity (12)
7-15 June
Transect time 4260 min.
Transect distance 68 nm (125 km)

Migration and Habitat Census - Pt. Hope
9-13 June
Observations 1110 min.

Aerial Census - Barrow to Icy Cape and return (4-7)
10 June
Aerial observations 137 min.
Trackline 360 nm (667 km)

Aerial Census - Chukchi Sea
11 June
Aerial observations 174 min.
Trackline 391 nm (725 km)

Aerial Census - Beaufort Sea

12 June

Aerial observations	184 min.
Trackline	325 nm (602 km)

Migration Watch - Wales

12-18 June

Observations

Breeding Biology, Habitat and Migration Census - Cooper Island (8)

16 June - 1 September

Station observations	23880 min.
Transect time	11340 min.
Transect distance	310 nm (574 km)
Specimens collected:	
Oldsquaw	48
Red Phalarope	16
Arctic Tern	14
Sabine's Gull	8
Glaucous Gull	7
Common Eider	3
Ross' Gull	1
Sanderling	1
9 species	98

Habitat Census (foot) - Peard Bay and vicinity (6)

17-21 June

Transect time	1140 min.
Transect distance	24 nm (45 km)

Aerial Census - Barrow to Pt. Lay and return (3-7)

17 June

Aerial observations	230 min.
Trackline	344 nm (637 km)

Aerial Census - Barrow to Pt. MacIntyre and return (8-12)

17 June

Aerial observations	300 min.
Trackline	330 nm (611 km)

Aerial Census - Wales to Pt. Lay (1-2)

18-19 June

Aerial observations

Trackline

Aerial Census - Barrow to Cape Lisburne and return (1-7)

19 June

Aerial observations	226 min.
Trackline	500 nm (927 km)

Aerial Census - Barrow to Icy Cape (4-7)

21 June

Aerial observations	84 min.
Trackline	134 nm (248 km)

Habitat Census (foot) - Icy Cape and vicinity (3)
21-29 June

Transect time	2520 min.
Transect distance	43 nm (80 km)

Breeding Bird Census - Prudhoe Bay and vicinity (12-13)
21 June to 15 July

Aerial observations	430 min.
Trackline	416 nm (770 km)
Transect time (foot)	3717 min.
Transect distance (foot)	89 nm (164 km)

Habitat and Breeding Bird Census (foot) - Barter Island (15)
23-24 June

Transect time	483 min.
Transect distance	12 nm (22 km)

Habitat and Breeding Bird Census (foot and small boat) - Kasegaluk Lagoon (South of Pt. Lay) (2)
23-28 June

Transect time	940 min.
Transect distance	19 nm (36 km)

Habitat and Breeding Bird Census (foot and canoe) - Beaufort Lagoon to Demarcation Bay and return (14)
23 June - 3 July

Transect time	2245 min.
Transect distance	94 nm (174 km)

Habitat Census (foot) - Cape Lisburne and vicinity (1)
25-28 June

Transect time	1308 min.
Transect distance	23 nm (43 km)

Habitat Census (foot) - Wainwright and vicinity (5,6)
28 June - 6 July

Transect time	1830 min.
Transect distance	35 nm (64 km)

Aerial Census - Barrow to Barter Island and return (8-14)
1 July

Aerial observations	156 min.
Trackline	485 nm (899 km)

Habitat and Breeding Bird Census (foot and small boat) - Kasegaluk Lagoon (Pt. Lay to Icy Cape) (3)
6-20 July

Transect time	2145 min.
Transect distance	70 nm (130 km)

Aerial Census - Barrow to Wainwright and return (5-7)
6 July

Aerial observations	110 min.
Trackline	180 nm (334 km)

Aerial Census - Barrow to Prudhoe Bay and return (8-13)
7 July
Aerial observations 190 min.
Trackline 430 nm (797 km)

Aerial Census - Barrow to Pt. Lay and return (3-7)
8 July
Aerial observations 263 min.
Trackline 415 nm (769 km)

Habitat Census (foot) - Lonely DEWline and vicinity (10)
8-12 July
Transect time 2610 min.
Transect distance 44 nm (82 km)

Habitat Census (foot) - Kasegaluk Lagoon to Cape Beaufort (1)
12-16 July
Transect time 1066 min.
Transect distance 34 nm (64 km)

Habitat Census (foot) - Colville River Delta (11)
13-15 July
Transect time 1170 min.
Transect distance 9 nm (17 km)

Aerial Census - Barrow to Barter Island and return (8-14)
15 July
Aerial observations 172 min.
Trackline 385 nm (713 km)

Aerial Census - Barrow to Cape Beaufort and return (1-7)
16 July
Aerial observations 175 min.
Trackline 274 nm (508 km)

Habitat Census (foot) - Oliktok and vicinity (12)
16-19 July
Transect time 3120 min.
Transect distance 51 nm (95 km)

Habitat Census (foot) - Barrow to Walakpa Bay (7)
18-19 July
Transect time 1418 min.
Transect distance 36 nm (67 km)

Aerial Census - Barrow to Demarcation Point and return (8-15)
20 July
Aerial observations 545 min.
Trackline 670 nm (1241 km)

Habitat Census (foot) - Bullen to Brownlow Pt. (13)
20-26 July
Transect time 3810 min.
Transect distance 58 nm (108 km)

Chukchi Sea Cruise - BURTON ISLAND
22-28 July

Transect time	1050 min.
Transect distance	

Habitat and Breeding Bird Census (foot and small boat) - Icy Cape to Wainwright (4-5)
22-29 July

Transect time	1945 min.
Transect distance	73 nm (136 km)

Aerial Census - Barrow to Icy Cape (4-7)
25 July

Aerial observations	52 min.
Trackline	99 nm (183 km)

Habitat and Breeding Bird Census (foot) - Utukok Pass and vicinity (3)
25-26 July

Transect time	625 min.
Transect distance	11 nm (20 km)

Aerial Census - Barrow to Demarcation Pt. and return (8-15)
28 July

Aerial observations	329 min.
Trackline	598 nm (1108 km)

Aerial Census - Barrow to Lonely (7-10)
30 July

Aerial observations	163 min.
Trackline	471 nm (873 km)

Habitat Census (foot) - Wainwright to Peard Bay (5-6)
30 July to 6 August

Transect time	3900 min.
Transect distance	59 nm (109 km)

Habitat Census (foot) - Peard Bay (6)
30 July to 6 August

Transect time	1500 min.
Transect distance	43 nm (80 km)

Breeding Bird Census (foot and small boat) - Plover Islands (8)
31 July to 5 August

Transect time	1110 min.
Transect distance	28 nm (52 km)
Specimens collected:	
Oldsquaw	3
Arctic Tern	2
2 species	5

Aerial Census - Barrow to Cape Lisburne and return (1-7)
6 August

Aerial observations	280 min.
Trackline	470 nm (871 km)

Chukchi and Beaufort Sea Cruise - GLACIER
6 August to 3 September

Station observations		482 min.
Transect time		4230 min.
Specimens collected:		
	Red Phalarope	25
	Black-legged Kittiwake	14
	Thick-billed Murre	10
	Glaucous Gull	9
	Arctic Tern	8
	Sabine's Gull	4
	Black Guillemot	3
	Ross' Gull	1
	Common Murre	1
	Herring Gull	1
	10 species	76

Migrant watch - Icy Cape (3)
6-16 August
Station observations

Habitat Census (foot) - Icy Cape and vicinity (3)
7-13 August

Transect time	3300 min.
Transect distance	58 nm (107 km)

Aerial census - Barrow to Demarcation Pt. and return (8-15)
12 August

Aerial observations	297 min.
Trackline	725 nm (1343 km)

General Survey (small boat) - Oliktok to Bullen (12-13)
12-19 August

Transect time		1140 min.
Transect distance		92 nm (170 km)
Specimens collected:		
	Oldsquaw	8
	Arctic Tern	2
	2 species	10

Aerial Census - Bullen to Barrow (8-13)
19 August

Aerial observations	110 min.
Trackline	200 nm (371 km)

Beaufort Sea Cruise - R.V. ALUMIAK (8-14)
19-31 August

Transect time		1999 min.
Transect distance		204 nm (378 km)
Specimens collected:		
	Oldsquaw	21
	Red Phalarope	17
	Arctic Tern	6
	Northern Phalarope	3
	Sabine's Gull	3

Glaucous Gull	2
Common Eider	1
7 species	53

Aerial Census - Barrow to Cape Lisburne and return (1-7)
20 August
Aerial observations 385 min.
Trackline 640 nm (1186 km)

Habitat Census (foot) - Lonely and vicinity (3)
30 August - 1 September
Transect time 2388 min.
Transect distance 50 nm (93 km)
Specimens collected:

Red Phalarope	3
Dunlin	2
Long-billed Dowitcher	1
3 species	6

Habitat Census (foot) - Barter Island (14)
31 August - 8 September
Transect time 190 min.
Transect distance 4.9 nm (9 km)

Habitat Census (foot) - Oliktok and vicinity (12)
4-7 September
Transect time
Transect distance
Specimens collected:

Red Phalarope	5
Dunlin	2
2 species	7

Beaufort Sea Cruise - GLACIER
5-17 September
Transect time 1910 min.
Station observations 165 min.

Aerial Census - Barrow to Demarcation and return
7 September
Transect time 292 min.
Transect distance 522 nm (967 km)

Chukchi Sea Cruise - DISCOVERER
10 - September

Habitat Census (foot) - Icy Cape and vicinity (3)
9-12 September
Transect time 1560 min.
Transect distance 32 nm (59 km)

Aerial Census - Barrow to Cape Lisburne and return (1-7)
11 September
Aerial observations 245 min.
Trackline 669 nm (1059 km)

Habitat Census (foot) - Peard Bay and vicinity
14-15 September

Transect time	1092 min.
Transect distance	21 nm (39 km)

Habitat Census (foot) - Wainwright and vicinity
13-14 September

Transect time	650 min.
Transect distance	19 nm (30 km)

Barrow

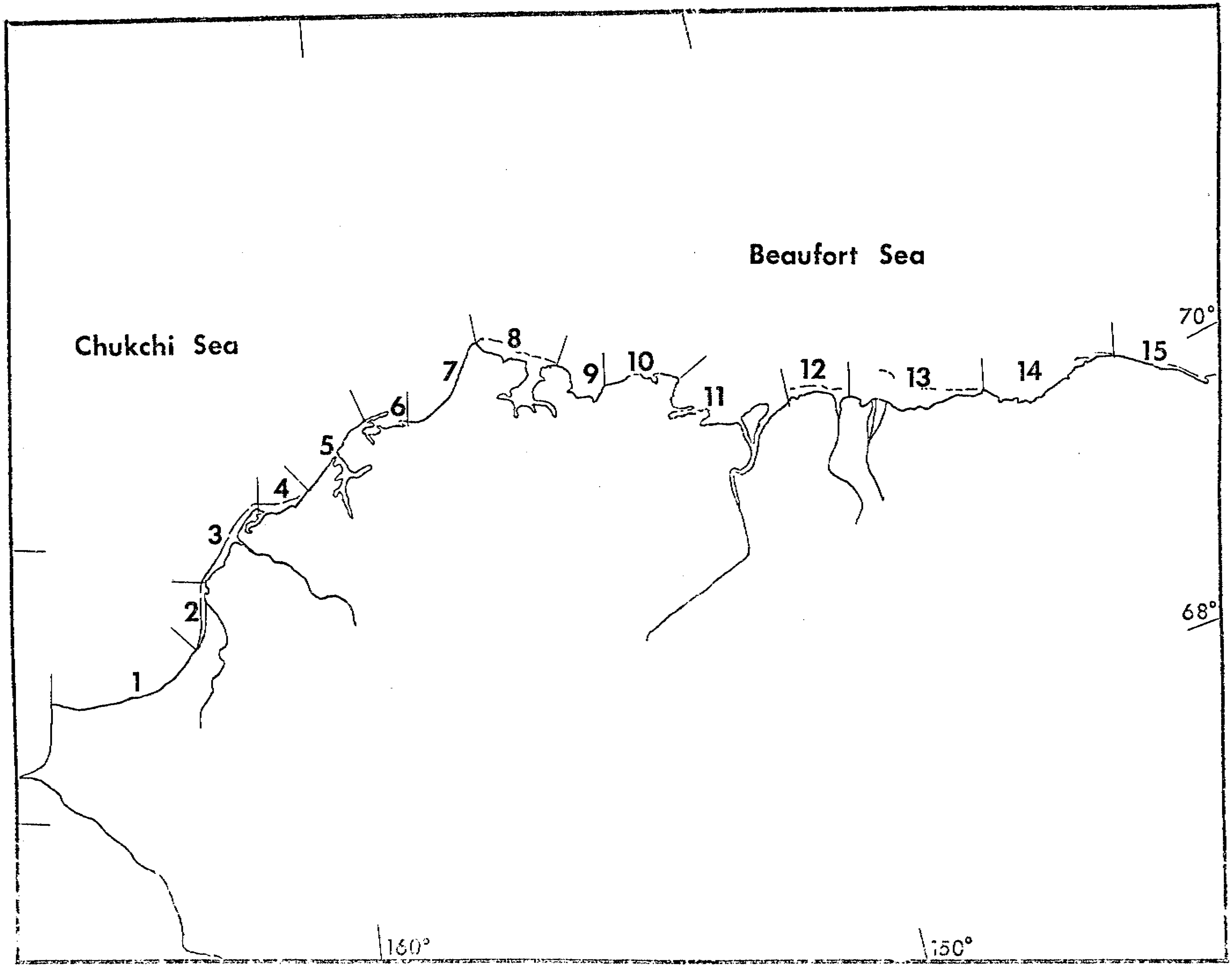
Migration Watch	not yet complete

Specimens collected:

Arctic Tern	22
Red Phalarope	19
Oldsquaw	14
King Eider	13
Black-legged Kittiwake	8
Sabine's Gull	7
Glaucous Gull	6
Steller's Eider	5
Arctic Loon	2
Thick-billed Murre	1
Common Murre	1
Herring Gull	1
Larus sp.	1
13 species	100

Habitat Census (foot) - Prudhoe Bay
24, 25, 27 June, 3, 6, 9, 26 July, 16 August

Transect time	1050 min.
Transect distance	42 nm (78 km)


Beaufort Sea
Chukchi Sea
70°
68°
160°
150°
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

III & IV. Results

Results for R.U. 3/4 are currently being compiled and will be completed by 1 January 1977.

Preliminary results for R.U. 196 cruises in the Bering Sea in spring are as follows:

General Findings - March, Bering Sea

The greatest concentrations of birds seen on the SURVEYOR cruise were in the leads and polynias of the ice over the continental shelf. These ice openings had densities averaging over 600 birds per square kilometer and ranged up to 8000 birds per square kilometer. Lower concentrations, averaging 180 birds per square kilometer, were found immediately south of the ice edge. Further south along the shelfbreak, densities were only slightly lower, averaging 130 birds per square kilometer. Much lower densities were characteristic of Bering Sea waters with depths greater than 200 meters. These open water areas averaged 11 birds per square kilometer and never exceeded 25 birds. Densities in Unimak Pass averaged 50 birds per square kilometer, while the Gulf of Alaska had the lowest densities, averaging five birds pér square kilometer.

Fulmars were seen in large numbers near the shelfbreak in the Bering Sea, with smaller numbers in the Gulf of Alaska, and only a few sightings over the ice. In general, dark phase birds predominated in the Gulf while most Fulmars in the Bering Sea were of the light phase.

Glaucous Gulls were rarely seen south of the ice and were usually in the company of Glaucous-winged Gulls. Many of the Glaucous Gulls seen were third year birds, and all of the adults were in breeding plumage.

Glaucous-winged Gulls were fairly common along the cruise track and were usually present as ship's followers south of the ice. When the SURVEYOR was within the ice, these gulls were more often seen standing on ice cakes then following the ship's wake. Overall, they were as common inside the ice as they were south of it, and were least common over deep water. Immatures were more numerous in the Gulf of Alaska than in the Bering Sea, but were always outnumbered by adults. Most adults seen were in breeding plumage, only a few were still in the streaked winter condition.

Black-legged Kittiwakes were most common south of the ice, especially near the shelfbreak. Adults in breeding plumage outnumbered both non-breeding adults and immatures.

Ivory Gulls were fairly common several miles into the ice and were never seen south of the edge. These small gulls were rarely associated with the ship as followers, but were attracted to the ship for short periods. Only a small percentage of the birds observed were immatures.

Common and Thick-billed Murres were the most abundant birds encountered during the cruise. They were seen during almost all transects made, but were most common at the ice edge and abundant several miles into the ice. Numerous feeding flocks with many thousands of birds were observed in leads and polynias as far as 30 miles into the ice. Approximately two-thirds of the murres seen were in breeding plumage.

General Findings - April, Bering Sea

The greatest concentrations of birds seen during the April SURVEYOR cruise were within the decomposing pack ice of Bristol Bay. Densities of birds in this area averaged 350 per square kilometer and ranged from 0 to well over 2,000, indicating a highly clumped distribution pattern. Birds were more evenly distributed west of the Pribilofs, where densities averaged 65 birds per square kilometer within the ice front, and 56 birds per square kilometer a few miles south of the edge near the shelfbreak. The lowest numbers of birds were found over deep water in the southern Bering Sea and near the shelfbreak in the northern Gulf of Alaska. Densities in these areas averaged two and four birds per square kilometer, respectively. Fair concentrations of birds were recorded within and to the north of Unimak Pass, where densities averaged 24 birds per square kilometer.

Together, Common and Thick-billed Murres comprised over half of all birds seen on the April cruise. They were in greatest numbers within the ice front and were only of moderate importance south of the ice. Within Bristol Bay, Common Murres were the dominant form often congregating in feeding flocks of over 10,000 birds. West of the Pribilofs, Thick-billed Murres outnumbered Common Murres. Observations of plumage conditions revealed that well over 95 percent of all murres seen had indicating breeding plumage.

Fulmars were especially numerous immediately south of the ice edge near the shelfbreak west of the Pribilofs reaching densities of over 500 per square kilometer. They occurred in lesser numbers over the ice and over deep water. Color phase observations indicate that Bering Sea Fulmars were almost exclusively light phase while Northern Gulf Fulmars were predominantly dark birds.

A moderate number of Black-legged Kittiwakes were seen within and south of the pack ice west of the Pribilofs, and in association with the murre feeding flocks of Bristol Bay. Red-legged Kittiwakes sometimes outnumbered the Black-legged species to the south and west of the Pribilofs and were seen over both ice and open water. The majority of Black-legged Kittiwakes seen were adults in breeding plumage, while 10 percent were immatures. No immature or winter plumaged Red-legged Kittiwakes were identified.

V. Problems encountered and recommended changes.

None.

VI. Estimate of funds expended.

As of 30 September we have expended the following amounts:

Salaries	$57,435.91
Travel and per diem	5,000.00
Contractual services	7,918.57
Commodities and supplies	387.64
Equipment	220.75
Total	$70,962.87

Fifth Quarterly Report

Contract #03-5-022-76

A Census of Seabirds on the Pribilof Islands

Joseph J. Hickey, P. I.
Department of Wildlife Ecology
Russell Laboratories
University of Wisconsin
Madison, Wisconsin 53706

October 1, 1976

I. Task Objective

To provide a systematic estimate of the nesting bird population on Pribilof Islands

II. Field and Laboratory Activities

A. Field Trip Schedule

Field work was carried out on the islands during the summer of 1976 from May 5 to August 19.

B. Scientific Party

F. Lance Craighead, Research Assistant
John B. Carey
Ronald C. Squibb

C. Methods

1. Census sampling sites were laid out at about 64 locations on St. George Id. and 35 on St. Paul, and the birds were counted at various hours and dates.

2. St. George Id. was twice circled by boat and all the cliffs photographed.

3. Flight counts were made at Ulakaia Ridge for the main least auklet population, and sample counts were carried on randomly selected parts of the ridge to estimate the breeding least auklet pairs nesting there under boulders.

D. Sample Localities

As mentioned above: 99. Colored photos of each site will accompany the data.

E. Data Collected

Birds were counted for the most part on their ledges. Ten areas were subjected to 23 days of attendence counting. Other areas were also counted for species composition.

F. Milestone Chart

A final report is to be turned in on December 1, 1976.

III. Results

1. Graphs of daily and hourly attendance by the birds are being prepared.

2. Ledge pictures totalled about 1,100. These are to be counted on a randomized sample basis.

IV. Preliminary Interpretations

1. The least auklet estimate will surely be far lower than any ornithologists have previously suspected.

2. The murre estimates will probably exceed one million.

V. Problems encountered

None

VI. Estimate of funds expended

To this date, about $30,000

FINAL REPORT

RU - 77

ECOSYSTEM DYNAMICS BIRDS AND MARINE MAMMALS

Part I

Preliminary Estimates of Pinniped - Finfish Relationships in the Bering Sea

by

W. Bruce McAlister and Michael A. Perez

September 1976

ENVIRONMENTAL ASSESSMENT OF THE ALASKAN CONTINENTAL SHELF

Sponsored by

UNITED STATES DEPARTMENT OF INTERIOR

BUREAU OF LAND MANAGEMENT

Prepared by:
Northwest Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Blvd. E.
Seattle, Washington 98112

An important task of scientists associated with the Alaskan Outer Continental Shelf Environmental Assessment Program is to conduct research and analyze all known data to determine the structure and behavior of the Bering Sea ecosystem. This research is essential if we are to understand the impact on the environment of man's activities on the outer continental shelf. We now know very little about the dynamic behavior of this ecosystem, but we do have some information which helps to shed some light on the subject. Most of our information exists as individual population assessments, oceanographic analyses, and the results of food chain studies which have been undertaken by several research agencies. All of these independent studies should be integrated into a single unified concept describing interrelationships among marine organisms in the ecosystem.

For years, marine mammals have been hunted and populations reduced or eliminated to control assumed predation on commercial stocks of fish and shellfish. Yet actual mechanisms of the cause and effect relationship between pinnipeds and fish abundance remain largely unknown. Some information is available on direct relationships such as feeding, but the nature and extent of indirect relationships remain obscure. Many of the marine mammal species that occur in Alaskan waters are seasonal entrants whose range includes thousands of miles of coastal and pelagic waters of other nations. The commercial fishery off Alaska is both U.S. and foreign. Consequently, the status of marine mammals there is of concern and potential value to other nations. The Marine Mammal Protection Act of 1972 established a moratorium on the taking of marine mammals by all U.S. citizens except for certain Alaskan natives who may harvest certain species for subsistence, and for others who may take animals for display and scientific collection. The northern fur seal, a species regulated by international treaty with Canada, Japan, and the USSR, is harvested on land by the United States. All activities which will affect either marine mammals or their environment must be consistent with provisions of the Marine Mammal Protection Act, particularly with the requirements to maintain a healthy ecosystem. Major changes in mammal or fishery stocks will affect the several components of the ecosystem, but the magnitude. extent, and even direction of the effects of a particular management action are difficult to predict in a complex ecosystem. In addition, impacts caused by environmental changes must be considered.

In order to improve our understanding of how fisheries and mammals interact in the Bering Sea, the Northwest Fisheries Center of the National Marine Fisheries Service has been examining some of the relationships between marine mammals and fisheries. Some of this research is being conducted as part of a study on the northern fur seal to fulfill obligations under the Interim Convention on the Conservation of North Pacific Fur Seals. In addition, research is being conducted on aspects of the ecosystem under the Alaskan Outer Continental Shelf Environmental Assessment Program. A detailed analysis of all eastern Bering Sea and eastern North Pacific pelagic data collected during research carried out on northern fur seals since 1958 on distribution, reproductive rates, and feeding has been started. Information on other marine mammals, fisheries stocks, and oceanographic data are also being combined with an analysis of fur seal data to determine the dynamics of the Bering Sea ecosystem.

Studies reported on in this paper represent the results of research proposed within Research Unit 77 of the OCSEAP to integrate and synthesize these data into a conceptual submodel of the ecosystem describing trophodynamic relationships in the eastern Bering Sea including interactions among northern fur seals, other marine mammals, marine birds, and several species of fish. The amount of food consumed by fur seals and other pinnipeds has been estimated and compared with the amount of fish caught by commercial fisheries in the same waters.

The Bering Sea Ecosystem

In terms of fishery exploitation and the distribution of marine mammals it is convenient to consider the Bering Sea as divided into two subunits: the eastern Bering Sea shelf and the Aleutian area (Figure 1). Pinniped stocks in the Bering Sea are large, including northern fur seals for which extensive research and population data are available, and provide a basis for estimating biological parameters for other pinnipeds where direct observations are not available. The area is one of high overall productivity and of heavy commercial utilization with a good historic fisheries data base. Although not adequate to the degree one would like, data exist for estimating productivity at the upper trophic levels, and by inference at least, throughout the food web.

The food web is enormously complex in the ocean and the eastern Bering Sea is no exception. Although much of the primary productivity of phytoplankton takes place in the water column, blooms of algae in and beneath the sea ice in late winter, and eelgrass and epibenthic phytoplankton growing on mud flats in summer all contribute to the total primary production of the area (McRoy et al., 1972). Progress has been made in understanding the amount of primary production in the water column which can be used as a basis to estimate overall productivity, however, the interrelationships between pelagic, in-ice, and epibenthic production remain to be properly identified. Sanger (1974) has reviewed the available data (Table 1), and obtained a value of 415 mg $C/m^2/day$ as an estimate of primary production in the Bering Sea. Estimated production in the Aleutian area is lower, averaging near 100 mg $C/m^2/day$.

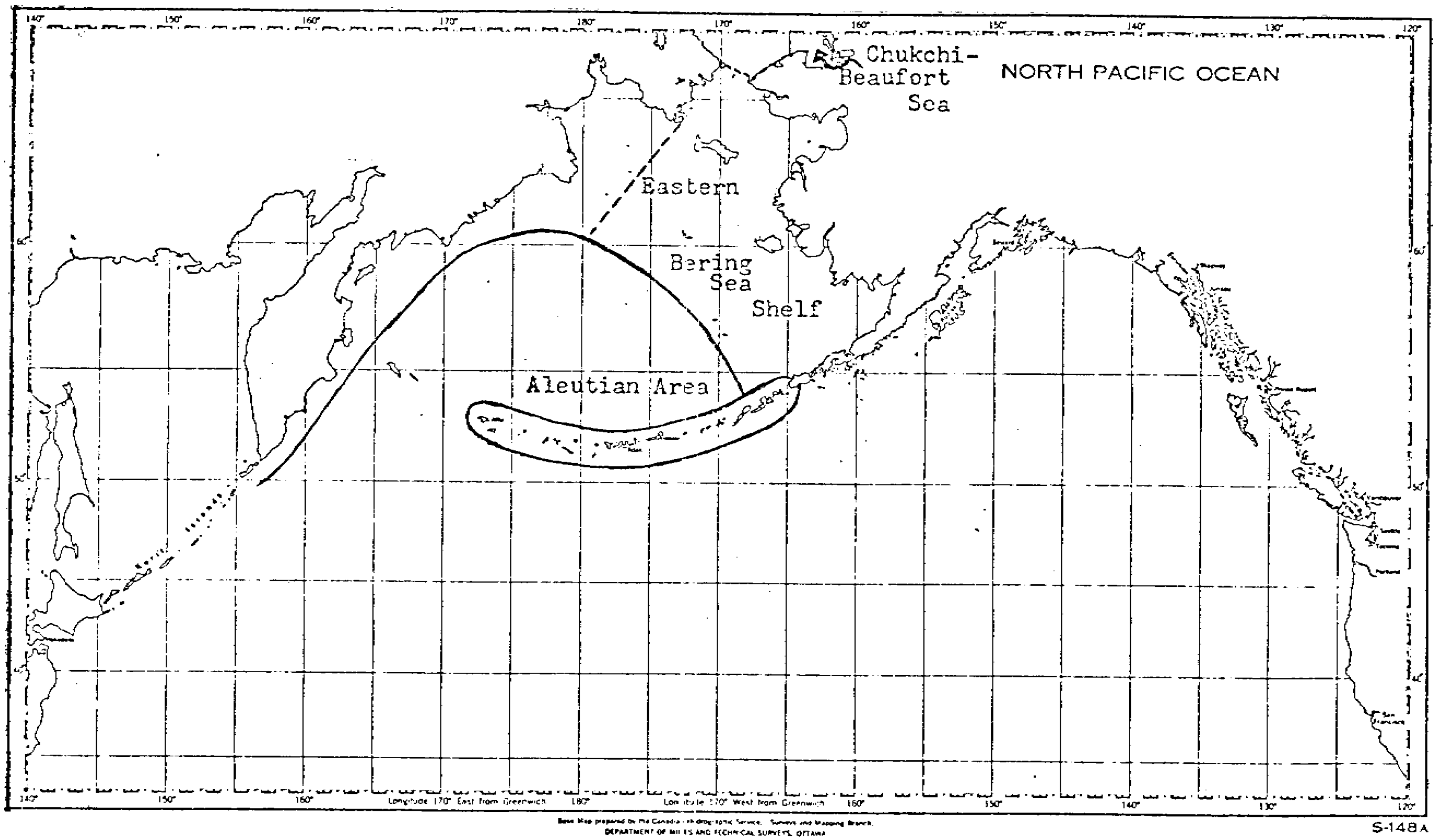


Figure 1. -- Oceanic areas adjacent to Alaska, based on the schematic Domains of Dodimead et al (1963).

Table 1. --Recent estimates of primary production in the water column for oceanic waters contiguous to Alaska (Carbon-14 method).[1/]

Region	Daily Rate (mg C/M^2/day)	Dates	Source
Bering Sea			
Bering Strait	4,100	June 1969	McRoy et al (1972)
Eastern Bering Sea	21	February 1970	McRoy et al (1972)
Aleutian Area			
Unimak Pass Area	243	June 1968 & 1970	McRoy et al (1972)
	85	February 1967	McAlister et al (1970
Amchitka Island Area	38-45	February 1968	McAlister et al (1968
Adak Island Coast	686	June-July 1967	Larrance (1971)
	581	August 1967	Larrance (1971)
	404	September 1966	Larrance (1971)
Adak Bay	350-460	March 1966	Larrance (1971)
	840-2,400	late spring-summer	Larrance (1971)
Central Subarctic Domain			
Subarctic waters south to Adak Island	133	February	Larrance (1971) (Fig. 5, p. 604)
	325	March	Larrance (1971)
	280	May	Larrance (1971)
	327	June	Larrance (1971)
	250	July	Larrance (1971)
	207	August	Larrance (1971)
	240	September	Larrance (1971)

1/ Adapted from Sanger, 1974.

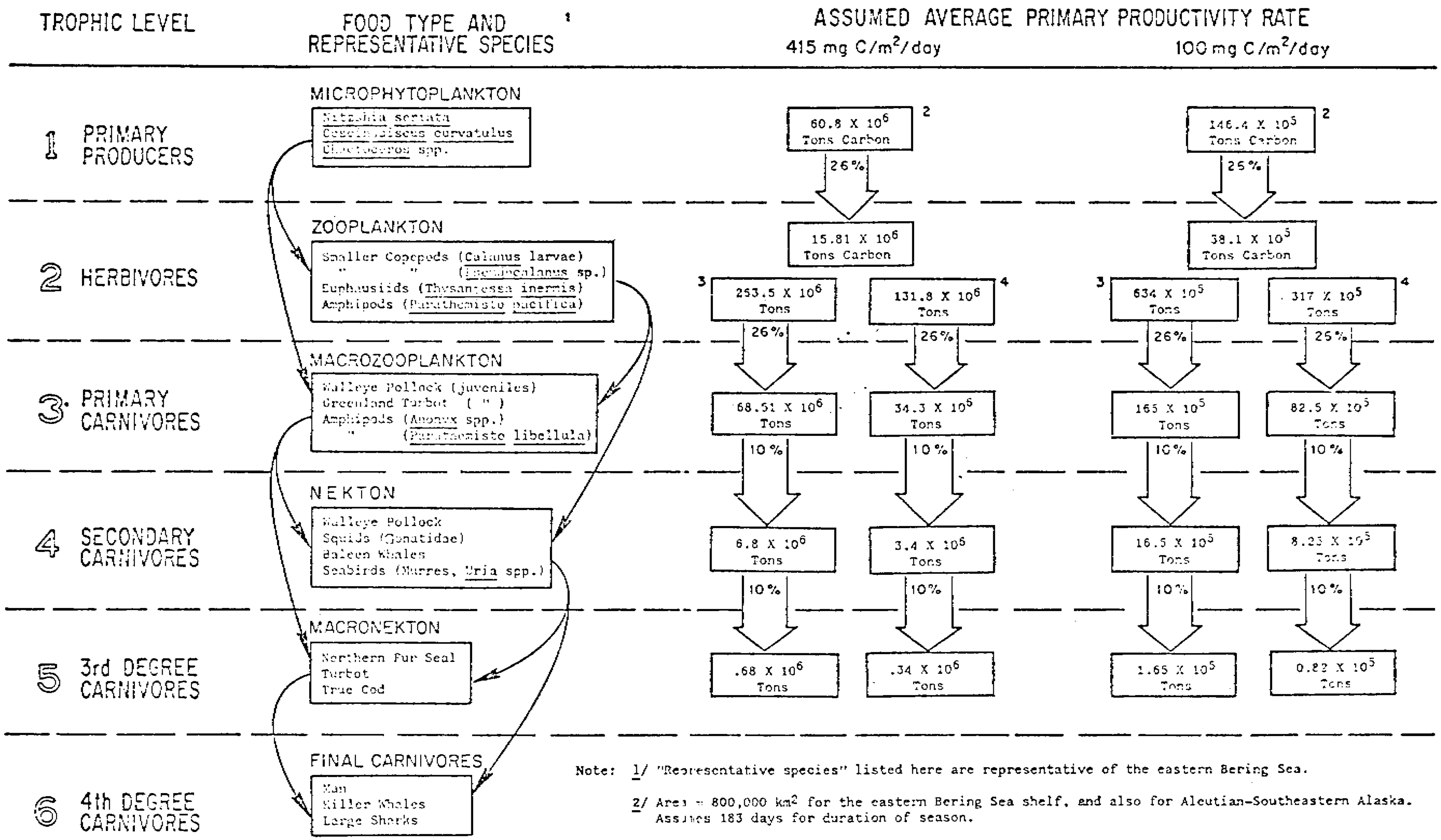
Figure 2 shows a schematic food chain for the eastern Bering Sea shelf area in summer (defined as June through November). Examples of representative species are given to show the kinds of organisms which would be expected to occur at the various trophic levels in the fur seal food chain. Karohji (1972), Hiroshi Kajimura (pers. comm.), and Donald S. Day (pers. comm.) provided suggestions for some of the representative animals used in Figure 2. Calculations of productivity at each trophic level are shown for average daily production rates of 415 mg C/m^2/day and of 100 mg C/m^2/day. The overall productivity rate needs to be revised upwards to account for ice edge/under ice, epibenthic, intertidal and eelgrass productivity.

Because primary productivity is measured and expressed in terms of organic carbon production, estimates of organic carbon at the herbivore level were converted to biomass to relate production to stocks of organisms at higher trophic levels. Sanger (1974) has reviewed the literature and discussed possible energy transfer coefficients between trophic levels and conversion factors of organic carbon to biomass for zooplankton. Figure 2 shows calculations for values of 6% and 12% as the carbon content of zooplankton biomass to represent the possible overall range of values. The values of energy transfer coefficients (percent of the production at trophic level n produced at trophic level $n+1$) used to calculate productivity at the next higher level are also shown in Figure 2; however, it should be stressed that many uncertainties exist concerning conversion factors between trophic levels in the fur seal food web, and that the calculations shown in Figure 2 should be considered as rough estimates only.

Food Consumption by Pinnipeds

In order to calculate the amount of food consumed by pinnipeds, it is necessary to know the size of the population, the biomass of each pinniped species in the ecosystem, and consumption per pound of biomass. Table 2 lists the current

Figure 2. Schematic, simplified summer (June-November) food chain, applicable to the eastern Bering Sea.



Note: 1/ "Representative species" listed here are representative of the eastern Bering Sea.

2/ Area = 800,000 km^2 for the eastern Bering Sea shelf, and also for Aleutian-Southeastern Alaska. Assumes 183 days for duration of season.

3/ Assumes a factor of 6% for conversion of the organic carbon content of biomass to wet weight.

4/ Assumes a factor of 12% for conversion of the organic carbon content of biomass to wet weight.

Table 2. Population and biomass estimates for pinnipeds in Alaska

Species	Total Alaska Population Size ($x10^3$)	Population Size in the: 1/ Aleutians Summer	Aleutians Winter	Eastern Bering Sea Shelf Summer	Eastern Bering Sea Shelf Winter	Average Animal Weight, Kg.
Northern Fur Seal	1,300 2/	37,000	97,300	55,000 3/	96,650	50.3 4/
Northern Sea Lion	225	41,000	62,000 5/	100,000	50,000	400 6/
Harbor Seal *Richardi*	270	85,000	85,000	65,000	65,000	140 6/
Harbor Seal *largha*	250	-	-	125,000	250,000	140 6/
Ringed Seal	250	-	-	125,000	250,000	65 6/
Ribbon Seal	100	-	-	50,000	100,000	80 6/
Bearded Seal	300	-	-	150,000	300,000	240 7/

1/ Population size for pinnipeds, except northern fur seal, based on status of stock reports in ITG, 1975, - ADFG, 1975.

2/ Northern fur seal numbers rounded to nearest 100,000 animals.

3/ Estimated summer distribution of northern fur seals based on pelagic observations by MMD, 1967-1973 and total population of 1,300,000 animals.

4/ Based on the following average weights: Pup=10Kg; males age 3 and older = 225Kg; all others (females age 1 and older; males age 1 and 2)=48Kg.

5/ ADFG, 1973 (b).

6/ Average weight based on ADFG (1973a), Nishiwaki (1972), and NMFS (1973).

7/ Adult bearded seals weigh up to 340Kg in winter.

data on standing stocks of pinnipeds and their average weight. Data for fur seals were obtained from pelagic observations by the Marine Mammal Division, NWFC, NMFS. Data on other pinnipeds are from reports by the Alaska Department of Fish and Game, except that the summer/winter distributions are estimates based upon observed seasonal migration patterns and given population sizes.

Many fishes and pinnipeds feed on either pelagic and benthic forms, or both. They also feed in migratory patterns, which makes it difficult to ascertain their actual impact on a given species in a particular area. A simple multiplication of estimated population numbers and average size gives only a very rough approximation of biomass. The accuracy of these estimates has been improved by taking into account the variable summer/winter distribution. Additional future improvements will consider size of different age classes and amount of time spent at sea, although estimates for fur seals in this paper do include the amount of time spent at sea.

Estimates of food consumption were made by multiplying biomass by number of days (based on a 6 month season) by a daily consumption rate as percent of total body weight. The data collected by the Marine Mammal Division are extensive enough to provide reasonable data for fur seals.

Estimates of food consumption for northern fur seals are shown in Table 3. Annual consumptions derived for these seals assume a daily consumption rate of 7.5% of the body weight. Most consumption rates have been calculated for animals held in captivity; they have ranged from 6% to 8% for fur seals (Scheffer, 1950) and harp seals (Geraci, 1972; Sergeant, 1973). Where direct data were noc available for other pinnipeds rates determined for fur seals were used as a first approximation. Therefore, a daily consumption rate of 7.5% of the body weight was also used for these other species. However, future data will lead to improved estimates of rates for the species.

Table 3. -- Estimates of total annual or seasonal food consumption by northern fur seals from the Pribilof Islands.

Estimated herd size (thousands)	Area	Season	Food consumption (thousands of metric tons)
1,530	North Pacific	Annual	689 1/
1,300	S.E. Alaska, Bering Sea	Annual	318-340 2/
37	Aleutians	June-Nov.	25.5
97	Aleutians	Dec.-May	67.0
550	Eastern Bering Sea	June-Nov.	379.7
97	Eastern Bering Sea	Dec.-May	67.0
66 3/	Gulf of Alaska	Annual	91.1
849 4/	South of Alaska	Dec.-May	448.6
1,300	North Pacific	Annual	1078.9

1/ Scheffer (1950)

2/ Ancel Johnson (pers. comm.)

3/ Average of summer and winter months

4/ Assumes age and weight composition of 25% yearlings at 10 kg, and 75% "other" at 48 kg.

Estimates of the total annual or seasonal food consumption by northern fur seals in the North Pacific Ocean and waters off Alaska are given in Table 3. The average amount of food consumed annually by fur seals in the North Pacific Ocean is estimated to be nearly 1.1 million metric tons, based on a present population estimate of 1.3 million animals. This value is much larger than that of 689 thousand metric tons estimated by Scheffer (1950) when the population was larger. A.M. Johnson (pers. comm.) recently estimated that fur seals in the eastern Bering Sea annually consume 318-340 thousand metric tons. Using a consumption rate of 7.5% of the body weight, an average annual value of 442 thousand metric tons has been obtained for the eastern Bering Sea (Table 3). Sanger (1974), using a consumption rate of 6.1% of the body weight, obtained an estimate of 357 thousand metric tons which is similar to the value obtained by A.M. Johnson.

The Marine Mammal Division, NMFS, has also collected extensive data on the amount and type of food found during examination of fur seal stomach contents. The proportionate weight by food type, based on data from pelagic research during the summers of 1968 and 1973 (NMFS, 1970; 1974), is shown in Tables 4 and 5. Finfish comprise nearly 90% of fur seal diets in the eastern Bering Sea (Table 4) and 70% of fur seal diets in the Aleutian area (Tabel 5). In both areas, walleye pollock represents over half of the finfish portion of the fur seal diet.

The length distribution of walleye pollock, unidentified fish also belonging to the family Gadidae (which were probably pollock too, as pollock were the only other gadids identified) and Greenland turbot found during examination of fur seal stomachs collected for pelagic research in the eastern Bering Sea in 1973 is shown in Figure 3, together with prerecruit limits for these fish. The minimum recruit size for fish entering the commercial fishery is 20 cm for walleye pollock and 22 cm for turbot (Bakkala, pers. comm.). It should be emphasized that fish eaten by fur seals are generally of prerecruit size, as evident in

Table 4. --Estimated amount of food consumed by northern fur seals in the eastern Bering Sea, by food type, based on relative food consumption observed during July-September 1973.

Food type	Percent of total 1/	Proportionate weight of food consumed (in thousands of metric tons)		
		Summer	Winter	Annual
Walleye pollock	67	254.4	44.9	299.3
Unidentified gadid	15	56.9	10.0	66.9
Gonatid squid	11	41.8	7.4	49.2
Bathylagid smelt	4	15.2	2.7	17.9
Greenland turbot	2	7.6	1.3	8.9
All others	1	3.8	0.7	4.5
Totals		379.7	67.0	446.7

1/ NMFS, 1974.

Table 5. --Estimated amount of food consumed by northern fur seals in the Aleutian area of Alaska, by food type, based on relative food composition observed between Kodiak Island and Unimak Pass, May-August, 1968

Food type	Percent of total 1/	Proportionate weight of food consumed (in thousands of metric tons)		
		Summer	Winter	Annual
Walleye pollock	37.8	9.6	25.3	35.0
Gonatid squid	30.8	7.8	20.6	28.5
Atka mackerel	16.3	4.2	10.9	15.1
Capelin	7.4	1.9	5.0	6.9
Salmonidae	5.1	1.3	3.4	4.7
All others	2.6	0.7	1.7	2.4
Totals		25.5	67.0	92.5

1/ NMFS, 1970.

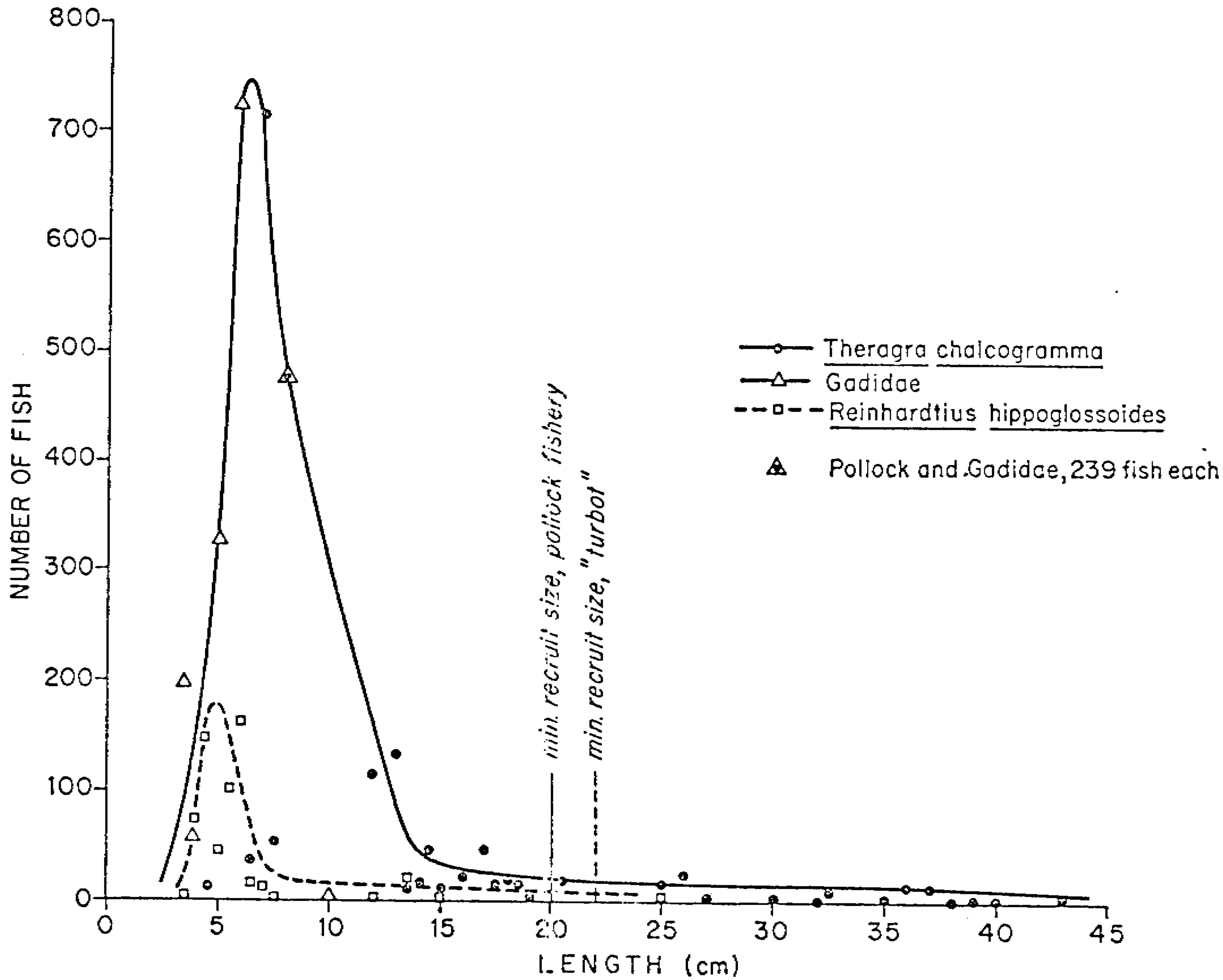


Figure 3. Approximate length distribution of pollock (Theragra chalcogramma), unidentified fish belonging to the family Gadidae, and Greenland turbot (Reinhardtius hippoglossoides) in fur seal stomachs from the eastern Bering Sea, July-September 1973. The minimum sizes the fish enter their respective fisheries are also noted ("turbot" here represents the minimum recruit size for the turbot fishery which includes arrowtooth flounder in addition to Greenland turbot; Bakkala, pers. comm.)

Figures 3 and 4. It should be noted that the data used to construct Figures 3 and 4 represent the total amount of fur seal stomachs in a season containing fish of measurable size. The contents of a large number of fur seal stomachs were in a state of digestion that did not permit identification of the partly consu fish. Also, the areas in which fur seal stomachs were collected varied throughout the season in each of two years.

Similar methods have been used to estimate food consumption by other pinnipeds. We have made a best estimate for each species of that percentage of total consumption which is finfish. Where data have been lacking or inconclusive, we have used rates observed for fur seals as a first approximation; yet recognizing that the food consumed by other seals will often be species different from those selected by fur seals. Some species, for example, ringed seals, appear to avoid squid completely, while squid form a major component of fur seal diets. Tables 6 and 7 show consumption figures and data sources for northern fur seals, northern sea lions, harbor seals, ringed seals, ribbon seals, and bearded seals in the eastern Bering Sea. Total food consumption by pinnipeds in this area is estimated to be 4,223 thousand metric tons per year, of which fur seals account for approximately 447 thousand metric tons, or about 18% of the total finfish consumed. Northern sea lions account for over one-third of the total finfish consumption (Table 7).

Tables 8 and 9 show similar calculations for the Aleutian area of Alaska. Concumption in the Aleutian area is about one-third of eastern Bering Sea shelf values, with northern sea lions again being the largest single consumer of fish.

Figure 4. Length frequency distribution of walleye pollock, Theragra chalcogramma, in fur seal stomachs from the eastern Bering Sea, July-September 1974.

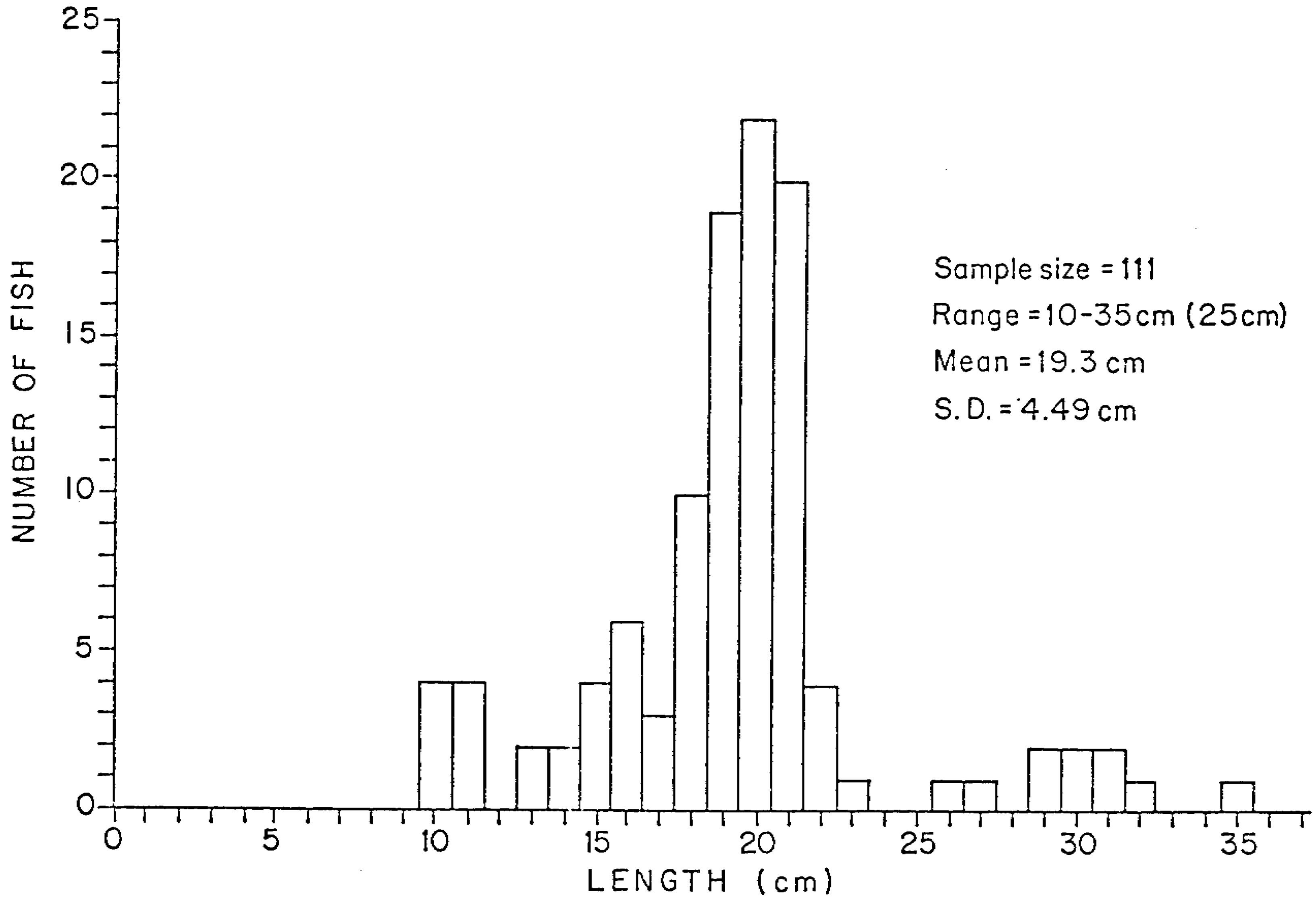


Table 6. -- Food consumption by pinnipeds in the eastern Bering Sea shelf (thousands of metric tons).

Species	Summer	Winter	Annual	Percent of total
Northern fur seal[1/] (*Callorhinus ursinus*)	380	67	447	11
Northern sea lion[2/] (*Eumetopias jubatus*)	549	275	824	19
Harbor seal[2/] (*Phoca* sp.)	365	605	970	23
Ringed seal[2/] (*Pusa hispida*)	112	223	335	8
Ribbon seal[2/] (*Histriophoca fasciata*)	55	110	165	4
Bearded seal[2/] (*Erignathus barbatus*)	494	988	1,482	35
Subtotals	1,955	2,268		
Total	4,223			

1/ Consumption (rounded) from Table 3.

2/ Consumption based on biomass from Table 2. Average rate of consumption 7.5% of body weight per day and a season of 183 days: (biomass in metric tons) x 183 days x $\left(\frac{0.075}{\text{day}}\right)$ = seasonal food consumption.

Table 7. -- Annual food consumption of finfish by pinnipeds in the eastern Bering Sea (thousands of metric tons).

Species	Food 1/ (thousands of metric tons)	Percent finfish (w = winter s = summer)	Finfish consumption (thousands of metric tons)
Northern fur seal 2/ (*Callorhinus ursinus*)	447	84	375
Northern sea lion 3,4/ (*Eumetopias jubatus*)	824	90	742
Harbor seal 3,6/ (*Phoca* sp.)	970	50	485
Ringed seal 5/ (*Pusa hispida*)	112s/223w	90w/40s	246
Ribbon seal 7/ (*Histriophoca fasciata*)	55s/110w	90w/40s	121
Bearded seal 5/ (*Erignathus barbatus*)	1,482	10	148
Subtotals	4,223		2,117

1/ From Table 6.

2/ NMFS, 1974.

3/ Spalding, 1964.

4/ Fiscus and Baines, 1966.

5/ Johnson et al., 1966.

6/ Fiscus, pers. comm.

7/ Present estimate.

Table 8. -- Food consumption by pinnipeds in the Aleutian area (thousands of metric tons).

Species	Summer	Winter	Annual	Percent of total
Northern fur seal 1/ (*Callorhinus ursinus*)	26	67	93	10
Northern sea lion 2/ (*Eumetopias jubatus*)	225	340	565	57
Harbor seal 2/ (*Phoca* sp.)	163	163	326	33
Total			984	

1/ Consumption (rounded from Table 3).

2/ Consumption based on biomass from Table 2. Average rate of consumption 7.5% of body weight per day and a season of 183 days: (biomass in metric tons) x 183 days x $\left(\frac{0.075}{\text{day}}\right)$ = seasonal food consumption.

Table 9. --Food consumption of finfish by pinnipeds in the Aleutian area (thousands of metric tons).

Species	Food 1/ (thousands of metric tons)	Percent finfish	Finfish consumption (thousands of metric tons)
Northern Fur Seal 2/ (*Callorhinus ursinus*)	93	69	64
Northern Sea Lion 3,4/ (*Eumetopias jubatus*)	565	90	509
Harbor Seal 3,5/ (*Phoca sp.*)	326	50	163
Sub-totals	984		736

1/ From Table 8.
2/ NMFS, 1970.
3/ Spalding, 1964.
4/ Fiscus and Baines, 1966.
5/ Fiscus, pers. comm.

Comparisons with Fisheries Catch Statistics

The eastern Bering Sea is the source of a major commercial fishery harvested principally by Japan, the USSR, and South Korea. Japan resumed fishing operations in the Bering Sea in 1954 after an interruption during World War II. A harvest of yellowfin sole, herring, and pollock, primarily by Japanese and Russian fishing fleets, exceeded 2.3 million metric tons in 1972. These totals were expected to decrease to slightly over 1.7 million metric tons in 1975. The total sustainable fishery harvest of groundfish in the Bering Sea and Aleutians in 1975 has been estimated to be between 1.4 and 1.7 million metric tons, under present harvesting and environmental conditions (Table 10).

An analysis of catch and effort statistics and biological data indicate that the present high harvest levels of pollock in the eastern Bering Sea are exceeding sustainable levels (Alverson, 1975), as shown in Table 10. From an examination of all available information, U.S. fisheries scientists have indicated that the pollock fishery for the eastern Bering Sea shelf should be limited to a harvest of about 1.0 million metric tons.

Values derived for food consumption by pinnipeds have been compared with the commercial harvest and standing stocks in Table 11. Because the best available statistical data on the commercial fisheries combined both the Bering Sea and the Aleutian areas, we have included both areas in the values for pinnipeds for comparison purposes. It can be seen that consumption of finfish by pinnipeds is of the same magnitude as the commercial fishery, which is presently in a state of overfishing. Total consumption of finfish by pinnipeds in the eastern Bering Sea is estimated to be between 2 and 3 million metric tons, which is approximately equivalent to or slightly larger than the present commercial fishery. It should be noted, however, that pinnipeds eat different kinds of fish, and ice seals

Table 10. --Expected fisheries catch in the eastern Bering Sea and Aleutians in 1975 (thousands of metric tons). 1/

Country	Pollock	Pacific Ocean perch	Yellowfin Sole and other	Herring	Totals
Japan	1,100	11	214	18	1,343
USSR	210	148	---	30	388
Other	3	---	---	--	3
Total	1,313	159	214	48	1,734
Estimated Sustainable Yield	1,000	350		40	1,390

1/ Letter Oct. 17, 1975, Dr. D.L. Alverson to Hon. Mike Gravel, U.S. Senate.

Table 11. -- Consumption of fish in the eastern Bering Sea and Aleutian areas

	Thousands of metric tons
Estimated finfish consumed by fur seals 1/	439
Estimated finfish consumed by other pinnipeds 1/	2,414
Estimated finfish consumed by sea birds 2/	500
Estimated vertebrate predation	3,353
Estimated 1975 catch by commercial fishery 3/	1,734
Estimated total catch plus vertebrate predation	5,087
Estimated stock of all finfish 4/	17,000
Percent standing stock annually consumed by man and other vertebrates -- approx.	30%
Percent consumed by fur seals -- approx.	3%
Percent consumed by marine mammals and birds -- approx.	20%
Percent consumed by fisheries -- approx.	10%

1/ Table 7, Table 9.

2/ Using the value given by Sanger, (1972) that seabirds directly or indirectly consume 0.8% of the primary carnivore production in the subarctic Pacific regions, finfish consumption by seabirds in the Bering Sea and Aleutian areas may range from 60 to 600 thousand metric tons depending on which estimate of the average daily production rate and energy transfer coefficient given in Fig.2 is used to calculate seabird predation on finfish.

3/ Table 10.

4/ INPFC Documents 1680 and 1663 (Pruter, 1973). The estimate of the finfish stock includes only commercial species. Noncommercial species such as the ice-edge fish (arctic cod, saffron cod, sculpins, etc.) have been excluded. Therefore, percentage of the finfish stock consumed by several predator groups may be slightly high.

may not eat commercial species such as pollock as a fish of preference.

Consumption values in Table 11 were calculated under the following assumptions: (1) fur seals and man are direct competitors for the same species of fish, (2) a direct correlation may exist between the size of the fur seal herd and the amount of fish consumed as food and (3) the ecosystem is presently in equilibrium (which is probably not the case).

These values show that fur seals account for approximately 3% of all fish taken annually in the eastern Bering Sea, an amount equivalent to approximately 25% of the amount taken by the fisheries.

The effects which fur seals and other pinnipeds may presently have on the commercial fishery are still not yet clear. As stated above, fur seals as well as other marine organisms may impact on the potential catch as competitors with man, but they may also affect the potential growth of the fish populations. As mentioned earlier, the data from 1973 and 1974 in Figures 3 and 4 show that fur seals generally consume juvenilles of walleye pollock and Greenland turbot. However, pollock conusmed by fur seals in 1974, as shown in Figure 4, were in a size range approximately equal to that of fish being recruited into the commercial fishery. Therefore, fur seals may not only compete with man directly in consuming fish of catchable size, but may also affect the potential population growth of the fish themselves because of their predation of juvenille fish. There interactions between fur seals and their fish prey need to be determined.

It should be emphasized, however, that pinnipeds also eat noncommercial species of fish, and there is no direct equivalence between the commercial fish catch and pinniped assumption of finfish. Johnson et al, (1966), for example, has shown that ringed seals and bearded seals (when the latter species eat fish at all; it primarily feeds upon benthic invertebrates) eat mostly sculpins, saffron cod and Arctic cod. It is also important to consider geographic differences between the distribution of pinnipeds and fish and their different feeding niches. For example, Phocids may have a lesser interaction with commercial fish species, as compared to that by Otariids.

Conclusions

Although this report is preliminary and the first step in a detailed process of analyzing all known data on the feeding relationships of pinnipeds, it does appear to provide a good estimate of the range of finfish consumption by fur seals and other pinnipeds. Pinnipeds do consume a quantity of food consisting of both noncommercial and commercial fish stocks, especially pollock, which is nearly as great as that of the commercial fishery; although, the impact of fur seals is apparently not as great as that of other pinnipeds such as the northern sea lion. Also, the fact that finfish consumed by fur seals are generally of prerecruit size means that the potential size that the adult fish population can reach is affected. What effects present exploitations have on the fishery is not yet clear, but with overfishing by man at present and predation of juvenile fish populations by pinnipeds, fish, and other marine organisms, it may be difficult to achieve a maximum sustained yield in the fishery.

It must be emphasized that finfish are not the only food of pinnipeds. Squid actually form a higher percentage of fur seal diets than finfish by occurrence. Because organisms change their diet from one species to another in their food web as a given species becomes increasingly difficult to find, it might be true that fur seals will consume a greater amount of squid as the standing stocks of fish decrease. How other species might react to specific food species reduction is uncertain. The impact of pinnipeds on the fishery is a complex interaction, and further analyses of data on the ecosystem and trophodynamic relationships of pinnipeds and finfish are required before the system can be understood.

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FINAL REPORT

RU-77

ECOSYSTEM DYNAMICS BIRDS AND MARINE MAMMALS

Part II

Food Web Structure and Trophic Relations of Bering Sea Avifauna (Preliminary Report)

by

Gerald A. Sanger

September 1976

ENVIRONMENTAL ASSESSMENT OF THE ALASKAN CONTINENTAL SHELF

Sponsored by

UNITED STATES DEPARTMENT OF INTERIOR

BUREAU OF LAND MANAGEMENT

Prepared by:
Northwest Fisheries Center
National Marine Fisheries Service
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FOOD WEB STRUCTURE AND TROPHIC RELATIONSHIPS OF BERING SEA AVIFAUNA

This report summarizes published and unpublished information on population sizes, seasonal changes in distribution and abundance, and feeding behavior and food habits of murres (Uria spp.) and short-tailed shearwaters (Puffinus tenuirostris) in the eastern Bering Sea. Information Products one through six of the Work Statement for the subcontract are included, essentially completing Phase I of the Work Statement. This report is largely a compilation of basic information in tabular form and has minimal explanatory text.

The final report will expand this information base to include other ecologically important species of marine birds in the eastern Bering Sea, it will complete the documentation and explanatory text, and it will describe a provisional food web structure for the bird community. Thus, the information for Phase II of the Work Statement will be integrated with Phase III and presented in the final report.

BACKGROUND INFORMATION

Murres: Two circumpolar species of murres are present in the Bering Sea, the common murre (Uria aalge) and the thick-billed murre (U. lomvia). With body weights of nearly a kilogram, they are the largest members of the 19-species marine bird family Alcidae. In the eastern Bering Sea, they are highly sympatric on many breeding colonies. Their ranges at sea also overlap, although the thick-bill generally occurs farther offshore than the common murre, particularly in winter. The two species are difficult to distinguish at sea, even by trained observers. Hence, pelagic population data for the two species is usually lumped.

Information on pelagic population sizes is scanty, a fact which is complicated by the lack of reliable information on relative proportions of the populations occurring at sea and on the breeding colonies during the breeding season. Immatures probably do not return to land until at least their second year. Thus, total population size estimates are uncertain.

Shearwaters: Two congeneric species of shearwaters occur in the eastern Bering Sea, the sooty shearwater (Puffinus griseus) and the short-tailed shearwater (P. tenuirostris). Both species breed in the southern hemisphere during the boreal winter, migrate to the northern hemisphere in the spring, forage heavily in summer throughout much of the Subarctic Pacific Region, and migrate to the southern hemisphere again in the boreal autumn. A small proportion of the sooty shearwater population occurs in the Atlantic, but the entire world population of short-tails occurs in the Pacific Ocean.

The short-tailed shearwater population occurs much farther north than the sooty population, and is the dominant species of the two in the Bering Sea. There is apparently a zone of overlap in their distribution in the southern Bering Sea, but most of the sooty population occurs in the North Pacific proper. Like the two murres, these two shearwaters are very difficult to distinguish in the field.

INFORMATION RATIONALE

The information in this report is desinged to facilitate use in the initial list of DYNUMES ecosystem model components (Table 1) (Laevastu and Favorite, MS 1976). However, it is anticipated that while the final report will also contain this design, it will also suggest additional components to more realistically reflect the "real world" of the marine bird community as presently understood or believed to be. This information should be useful for future refinements of DYNUMES.

MURRE COLONIES

Table 2 lists the names and best available size information for the known colonies of common and thick-billed murres in the eastern Bering Sea. Figure 1 locates these colonies geographically. Even though this information is the best available, it should be noted that the size estimates need considerable refinement. Work on some intensively studied colonies has shown that murres have marked occupancy cycles on the colonies, and if a particular survey of a colony happened to coincide with when most of the birds were at sea, the colony size would be underestimated. Current intensive studies on a few selected colonies (Pribilofs, Cape Peirce) will help delineate this phenomenon much better, and thus give more reliable estimates of true colony sizes.

MURRE BREEDING CHRONOLOGY

The timing of events associated with breeding of murres is linked closely with their presence or absence on their breeding colonies and therefore with their distribution and density at sea. Table 3 outlines a generalized breeding chronology for murres in the southern Bering Sea, based on the observations of Matthew Dick (USFWS) at the Cape Peirce common murre colony in 1973. The timing of breeding is closely associated with the breakup of sea ice, so breeding occurs progressively later with increasing latitude. It seems probable that the more northern populations follow the ice edge as it retreats northward, and "drop behind" as the latitude of their particular colony is reached by the retreating ice pack.

SEASONAL PELAGIC DISTRIBUTION AND ABUNDANCE

Shearwaters: Shearwaters are completely absent from the Bering Sea in winter, yet they are the most abundant form of marine bird at sea in summer, outnumbering even the murres. The migration of shearwaters into the Bering Sea is explosively dramatic. During May 1976, an OCSEAP Fish and Wildlife Service observer stationed at Unimak Pass during a two-week period observed that shearwaters migrating northward through the pass increased from none to an average of 5,000 per hour.

This explosive influx of shearwaters into the Bering Sea is reflected also by the data of Shuntov (1972), as adapted by Sanger and King (in press) (Table 4). When the more recent and more comprehensive data on the pelagic distribution and abundance of shearwaters (and murres) obtained by the U.S. Fish and Wildlife Service in OCSEAP studies has been completely analyzed, a far more complete picture of shearwater numbers in the eastern Bering Sea will be available. Table 4 also suggests that the fall exodus of shearwaters from the Bering Sea is more leisurely, and a few birds (probably immatures) linger as late as November.

The important point bearing on the DYNUMES modeling efforts is that very little is known about what governs shearwater distibution within the Bering Sea once they get there. They may concentrate over the shelf break, but large concentrations have also been noted over the shelf itself (Shuntov 1961). They also have a decidedly clumped distribution (see Figure 2, discussed in more detail below), so it is difficult to assign specific density figures for the DYNUMES grid system, other than merely assuming average densities. Current OCSEAP studies (USFWS and Juan Guzman, University of Calgary) will probably shed light on this situation.

<u>Murres</u>: Two factors overwhelmingly influence murre distribution in the eastern Bering sea: the location of breeding colonies in spring and summer, and the location of seasonal pack ice in winter. Table 4 represents average conditions, and the only data reflecting either factor in these data is the decrease in bird density from spring to summer. With most of the population engaged in breeding, one would expect murre densities at sea to decrease.

Figure 2 demonstrates the pronounced orientation of murres to breeding colonies at the height of the breeding season, and also demonstrates how unrelated to land and how patchy that shearwater distribution can be. However, as far as ecosystem studies are concerned, it should be borne in mind that the mere presence of birds in an area does not necessarily coincide with their feeding there. This applies to shearwaters as well as murres. Similar data on murre distribution in relation to distance from the ice edge in winter will be included in the final report.

It would seem that a goal of realistically modeling murre distribution in the DYNUMES system would be to attempt to portray average densities within the DYNUMES grid which reflect distribution relative to breeding colonies and the ice edge. A way of accomplishing this could be to assume that the total populations are some number, say 7 million (information adapted from Sanger and King, Table 4, suggest a population of 6.8 million) in such a manner that their total would equal the total estimated population. As a start, "high", "medium", and "low" values reflecting observed densities in relation to colonies and the ice, could be used. The "high" densities would reflect concentrations near colonies and the ice edge, the "low" densities areas far from these, and "medium" densities a narrow band adjacent to the high densities (see Figure 2).

FEEDING METHODS AND BEHAVIOR

Table 5 summarizes the feeding behavior and methods of shearwaters and murres. The important points concerning ecosystem studies is that shearwaters are strictly epipelagic feeders, probably rarely obtaining their food deeper than 5 m, while murres are capable of exploiting the entire water column over much of the eastern Bering Sea shelf. Murres likely get much of their food from mid-depths to the bottom.

FEEDING HABITS

Data on feeding habits of murres and shearwaters in the eastern Bering Sea are very scanty (Table 6), but they suggest that murres feed heavily on fish (equivalent DYNUMES trophic component, Pollock I), and that shearwaters feed heavily on euphausiids. This view should be regarded as quite preliminary, and probably is not the case universally throughout the eastern Bering Sea. Anatomical, morphological, and behavioral studies on captive common and thick-billed murres by Spring (1971) suggest that the common murre is a fish specialist, but the thick-bill is better adapted to feed on a wider variety of prey. Wiens and Scott (1976) showed that common murres feed mostly on fish off the Oregon coast but euphausiids and other planktonic crustaceans sometimes account for as much as 27% of their diet. Preliminary data from U.S. Fish and Wildlife Service OCSEAP studies bear out Spring's (1971) theory that thick-billed murres can eat a wider variety of prey than common murres; squid, shrimp, and other crustaceans have frequently occurred in thick-billed murre stomachs, as well as fish. The main point of this preliminary information bearing on DYNUMES modeling is that the list of model components will have to be expanded if it is to realistically reflect the feeding habits of the marine bird community in the eastern Bering Sea.

MURRE AND SHEARWATER FEEDING RATES

Estimates of the rate of food intake for murres was summarized by Sanger (1972), and ranged from 8% to 25% of body weight per day.

There is no published information on feeding rates of shearwaters, but circumstantial evidence from U.S. Fish and Wildlife OCSEAP marine bird feeding studies suggests that shearwaters could consume as much as 20% of their body weight per day. Analysis of shearwater stomach samples is incomplete, but the maximum weights of the contents from incompletely full stomachs has ranged up to 125 grams. For a 700-gram bird, this is 18% of the body weight. It is probable that a shearwater could easily hold 150 grams of food, and it is not unreasonable to assume that they fill up with food on an average of once per day. Thus, a food consumption rate of 20% per day for shearwaters seems possible. Further, without exception, shearwaters examined thus far which were collected in summer have had very heavy fat deposits, suggesting that their food has been plentiful regardless of their stomach contents at the time of collection.

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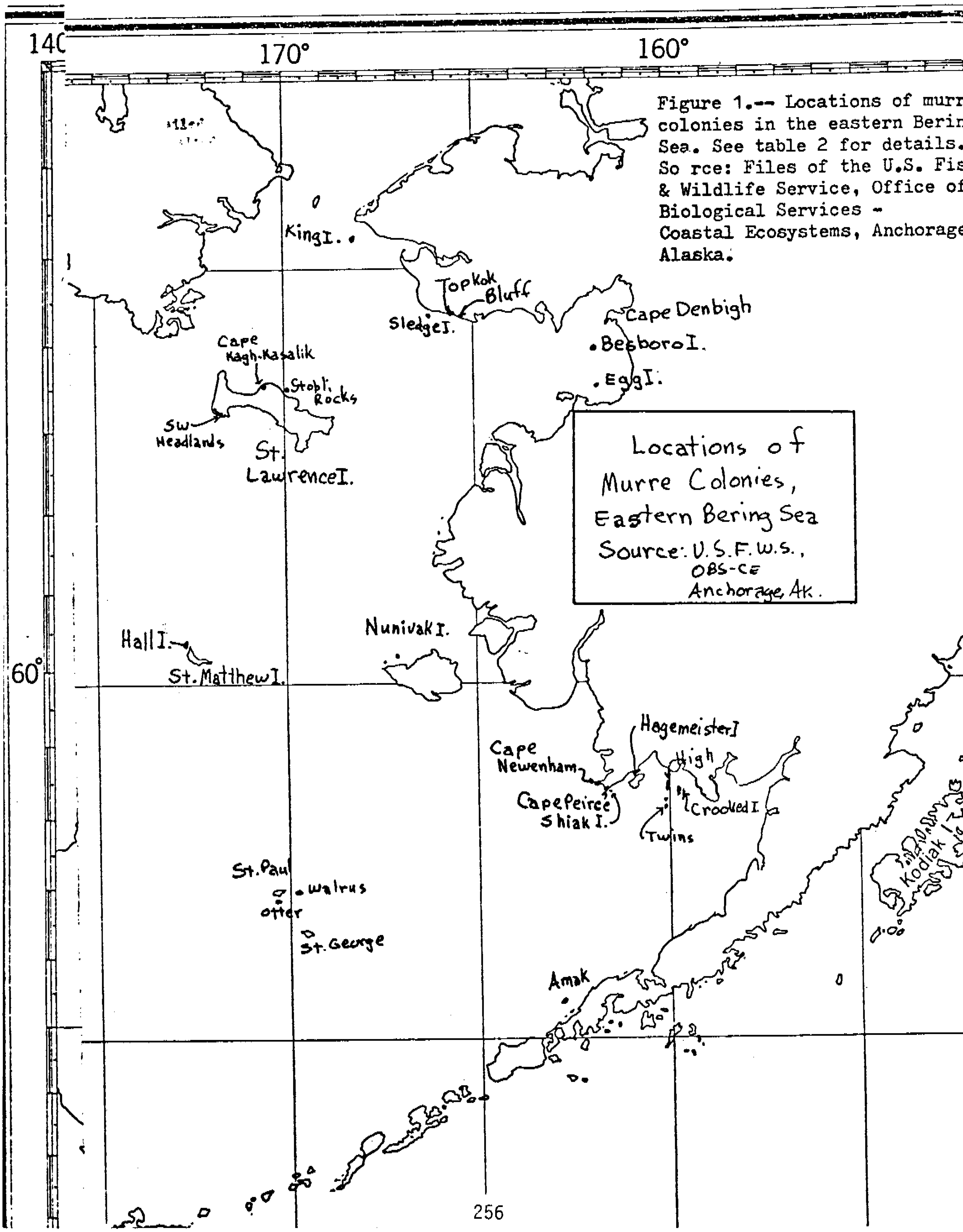
140
170°
160°
60°
Figure 1.-- Locations of murr
colonies in the eastern Berin
Sea. See table 2 for details.
So rce: Files of the U.S. Fis
& Wildlife Service, Office of
Biological Services -
Coastal Ecosystems, Anchorage
Alaska.
King I.
Topkok Bluff
Sledge I.
Cape Denbigh
Besboro I.
Egg I.
Cape Kagh-Kasalik
Stobli Rocks
SW Headlands
St. Lawrence I.
Locations of Murre Colonies, Eastern Bering Sea
Source: U.S.F.W.S., OBS-CE Anchorage, Ak.
Nunivak I.
Hall I.
St. Matthew I.
Hagemeister I
High
Cape Newenham
Cape Peirce
Shiak I.
Crooked I.
Twins
St. Paul
Walrus
Otter
St. George
Amak
Kodiak I.

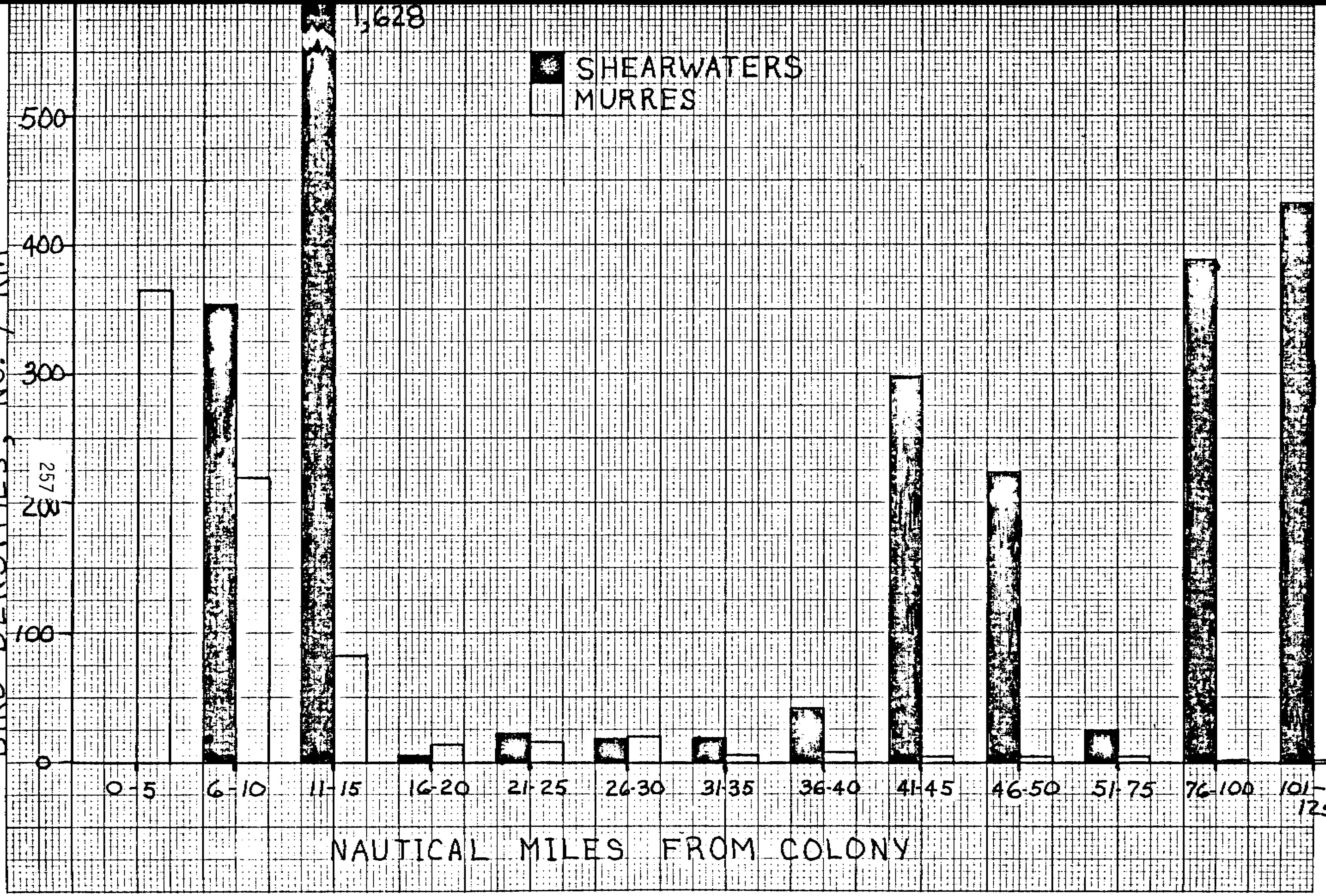

Figure 2. Relative densities of murres and short-tailed shearwaters in relation to distance offshore from the Cape Newenham murre colony (northern Bristol Bay), 15 July 1973. (Unpublished data, U.S.F.W.S., Office of Biological Services, Anchorage, Alaska.

Table 1. List of model components for initial trials of the eastern Bering Sea ecosystem model, "Dynamical Numerical Marine Ecosystem Model," (DYNUMES) (Laevastu and Favorite, MS 1976)

Ichthyoplankton

Euphausiids

Benthos (decapods, etc.)

Pollock I (0-30 cm)

Pollock II (30-40 cm)

Pollock III (> 40 cm)

Herring

Fur Seals

Bearded Seals

Murres

Shearwaters

Table 2. Murre colonies of the eastern Bering Sea. Source: Files of the U.S. Fish and Wildlife Service, Office of Biological Services - Coastal Ecosystems, Anchorage, Alaska. X = present as a breeder or as dominant species; P = present but not breeding.

Location	Breeding Status		Dominant Species		Estimated Colony Size, Thousands of Birds
	Common	Thick-billed	Common	Thick-billed	
King Island	X	X	X		10's
Sledge Island	X	X	X		low 1's
Topkok Head	X	X			?
Bluff Head	X	X			?
Cape Denbigh	X	X			?
Besboro Island	X	X			?
Egg Island	X	P	X		?
Stobli Rocks	X	P	X		?
Cape Kagh-Kasalik	X	P	X		?
SW Headlands	X	P	X		?
Nunivak Island	X		X		?
St. Matthew Island	X	X			10's
Hall Island	X	X			10's
Cape Newenham	X		X		high 100's
Cape Peirce-Shiak Is.	X		X		high 100's
Hagemeister Island	X				?
High Island	X		X		10's
Crooked Island	X		X		?
Twins Island	X		X		high 100's
Amak Island	X				?
St. George Island	X	X		X	high 100's
St. Paul Island	X	X		X	high 100's
Otter Island	X	X		X	10's
Walrus Island	X	X		X	100's

Table 3. Generalized breeding chronology for murres in the southeastern Bering Sea. Breeding is progressively later with increasing latitude, occurring 3-4 weeks later near Nome.

Approximate Dates	Events
Late April	Birds begin concentrating near colonies; a few aggregate on the colonies.
May	Numbers of birds and their duration on the colonies increase.
Early June	Copulation and egg laying commences. Birds concentrated on and very near colonies probably comprise 60-80% of the populations.
Early July to mid-August	Eggs begin hatching. Chicks on colonies fed by adult birds.
Late July to early September	"Sea going" of chicks.

Table 4. Seasonal abundance cycles of short-tailed shearwaters and murres in the eastern Bering Sea. Bird densities are from Shuntov (1972) and the bird population sizes are adapted from Sanger and King (in press). Population sizes assume the eastern Bering Sea shelf is one million km^2.

Season	Sample Size[1]	Murres (*Uria* spp.)			Short-tailed Shearwater		
		Density birds/100km^2	Numbers millions	Biomass[2], M tons	Density birds/100km^2	Numbers Millions	Biomass[3], M tons X 10^3
December-March	170	680	6.8	6.1	---	---	---
April-May	460	460	4.5	4.1	720	7.2	5.0
June-August	280	270	2.7	2.4	702	7.0	4.9
September-November	130	240	2.0	1.8	240	2.4	1.7

1 Number of transects of 30 or 60 minutes (V.P. Shuntov, personal communication).

2 Assumes average murre weight of 0.9 kg.

3 Assumes average shearwater weight of 0.7 kg.

Table 5. Summary of feeding behavior and methods by murres and short-tailed shearwaters.

Species	Method Used For: Underwater Propulsion	Method Used For: Feeding	Method Used For: Food Capture	Portion of Water Column Prey Captured From	Maximum Feeding Depth
Short-tailed Shearwater	Feet and Wings	Pursuit diving, pursuit plunging, some surface seizing.	Grasps prey one at a time in bill, swallows whole, underwater or surface.	Near surface	$\geq$5 M
Murres	Wings	Pursuit diving	Grasps prey one at a time in bill, swallows whole underwater or at surface. Adults feeding chicks carry whole prey to chicks on land.	Mid depths to bottom (epibenthic).	$\geq$40-60 M

References: Ashmole (1971); Tuck (1960); Brown *et al* (in prep).

Table 6. Food habits of murres (Uria spp.) and short-tailed shearwaters in the eastern Bering Sea (adapted from Ogi and Tsujita 1973).

Prey Item	Prey Lengths, cm.	% Composition (weight)	Equivalent DYNUMES Trophic Component
	Murres (Uria spp.), N = 163		
FISH		72	Pollock I
Pollock	10-24		
Sandlance	5-20		
Capelin	11-12		
EUPHAUSIIDS		15	Euphausiids
SQUID		8	Euphausiids
OTHER		5	Euphausiids
	Short-tailed Shearwaters, N = 29		
FISH Sandlance	-	tr	-
EUPHAUSIIDS		100	Euphausiids

FINAL REPORT

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ECOSYSTEM DYNAMICS BIRDS AND MARINE MAMMALS

Part III

A Dynamic Numerical Marine Ecosystem Model for Evaluation of Marine Resources in Eastern Bering Sea

by

Taivo Laevastu, Felix Favorite, and W. Bruce McAlister

September 1976

ENVIRONMENTAL ASSESSMENT OF THE ALASKAN CONTINENTAL SHELF

Sponsored by

UNITED STATES DEPARTMENT OF INTERIOR

BUREAU OF LAND MANAGEMENT

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DYNAMICAL NUMERICAL MARINE ECOSYSTEM MODEL (DYNUMES)
AND EVALUATION OF MARINE RESOURCES IN EASTERN BERING SEA

by

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Northwest Fisheries Center
Seattle, Washington

ABSTRACT

The objective of this project is to design and program a complete marine ecosystem model for quantitative evaluation of: the effects of man, environmental changes (anomalies), and interspecies interactions on the dynamics of marine ecosystem, with emphasis on economically important species. The five basic groups of components in this model are: (1) static components (e.g. depth, type of bottom); (2) dynamic environmental components and factors (e.g. temperature, mixed layer depth); (3) dynamic biological components and factors (e.g. transient stocks of species, composition of food, feeding rates); (4) effects of man (e.g. fishing effort); and (5) "feedback channels" (e.g. interspecies competition for food).

The concept and design of Dynamical Numerical Marine Ecosystem Model (DYNUMES) is described and results obtained from an 8-component version of the model are presented in some detail. In the time-dependent, two-dimensional model some of the transient stocks are prescribed as first guess input fields together with available information on their seasonal migrations, and various coefficients (such as growth) are introduced. In the process of tuning of the model, the first guess fields and various coefficients are changed to arrive at plausible sustainable transient stocks of species and

groups of species. Much of the descriptive biological information has been converted from descriptive into numerical form through the use of special restrained functions, and many numerical modeling approaches from meteorological/oceanographic models are also utilized. This tuning process indicates the need for further basic and applied research in various subjects which are pointed out.

The use and utility of the DYNUMES model is tested with the 8-component submodel and results indicate several phenomena within the ecosystem that have received little attention in the past research, but which seem to be among major determinants of the balance within the system. One of the general conclusions from the use of the model is that availability of food is a limiting factor for most ecological levels and groups. Furthermore, the model indicates that some transient stocks, such as pollock, have long-term periodicities of abundance, caused by interactions of several factors determining their abundance. The use of the submodel also demonstrates that the dynamics of marine ecosystem and man's effect on it can only be ascertained in detail with a rather sophisticated, reasonably complete model.

I. INTRODUCTION

Although need for multispecies analyses of living marine resources has been recognized and some attempts at ecosystems models (largely estuarine) are suddenly prevalent in the literature, the scope and intensity of the OCSEAP program signalled an opportune time had come to initiate development of a model which would define and quantify the interrelationships of major physical and biological components of a marine ecosystem, and which could be expanded iteratively on the basis of its outputs and acquisition of new knowledge. The eastern Bering Sea provides a somewhat optimum area for such a study--the available data are adequate, the present studies provide information to test some aspects of initial formulations, and future studies could verify the validity of model results. Initially our OCSEAP proposal called for only a conceptual Bering Sea ecosystem model with two components--mammals and birds. However, even before background studies were completed (McAlister and Perez, 1976; Sanger and King, 1976), it was apparent that even a gross understanding of the ecosystem required additional components and interactions of plankton and fish were also incorporated. This resulted in an 8-component model. Because continued funding was anticipated, some effort was expended in assessing the ultimate structure of a total ecosystem model, a Dynamic Numerical Marine Ecosystem (DYNUMES) Model.

A dynamic marine ecosystem model permits simulation of the statics and dynamics of standing stocks of various species and groups of species (i.e. abundance and distribution) in space and time as affected by interspecies interactions (e.g. predation), environmental factors (e.g. temperature, currents) and the activities of man (e.g. fishing), which are depicted in model outputs. Thus, energy requirements of trophic levels and realistic hypotheses as to constraints on population growths can be formulated. Figures 1 and 2 show schematically the concept and general processes computed; these consist of five basic groups: (1) static factors which are prescribed in digital form, and do not change during computations such as the grid net with sea-land table and depth of water; (2) dynamic environmental factors, which are either extracted from other environmental analysis/forecasting models or computed with special subroutines in an ecosystem model (e.g. mean monthly temperature and its anomalies, current); (3) various biological components, which are nearly all dynamic as is the case with living organisms in general; (4) components consisting of factors dependent on man, such as fishing mortality; and (5) "feedback channels" (i.e. interconnected computational loops), which allow iterative solutions to be sought if, when, and where factors and interactions are changed which affect the changes of other processes and quantities.

The model is initialized with the best available data on standing stocks of essential components and their spatial distributions at an initial stage (e.g. January). The best available information on trophic relationships, feeding rates and other interspecies interactions, seasonal migrations, sensitivity to environmental changes, and/or optimum environmental requirements for the various components, are prescribed in numerical form on a month to month basis. In addition, all available pertinent models and modeling techniques, such as the conventional population dynamics models, are used in modified form as parts of various subroutines. Some concepts of "energy flow" models have also been used, but in different form--i.e. in the form of the "flow" of biomass.

The main objectives of any numerical modeling scheme of a marine ecosystem are defined by its prospective use. The primary prospective uses of the ecosystem model presented in this report are tailored to OCSEAP's objectives, and fall into the following three categories: (1) synthesis of the

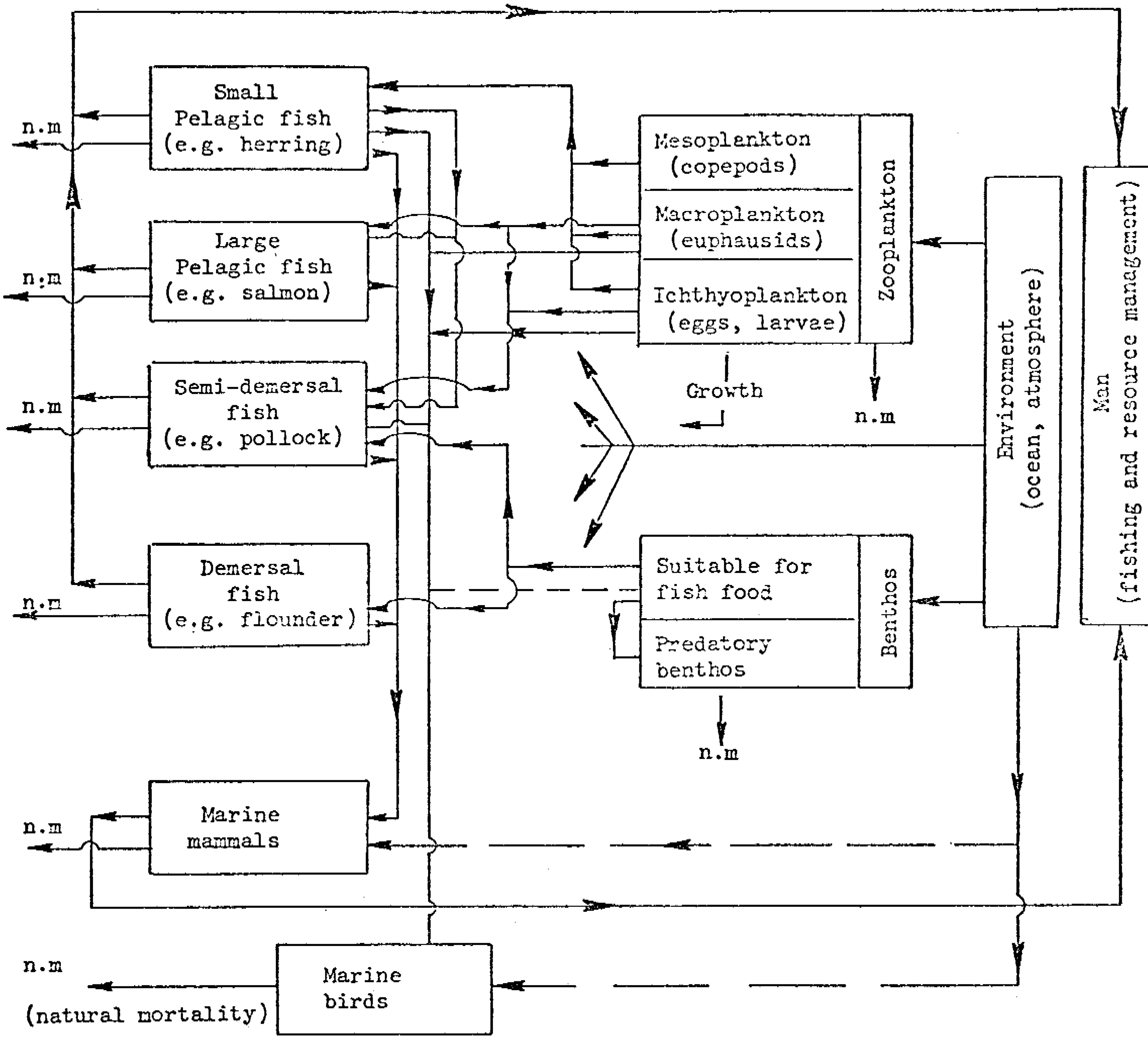

Figure 1.--Generalized scheme of major components of dynamic marine ecosystem model.

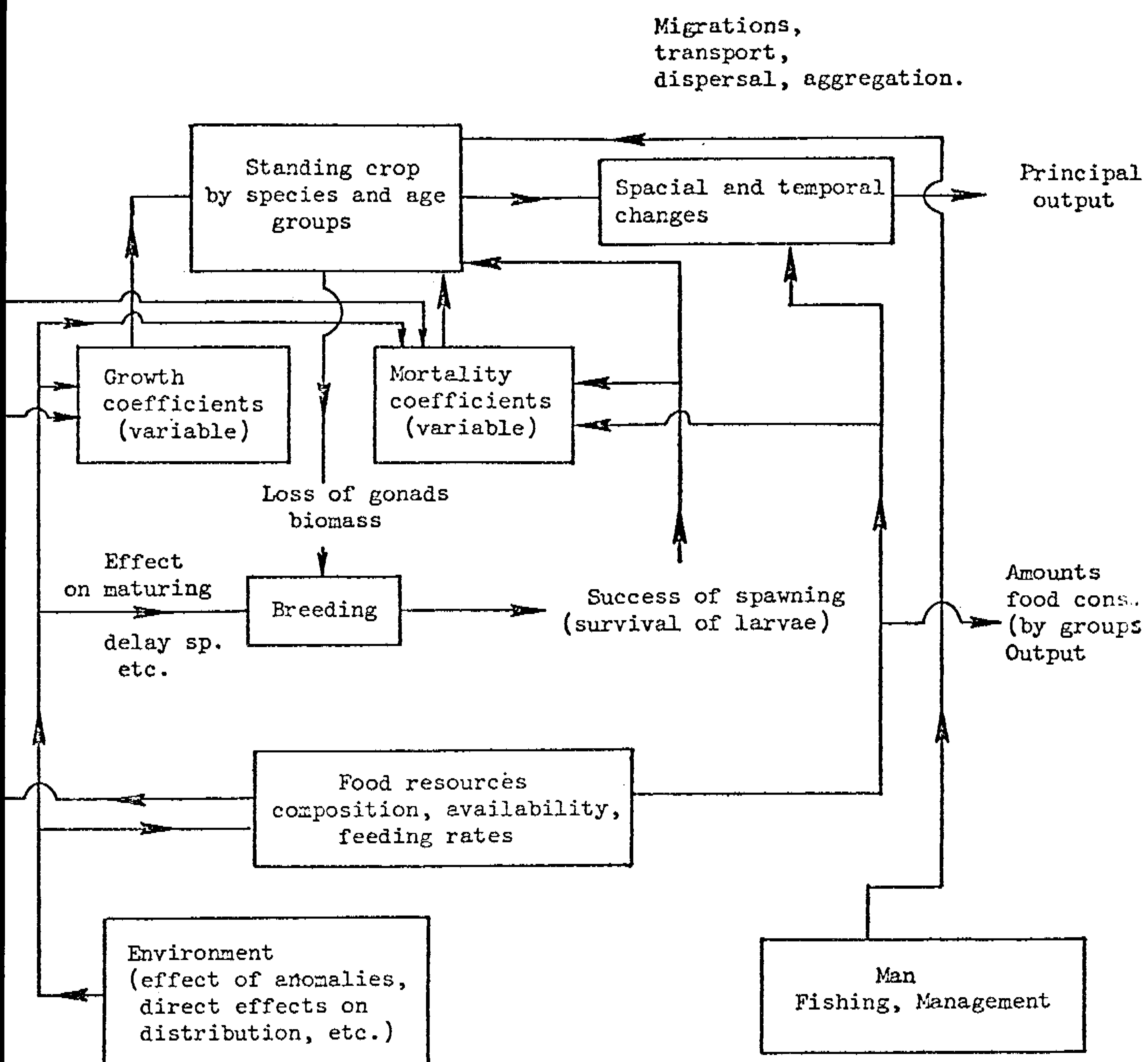

Figure 2.--Principal processes in a dynamic marine ecosystem model.

results of baseline studies (i.e. ascertaining of the present state of populations and their interactions) before exploration and exploitation of the continental shelf oil resources; (2) estimating the magnitudes of natural fluctuations of abundance and distribution of living resources and thus distinguishing these fluctuations quantitatively from any man-made changes as a result of oil exploration and exploitation; and (3) investigating the possible magnitudes and geographical extents of any man-made changes in the ecosystem. In addition to the above specific uses, the model can be utilized to solve other practical as well as scientific problems such as: (1) the evaluation of the effects of exploitation, which permits achieving optimum management of marine resources; (2) the evaluation of the effects of environmental conditions (e.g. climatic changes) and short- and medium-range anomalies on the exploitable resources and on the marine ecosystem at large, and (3) the reduction of all quantitative and descriptive data into easily accessible and reviewable form assists in the determination of additional research needs and priorities.

It is expected that a multitude of additional uses and applications of the model will arise as a relatively complete ecosystem model can be used as an encyclopedia for the extraction of various information, as well as a system for prognostication of plausible data on missing data and on future conditions.

II. BASIC MODEL DESIGN

A. Computational Grid and Inputs and Outputs

In the initial formulation the model is essentially a time-dependent, two dimensional model, whereby the third dimension (e.g. depth distribution of species, distribution of temperature and currents, etc. with depth) applies implicitly in some parts of the model. A basic, two-dimensional grid for the eastern Bering Sea model (Fig. 3) is an equal-area rectangular grid, which is a subset of NOAA/NWFC standard hemispheric grid. The grid size at 60° North is

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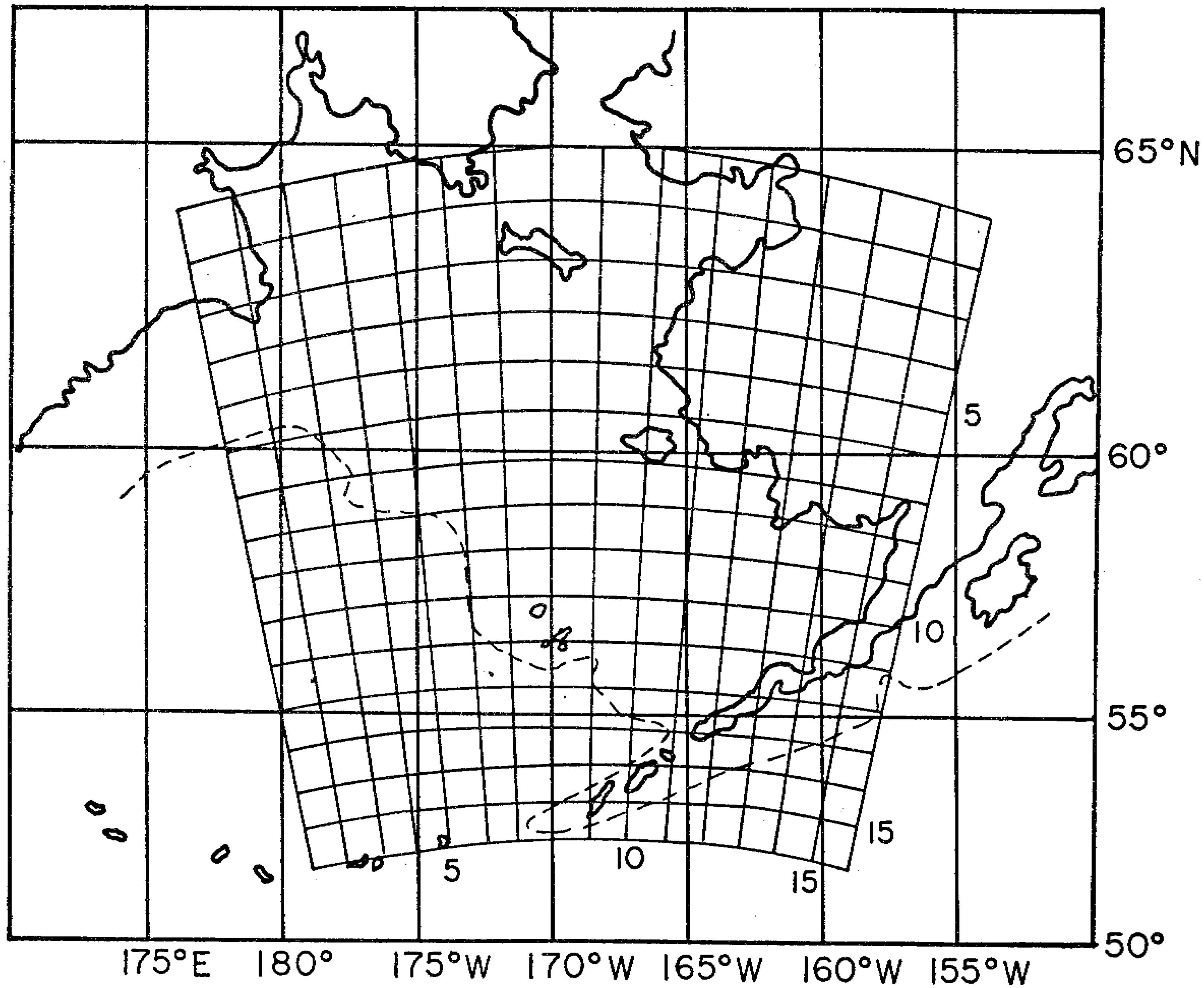


Figure 3.-Computation (model) grid for Eastern Bering Sea drawn on a Mercator projection.

95.25 km. Although the size of the basic grid is determined by the economy of the computer core and time requirements/availability, it is often necessary to look at the distributions and dynamics of a given species at a given restricted location (e.g. on spawning grounds) in much greater detail than the relatively coarse grid allows. For this purpose a zooming technique can be provided in the model, whereby detailed computations are carried out in fine grid inserts by special instructions for which the boundary and initial values are obtained from a large scale model and its subroutines. The zooming techniques allow modeling and consequent verification of research planning of the micro- and meso-scale effects of environmental changes, such as determining the consequences of a displaced and delayed spawning, and formulating detailed prognostications of the location and timing of fish aggregations that aid in management decisions.

In order to obtain realistic results, any model requires an initial extensive input of various knowledge and data. Static input parameters for the model (e.g. depth) have been obtained from available charts. The dynamic environmental input parameters will be mostly obtained from separate environmental analysis/forecasting models. Subroutines will be provided for the input of some environmental data (e.g. in form of anomalies), obtained either as observational data at a few points or as test and research modes to study the response of the ecosystem to possible changes and/or anomalies. This is accomplished with a separate analysis programme which uses a first-guess field (e.g. time-interpolated climatology) and analyses the new introduced "observations" at specified locations into the first-guess field with a variable (determinable) smoothing coefficient.

The initial inputs are digitized in the grid, (shown in Fig. 3), punched on cards and read in main subroutine. The sea and land table uses indices at present (3-land, 2-<200m depth, 1->200m), whereas future versions will use actual depths. A special indices field divides the Bering Sea into specific regions (e.g. coastal areas S and N, central shelf, continental slope area, deep sea, etc.). This special indices field is used to create various area-dependent distributions, such as bird and zooplankton standing stock distributions. Monthly ice cover is also punched in the grid as is the initial distribution of fish and monthly distribution of fur seal. Monthly "fishing intensity" is introduced as relative indices at grid points and tuned to quantitatively meaningful values later in the programme.

The input of biological information to the model is either in form of first-guess fields of distribution and abundance, derived from available descriptions in literature, often as fragmented information, or as dynamic variables such as migration directions and speeds, including aggregation and dispersal. The latter information, although given initially as direction and speed, is decomposed into u and v components. Much of the other biological information is given either as time-dependent variables for a given species (e.g. pollock) or groups of species (e.g. copepods) in the form of seasonal variation of composition of food and changes of growth rate with time and/or age, or as predetermined coefficients, such as feeding rates or food requirements for maintenance and growth and optimum temperature requirements (temperature preference limits).

Several of the initially prescribed input coefficients will not remain constant during the computation, but are made dependent variables in certain conditions with the use of restrained functions (briefly described in next chapter), such as composition of food and feeding rates, which can become functions of food (prey) density as well as predator density. The natural mortality coefficients (in our model only "death from old age" and from diseases) are also initially estimated and introduced into the model. The grazing, which in conventional population dynamics models are included into natural mortality, is in our model computed separately as an important determinant. In the subsequent complete ecosystem model most of the coefficients will be made time and space dependent variables for a given year-class, species or group of species, which will then be changed during the course of computation.

The fishing mortality is used in the model as a time and space variable input, which can be changed by the operator during the course of the use of the model. When using the model as a decision making tool, variations in fishing mortality will in most cases affect the resultant abundance and distribution of the given species under consideration and will affect, in most cases, the statics and dynamics of the whole ecosystem.

The model outputs are tailored to the principal use of the model, both in a research, as well as in a decision-making, mode. Spacial distributions of abundance of any species can be extracted and displayed at any desired time step (e.g. monthly); time series outputs can be taken at any given point, or the static and dynamics of the entire stock can be summarized over the entire areas of the computational grid. Furthermore, the outputs are displayed on a C/R scope; thus, time series records can be projected and sequenced in any time frame.

B. Restrained Functions and Other Formulas

Much use must be made of "restrained functions" in an ecosystem model which uses descriptive information converted into numerical form. These functions are not new or "revolutionary", but are essentially widely used programming techniques in semi-mathematical form. The IF statement in FORTRAN is a multipurpose, powerful tool for "solving" the restrained functions, and has been used frequently by scientists and programmers in all kinds of models and programs. It essentially allows the specific test of conditions and specifications for different types of formulations (or changing coefficients) if and when the specified conditions are or are not fulfilled. An example of the use of a restrained function for presentation (and computation) of temperature preference limits and effects on the distribution of a given fish species is given below.

If: $T_w > T_1$ and $T_w < T_2$, then $\vec{W}_t = 0$ and $\frac{\partial Bt}{\partial t} = 0$

If: $T_w < T_1$, or $T_w > T_2$, then

(I.) $\frac{\partial B_t}{\partial t} = - \underline{\vec{W}} \cdot \nabla B$ which in forward time, backward space, finite difference approximation is : $B^{t+1}_{t,m} = (1 - \sigma)\, B^{t}_{t,m} + \sigma B_{t,m-1}$

Symbols:

T_w - actual water temperature

T_1, T_2 - lower and upper limits of optimum temperature for a given species. Both can be changed annually, if this change is known or deduced from distribution maps:

(II.) $T_1 = T_{1a} + T_{1c} \cos(\alpha t - \mathcal{H}_1)$; $T_2 = T_{2a} + T_{2c} \cos(\alpha t - \mathcal{H}_2)$

T_{1a}; T_{2a} - mean optimum temperature limits

T_{1c}; T_{2c} - magnitudes of annual change

α - phase speed (30° per month)

$\mathcal{H}_1, \mathcal{H}_2$ - phase angles (allows e.g. narrow temp. tolerance during spawning if $\mathcal{H}_1$, and $\mathcal{H}_2$ are different).

t - time

$\vec{W}$ - migration speed and direction (i.e. by u and v components) caused by temperature effects, function of $T_w - T_1$ and/or $T_w - T_2$ gradients).

$\frac{\partial Bt}{\partial t}$ = biomass change caused by "temperature" migrations

m - grid point

σ - $\vec{W} \frac{\Delta t}{\Delta x}$, Δx is grid size, Δt is time step

The general principle of the above formulation is that a check of temperature at the grid point at time t and t+1 is made and compared to the temperature optimum curve for a given species. If the temperature falls within the "slopes" of the tolerance curve (i.e. outside the optimum temperature limits), the fish is moved towards the optimum temperature by changing the u or v component of the migration (movement) field in the direction of the optimum temperature in proportion to the deviation of the actual temperature from the prescribed optimum.

Additional examples of some types of simple formulas applied in the model are given below. The formula (III) is an example of a slightly modified population dynamics formula for presentation of fishing mortality.

(III.) $B_{t,m,n} = B_{t-1,m,n}\, e^{-K_{t,m,n}}$

Symbols:

$B_{t,m,n}$ - biomass at time t at grid point m, n

$K_{t,m,n}$ - fishing mortality coefficient, function of fishing effort, season location, age.

The fishing mortality coefficient in above formula is a different restrained function for each species and age group. In addition, a time-step dependent natural mortality (mortality from "old age" and diseases) coefficient is computed (also made a function of season and age group, if required). The fishing mortality is usually a space and time-dependent input coefficient.

The following harmonic type formula (IV) is for reproduction of an annual zooplankton standing crop curve.

$$Z_{t,m,n} = Z_{o,m,n} + Z_{c,m,n} \cos(\alpha_1 t - \mathcal{K}_1) + Z_{s,m,n} \cos(\alpha_2 t - \mathcal{K}_2)$$

Symbols:

Z - zooplankton biomass

$Z_o = Z_{max} + Z_{min}) /2$

$Z_c + Z_s = Z_{max} - Z_{min}$

α - phase speed

$\varkappa$ - phase angle

An example of a simplified trophodynamics formula is given below where food requirements for maintenance and growth are computed separately. The food coefficient will be made a function of availability of food (food density) in a complete ecosystem model.

$$\text{(V.)} \quad F_{mt} = \underbrace{B_t\ (2-e^{-k})\ g_r}_{\text{food for growth}} + \underbrace{d_m p B_t}_{\text{food for maintenance}}$$

Symbols:

F_{mt} - monthly food consumption of a given biomass (B_t) of a given age group.

g_r - food coefficient for growth (e.g. 1:3).

p - food coefficient for maintenance (expressed here as % of body weight per unit time (time step).

d_m - food density dependent feeding coefficient, similar to the expression of k below.

k - growth coefficient, function of age and availability of food: e.g.

$$\text{(VI.)} \quad k = k_b(k_p \frac{Z_{max} + P_{max}}{Z_t + P_t})$$

Symbols:

k_b - basic growth coefficient for unit time.

k_p - proportionality factor

Z_{max}, P_{max} etc. = annual maximum standing stock of principal food items at the given location

Z_t, P_t - standing stock of food items at time t.

The proportioning of food items in the following complimentary trophodynamics formula is also made a function of relative availability of these items at each grid point and time step.

(VII.) $Z_{cons} = A_t \times F_{mt}$

(VIII.) $A_t = A_o + A_v \cos(\alpha t - \mathcal{K}_A)$

Symbols:

Z_{cons} - amounts of given food item consumed (e.g. zooplankton).

F_{mt} - monthly food consumption of a given biomass.

A_t - proportions of given food item in the diet at time t.

A_o - annual mean of a given food item in the diet.

A_v - annual range of change of a given food item in the diet.

α - 30°

t - time

$\mathcal{K}_A$ - phase angle

The computational time step is variable throughout the model, as it is in some formulas dependent on satisfying the stability criteria (i.e. grid size and "speed" dependent), but the basic computational step can be selected with inputs as a week or up to a month.

C. Basic Logic and Organization of the 8-component Submodel

The present 8-component marine ecosystem submodel constitutes a conceptual model and is the first step in the development of a total ecosystem model. The selection of the biological components was somewhat arbitrary in view of the diversity of organisms in the Bering Sea. Two organisms in each of four categories (plankton, fish, mammals and birds) were selected, primarily as a result of dominance and/or distinctly different migration patterns so as not only to achieve representativeness, but also to tax the dynamic capabilities of the model. It is recognized that the omission of benthonic components may be a shortcoming of the present model, but provisions for incorporation have been made. This submodel, which is completely defined in the Appendix, has already produced useful results and has indicated the manner and priorities of its extension, the DYNUMES model which is in progress.

The main (control) program reads timekeeping parameters, inputs of initial fields (such as the sea and land table, monthly ice fields, initial (January) pollock and herring distribution, monthly fur seal distribution, etc.); calls all other subroutines, and establishes storage space for various subjects. For the latter purpose the program uses random access mass storage medium (discs in CDC 6000 series). Furthermore, the main program puts out some common fields (e.g. monthly consumption of a given species), which are computed in several subroutines. The graphic output is at present being adapted to a Tektronix graphic terminal. The various fields, listed in common, are reused in various subroutines for a variety of subjects, to optimize the computer core requirements; thus they do not contain a specific field, with few exceptions, such as sea-land table, which is frequently used.

1. Mammal subroutine

Fur seals and bearded seals were selected as representative of marine mammal populations. Monthly distribution of the numbers of fur seal are prescribed, whereas monthly distribution of bearded seal was created in the program in relation to the ice edge. These bearded seal fields are also read from cards in the main (control) program and stored on discs. The numbers of mammals are converted to weight of biomass per unit area (e.g. kg/km^2)

Although provision is made in the program for computation of growth and mortality of mammals, this provision is not used, as the errors (uncertainty) of monthly numbers of animals present in Bering Sea would entirely mask the effects of growth and mortality computations. Food consumption per unit time by mammals is assumed only as 4% of body weight daily in the model run, which is presented in this report, whereas the data available in literature indicates 6 to 8% of body weight daily. The latter data originates from feeding experiments of mammals in captivity. The composition of fur seal food is assumed in the presented run as 77% of pollock, 5% of herring and 18% other fish. The composition of bearded seal food is 8% pollock, 8% herring, mackerel and other related pelagic species, and 70% of benthos. All the above mentioned numbers are variable inputs and are changed in different runs for the study of their individual effects on the ecosystem as a whole and for testing of the reported data to find the plausible numerical values.

2. <u>Fish subroutines</u>

Pollock and herring were selected as representative of fish populations. The initial distribution of pollock in January is prescribed. The population is divided into three size (age) groups in the reported model run as follows: group 1, <30 cm, 38% of total biomass; group 2, 30 to 50 cm, 43% and group 3 >50 cm, 19%. Thereafter the computations are carried out separately on each size group. Again this quantitative division is preliminary and subject to further tuning in future use of the model. The pollock biomass is moved from deep water (winter) to continental shelf (summer) and back to deep water for next winter with a migration speed and pattern, ascertained from literature; the migration speed (u and v components) being generated within the pollock subroutine. The same migration speed is used initially in present submodel for all three size groups. The numerical advection scheme, used in the model, has been developed earlier for studies of pollutants and is one of the few available, tested advection schemes which permit the conservation of biomass. The growth, intergroup transfer and consumption of each size group is computed in monthly time steps with the following coefficients (subject to future tuning):

	Bulk growth (% monthly)	Transfer to next group (% monthly)	% of total pollock consumption by other groups applied*	Fishery* (% of total)	Natural mortality (% monthly)
Group 1	9.7	3	40	--	--
Group 2	3.9	3	50	40	--
Group 3	0.8	-	10	60	2.8

*e.g. of the total consumption of pollock by mammals 40% is taken from size group 1; the same applies to Fishery.

It is assumed that food coefficient for growth is 1:2 and 1% of body weight of food daily is required for maintenance. These coefficients can be changed with ease in the program. The composition of pollock food in the present program can also be changed. The model runs were made with the following food composition:

Group 1. 30% copepods, 70% euphausids

Group 2. 18% copepods, 56% euphausids, 10% herring, 8% benthos and 8% of pollock from group 1.

Group 3. 5% copepods, 30% euphausids, 10% herring, 25% benthos and 30% pollock (groups 1 and 2).

Pollock biomasses from Groups 2 and 3 are affected by the fishery, and these data are tuned to available fishery statistics.

The pollock subroutine allows various outputs, either for tuning of the model or as results of a particular model application. The implications of the presently used numerical values and the preliminary results are described in a later section.

The herring subroutine is in many aspects similar to pollock subroutine, except no division into different size groups is made as yet. Growth of herring biomass is assumed to be 8.5% per month, no natural mortality from "old age" is computed at present and the consumption of herring is computed in other subroutines as dictated by composition of food of different species. Fishery is computed at present in two seasons only (i.e. winter offshore fishery and summer fishery on spawning stocks near the coast). The composition of herring food is assumed to be 70% of copepods and 30% of euphausids, as ascertained from literature. The effect of growth coefficient on total standing stock of herring is described in a later chapter.

3. Zooplankton subroutine

The consumption of zooplankton (copepods and euphausids) is computed in other subroutines as dictated by composition of food and food requirements of corresponding species feeding on zooplankton. In zooplankton subroutine, a monthly mean zooplankton abundance is created, which is used for comparison with consumption. The distribution and magnitude of the abundance is tuned to the corresponding data (available in literature). The numerically created field is a function of latitude, time (month) and specific location (e.g. depth of water, distance from coast and continental slope). In converting the consumption from unit area (kg/km^2) to unit volume (mg/m^3) a uniform depth distribution of 50 meters (approximate mean shelf depth) is assumed.

4. Bird subroutine

Shearwaters and murres were selected as representative of marine bird populations. The monthly numerical spatial distributions are created using the available estimates on the number of birds in the Bering Sea and their geographic distribution on one hand and special index field (i.e. distance from the coast, depth of water, etc.), ice field and latitude on the other hand. However, the created bird fields have been punched on cards and read in main program in the program presented in the appendix.

No growth or natural mortality is computed for the birds at present, as the results from these computations would be entirely masked by the uncertainties in the estimates of the numbers of birds present in the area. The composition of food for birds in present submodel is: shearwater--50% euphausids, 10% small herring, 10% small pollock and 30% other small fish; murres--10% small herring, 30% other small fish, 30% benthos and 30% other various food items.

The food consumption is assumed to be relatively low - 9% of body weight daily in the presented test run. The values of food requirements of birds, given in literature, reach up to 20% body weight daily. However, as shown later, the consumption by birds affects marine ecosystem relatively little.

III. PRELIMINARY RESULTS OBTAINED WITH AN 8-COMPONENT DYNUMES FOR EASTERN BERING SEA

The numerical model serves as a powerful tool among others for investigation of various processes within the ecosystem and their effects on the marine ecosystem as a whole, and for determination of magnitudes of standing stocks and their dynamics. For solving individual questions and problems, specific use (and runs) must be made with the model.

The purpose of this report is to describe the 8-component submodel and demonstrate its utility. Thus, only few results of the preliminary runs with the model are prescribed below, emphasizing new findings.

Synopses of economically important fish species, as well as marine mammals, have recently been prepared in Northwest Fisheries Center in Seattle. These synopses are available upon request, therefore, only brief notes on the stocks of the eight components of the present model are given in this section which are necessary for following discussions and presentation of preliminary results.

A. Mammals

1. <u>Mammal stocks in the Eastern Bering Sea</u>

Basic information on pinnipeds in the Bering Sea has been summarized as part of the task of this Research Unit (McAlister and Perez, 1975). Table 1, which gives the estimated number of pinnipeds in the Bering Sea during winter and summer, their mean weight and average food composition, is extracted from their summary and slightly modified. The present 8-component ecosystem submodel contains only two species of mammals, fur seal and bearded seal. The consumption of fin fish by fur seal and bearded seal which are included in the submodel is about one-fourth of the total fin fish consumption by all pinnipeds in the Bering Sea and this must be borne in mind when evaluating results from present submodel with respect to fish consumption within ecosystem. Furthermore, on examination of the relatively pronounced spatial and temporal effects of fish consumption by the two mammals on the resulting distribution of fish and considering that fur seal and bearded seal consumption of fish is 20% of commercial catch of pollock, it becomes obvious that one needs to use complete ecosystem models for proper evaluation of ecosystem dynamics. Nevertheless, in order to hold the complete model to a reasonable size it is convenient to combine computation components into "bulk ecological groups"--i.e. lumping of species with reasonably similar distribution and food composition into single ecological groups.

Table 1.--Estimated number of pinnipeds in the Eastern Bering Sea and their average consumption (after McAlister and Perez, 1976).

Species	Number, 10^3		Mean Weight kg.	Biomass 10^3 tons		% composition of food					
	Winter	Summer		Winter	Summer	Pollock, cod, etc.	Herring & other pel. fish	Salmon	Squids	Benthos	Others
Fur seal	50	1000	65	3.3	65.0	80	5	2	11		2
Sea lion	50	100	400	20.0	40.0	80	10	10			
Bearded seal	260	120	240	62.4	28.8	8	8	1	8	70	5
Harbor seal	315	190	140	44.1	26.6	30	10	2	30	23	5
Ringed ribbon seal	350	175	70	24.5	12.3	35	34	1	10	15	5

The grouping of organisms into "bulk ecological groups" has been done with consideration of their effects on total ecosystem. As an example, the effect of fur seals and sea lions on the most abundant commercial species in the Bering Sea - pollock, is considerably different only due to the fact that the fur seal consume smaller pollock, wheras sea lions consume the older, larger ones. This affects the pollock population growth via cannibalism (see further discussion on pollock) as well as whole ecosystem in respect of substitution of prey in areas and times of the lack of preferred food.

Nearly all mammals in the Bering Sea are highly migratory, moving in and out of the area with changing seasons. It is extremely difficult and/or costly to obtain reasonably accurate counts on the mammals present. In the present and future models we must work with the best available estimates as well as with descriptive knowledge on the migration of the animals. Due to the inaccuracies in the estimated numbers of mammals, it is not necessary to include growth and mortality rates of the mammals, as the effect of mammals on the total ecosystem (and the possible information for management decisions) can be obtained by changing simply the estimates of the number of mammals present. Other important mammal groups besides pinnipeds, which occur in the Bering Sea are the baleen whales and toothed whales, but these are not incorporated in the present submodel. The summary discussion of the first results below is limited to fur seals and bearded seals.

2. Fur seal

The monthly distribution of fur seal in the Bering Sea is prescribed from best available estimates. Examples of fur seal distributions in February and August are given on Figures 4 and 5. High concentration of fur seal occurs during summer around Pribilof Islands, which are the major breeding grounds.

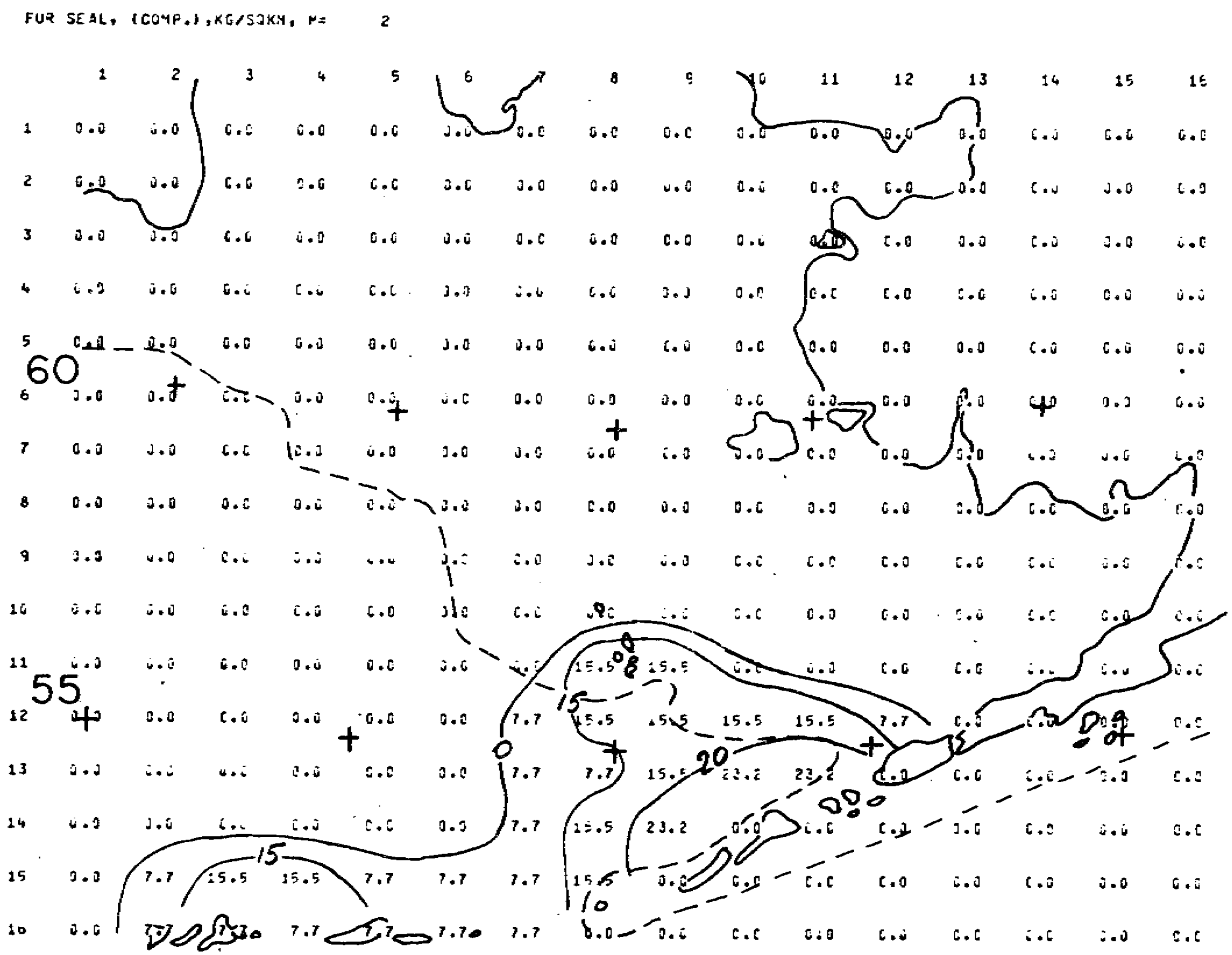


Figure 4.-Distribution of fur seal in the Eastern Bering Sea in February.

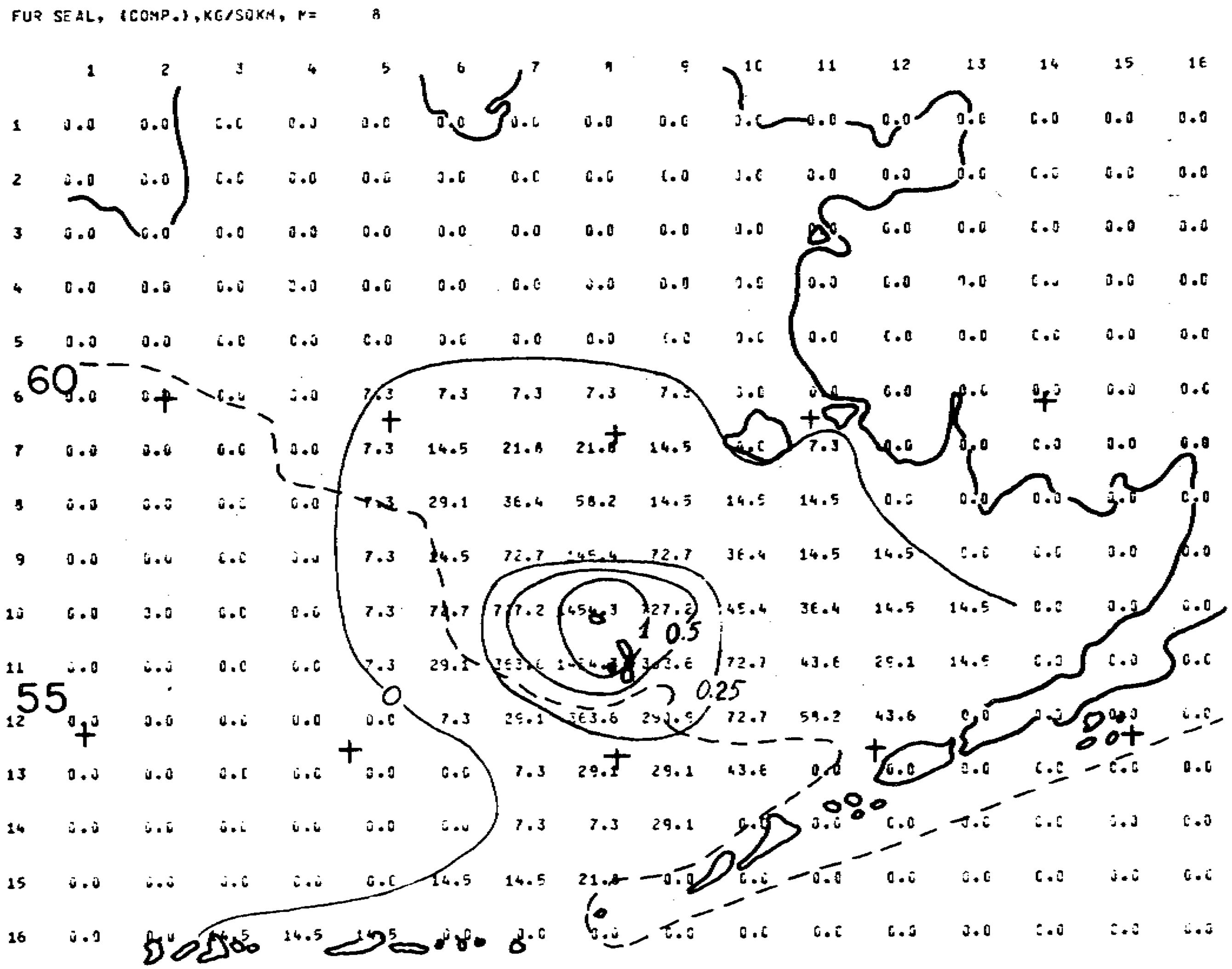


Figure 5.-Distribution of fur seal in the Eastern Bering Sea in August.

Total number of fur seal and bearded seal present in the Bering Sea in any given month (as used in the model) is shown in Figure 6. The amount of pollock consumed by fur seal and bearded seal is given in Figure 7 as the difference between total consumption and cannibalism. The bearded seal consume only one-tenth of the pollock biomass as compared to the consumption by fur seal (Table 2). Furthermore, in relative evaluation of the fur seal and bearded seal as fish consumers, it should be borne in mind that in the present submodel run: (a) the food consumption of the seals has been computed with a relatively conservative food coefficient (intake 4% of body weight daily); and (b) that fur seals and bearded seals consume less than one-fourth of the total amount of fish consumed by all pinnipeds in Bering Sea. Main area of consumption of the pollock by fur seal occurs over the continental shelf around the Pribilof Islands. The availability of food there might affect the mortality rate of the pups, especially if the standing stock of the pollock would be lower than estimated in present model (see further in the chapter on pollock). Further elaboration of the effects of food availability on the whole ecosystem will follow after planned extension and completion of the model. It is obvious that the present model allows the evaluation of the marine mammals as competitors to man in the harvest of fishery resources, which is at present relatively high.

3. Bearded seal

The available information on bearded seal is scantier than that on fur seal. We have at hand the estimated number of bearded seal present in the Bering Sea during winter and summer and that bearded seals are associated with ice edge (Fig. 6). Using this information and monthly mean data on ice, monthly distribution charts of bearded seal were derived.

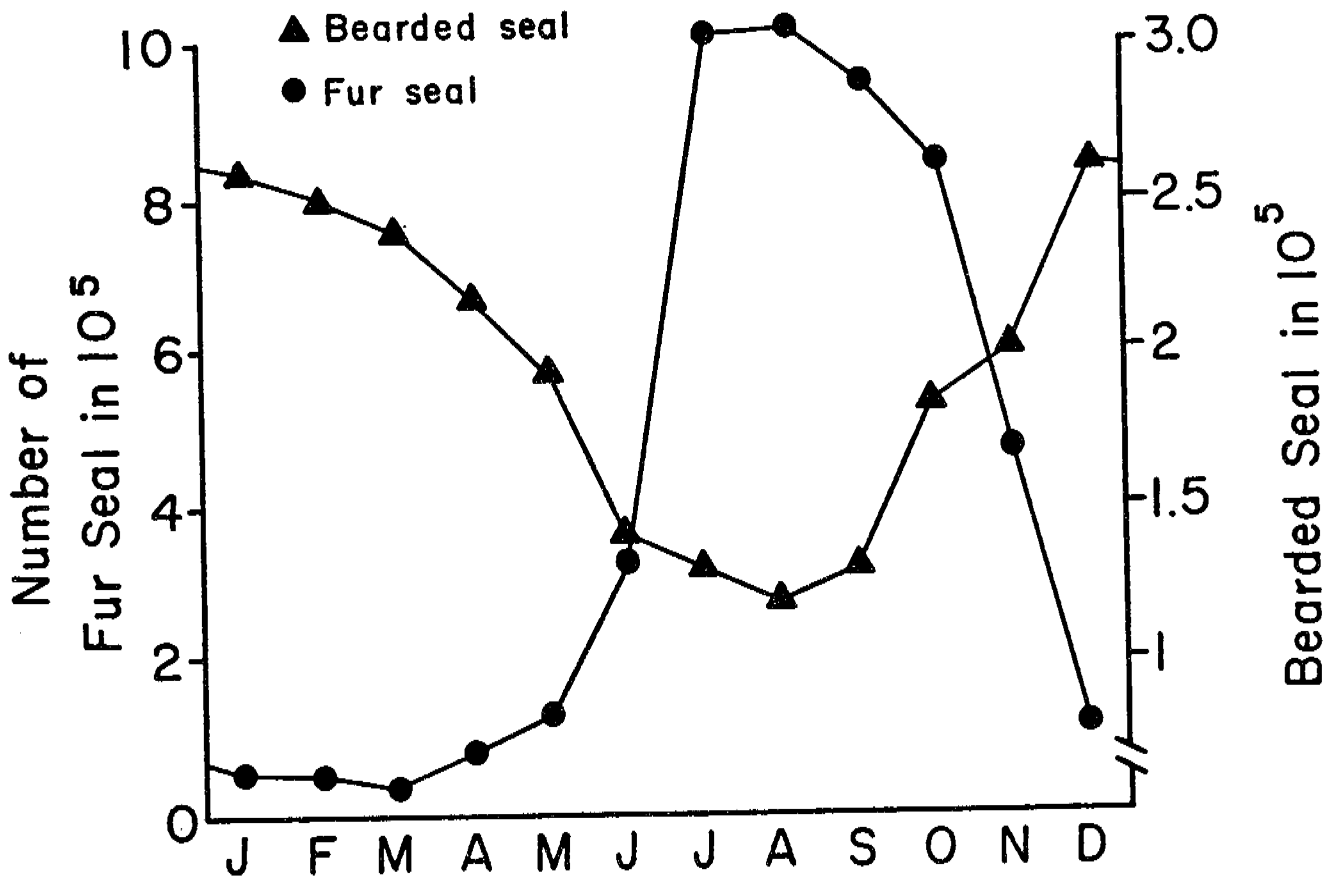


Figure 6.-Monthly mean number of fur seal and bearded seal in the Eastern Bering Sea.

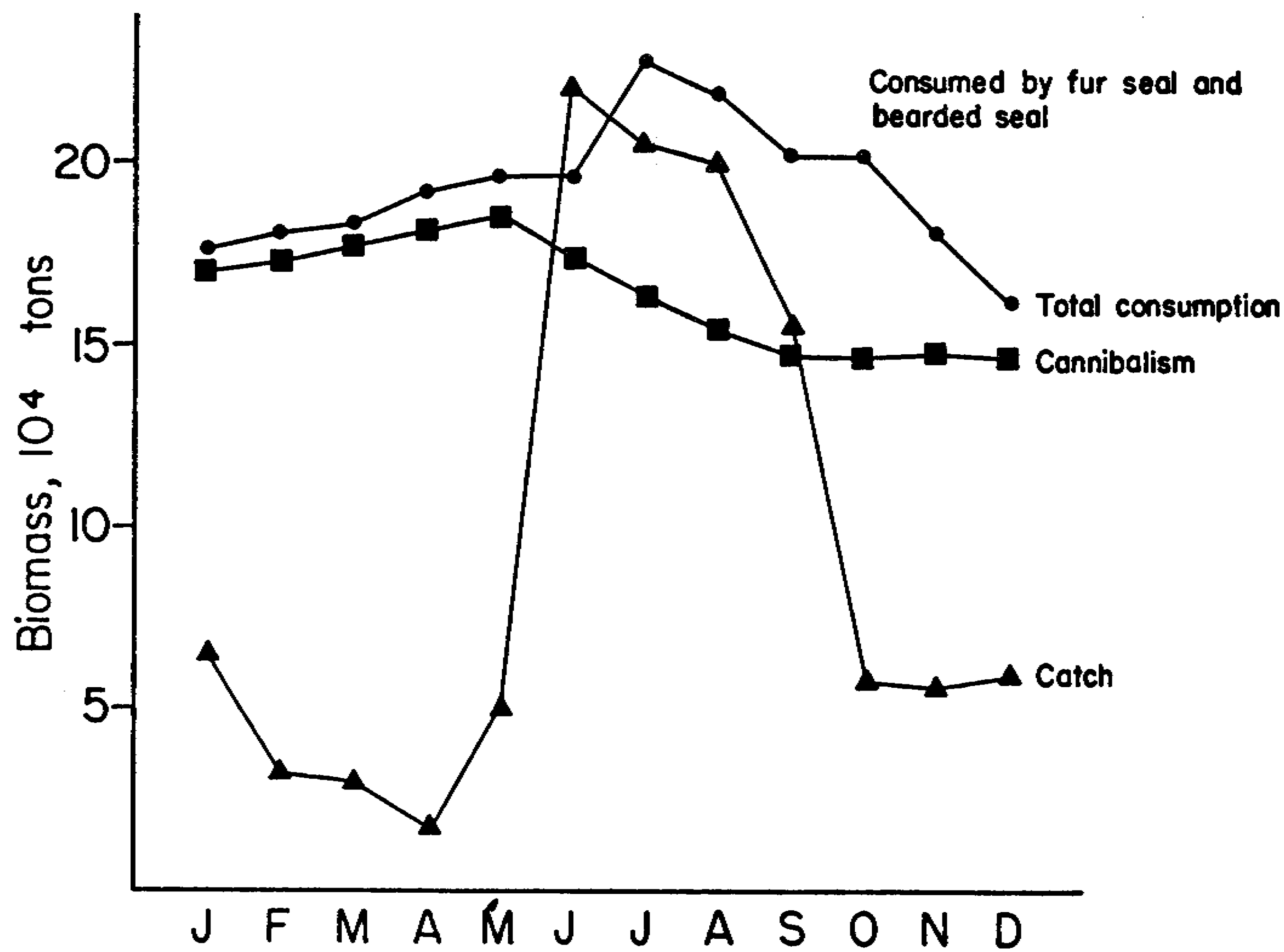


Figure 7.-Consumption of pollock by seals, cannibalism and commercial catch (restraints see text).

As bearded seals occur mainly over the continental shelf, seventy percent (70%) of their food consists of benthos. The highest monthly consumption of benthos by bearded seal is in excess of 60,000 tons and occurs in a relatively narrow band near the ice edge. The standing stock of benthos in the Bering Sea is highest where the bottom temperatures are below 0°C (i.e. on the shelf north of 58°N and west of 168°W). (Substantiating the theory of successive accumulation of generations of benthos in cold areas.) It might be speculated that as the ice edge moves over this high benthos standing stock area twice a year, this area might be the main area of occurrence and feeding of bearded seal. During the summer season the bulk of bearded seal standing stock is north of the Bering Strait. The annual consumption of herring and pollock by fur seal and bearded seal, as compared to fishery and total consumption, is given in Table 2.

B. Fish

1. <u>Fish stocks in the Eastern Bering Sea</u>

There are several excellent summaries on present state of knowledge of major demersal fishery resources in the Bering Sea (e.g. Low, 1976, Pereyra, Reeves and Bakkala, 1976). The present catch and state of exploitation of the commercial species shown in Table 3, is extracted from Low (1976).

Although a reasonable amount of knowledge of biology and behavior of most adult demersal resources is at hand, the knowledge on juvenile stages is scant, knowledge on some pelagic species is short, and very little knowledge is available at present on non-commercial species such as capelin and sand lance, which might play an important role in the ecosystem of the Bering Sea.

Table 2.--Annual consumption of herring and pollock by fur seal and bearded seal, as compared to fishery and total consumption (in thousand tons).

	Herring	Pollock
Consumption by fur seal	20	305
Consumption by bearded seal	60	30
"Total" consumption*	1352	2320
Fishery (rounded estimates)	50	1600

*"Total" consumption includes consumptions by fur seal, bearded seal, shearwater, murres and pollock (the latter consuming herring and their own kind - i.e. cannibalism).

Table 3.—State of exploitation of major fisheries in the Eastern Bering Sea (after Low, 1976).

Species	Principal fishing countries	Estimated potential	Catch in thousand metric tons							State of exploitation
			1961	1965	1970	1971	1972	1973	1974	
Walleye pollock	Japan, USSR, ROK	850–1,200	24	231	1,256	1,744	1,874	1,785	1,599	Over-exploited
Pacific cod	Japan, USSR	58	7	17	74	49	48	58	68	Fully-exploited
Yellowfin sole	Japan, USSR	110–120	610	62	158	201	72	62	45	Over-exploited, recovering slightly
Flathead sole	Japan, USSR	?	+	6	41	50	15	26	28	Becoming fully exploited
Rock sole	Japan, USSR	?	+	3	21	50	68	34	36	Becoming fully exploited
Turbot	Japan, USSR	?	57	14	20	15	57	3	9	Becoming fully exploited
Other flatfish	Japan, USSR	?	?	1	64	61	50	—	—	Fully-exploited
Pacific ocean perch	Japan, USSR	12–17	47	127	77	32	40	15	36	Over-exploited
Other rockfish	Japan, USSR	?	—	10	—	—	—	—	—	Fully-exploited
Sablefish	Japan, USSR	12	26	9	14	18	19	11	8	Over-exploited
Herring	Japan, USSR	a/	—	38	146	89	81	40	20	Over-exploited
King crab[b/]	Japan, USSR, USA	?	65	67	41	36	49	52	91	Fully-exploited
Tanner crab[b/]	Japan, USSR, USA	120–170	—	170	244	200	156	141	165	Becoming fully exploited
Shrimps	Japan, USSR	?	14	10	6	3	+	+	+	Over-exploited
Pacific halibut	Japan, USSR, USA, Canada	5	14	4	7	8	6	4	2	Fully-exploited

\+ Small catches.

? Unknown or uncertain.

a/ Unpredictable, dependent on highly variable recruitment.

The available fishery statistics indicate relatively large fluctuations in most fish stocks and/or their availability from year to year, which is mostly attributed to the effects of fishery. However, there are also indications of relatively long-term fluctuations of abundance of some species with relatively large magnitude which might have been caused within the shifting balances within the ecosystem itself. A properly programmed, relatively complete ecosystem model would enlighten the last mentioned problem, as to causes, magnitudes and periods of such "internal" fluctuations. The present submodel has already clearly shown the presence of these long-term fluctuations in abundance of pollock.

The present submodel includes only two fish species as representative for a pelagic regime (herring) and another for demersal (and/or semi-demersal) regime (pollock). The flatfishes (or ground fishes) will be included in future update of the model.

2. Herring (and ecologically kindred species)

Herring concentrations are/were fished at and near the continental slope during the midwinter and early spring months by Russians and Japanese. In early summer the herring is found near the coast in shallower water, where it spawns and is caught by local U.S. and Canadian fisheries. After spawning, herring is known to disperse for feeding over large areas of the Bering Sea shelf (Fredin, 1974).

There are no reliable estimates of the average standing stock of herring in the Bering Sea. However, a plausible standing stock size can and has been computed with the present model, using the following indirect data (and assumptions): Food coefficients and composition of food (in respect to herring predation) as given in Table 4, growth and mortality rates as given in Table 5. Furthermore, no other natural mortality of herring is computed,

Table 4.--Food composition and food requirements used in 8-component submodel, (run 12)

Species	Food coeff. for growth	Food for maintenance, % body weight daily	Total food coeff.*	Percentual composition of food						
				Herring	Pollock	Copepods	Euphausids	Benthos	Others	Small fish
Fur seal	--	4	--	5	77				18	
Bearded seal	--	4.5	--	8	4			70	18	
Herring	1:2	1	(5.5)			70	20		10	
Pollock Gr. 1	1:2	1	(5.1)			30	70		0	
Gr. 2	1:2	1	(9.7)	10	8	18	56	6	2	
Gr. 3	1:2	1	(18.3)	10	34	5	30	16	5	
Shearwater	--	9	--	10	10		50			30
Murres	--	9	--	10				30	30	30

*Total food coefficient = $\frac{\text{Growth of biomass}}{\text{Food biomass consumed}}$, these are recomputed values for comparison (computation uses growth as well) and are not used in model computation.

Table 5.—Bulk growth and mortality rates in % per month.

Species	Growth rate % per month	Mortality rate and/or consumption and remarks
Fur seal	(4.5) *	(4.8) * } Monthly abundance prescribed
Bearded seal	--	Steady state assumed } Monthly abundance prescribed
Herring	8.5	Consumption by seals (2 species), birds (2 species), and pollock; fishery
Pollock, group 1	9.7	40% of total pollock consumption, 3% moved to group 2
group 2	3.9	50% of total consumption, 3% moved to group 3; fishery
group 3	1.8	10% of total consumption, fishery, 2.8% of natural mortality
Shearwaters	(2.0)*	Monthly abundance prescribed
Murres	(2.0)*	Monthly abundance prescribed

* Not used in the submodel.

Note: Bulk growth rate (or biomass growth rate) is only indirectly comparable to individual species growth rate.

except the consumption of herring by mammals (two species), birds (two species), and pollock. Assuming a quasi-steady state (i.e. no increase or decrease of herring population through the year), the model runs show that the minimum herring (and kindred species) population in Bering Sea must be 1 million metric tons. This is a preliminary figure as several other possible predators of herring are not yet included in the model. Furthermore, it is possible that not all fish, which has been reported as herring in stomach analyses, might not be herring, but capelin and sand lance.

One of the methods of finding a plausible and sustainable standing stock of herring (and other fish species) as well as demonstrating the extreme sensitivity of the total ecosystem to many parameters (specially to bulk growth rate) and their changes, is shown in Figure 8. The herring biomass is computed with two different growth coefficients (8.5 and 7.9% per month), starting with some initial biomass (975,000 tons), whereby the consumption level of herring is determined by the amount of predators, whose food composition is kept constant throughout the year. As shown in Figure 8, a small decrease of growth coefficient (0.6% per month) causes a relatively rapid decline of herring population.

The total monthly consumption of herring in the Bering Sea is given in Table 6 as computed with the model using food coefficients and food composition as given in Table 4. As seen from this table, the internal consumption of herring in the Bering Sea ecosystem is more than an order and half of magnitude larger than the fishery (at present about 50,000 tons annually). This clearly indicates among others that a total ecosystem dynamics and not only fishery must be considered in fisheries management (and in setting maximum catch limits).

Examples of herring distribution during winter (January) and summer (July) are given in Figures 9 and 10 respectively.

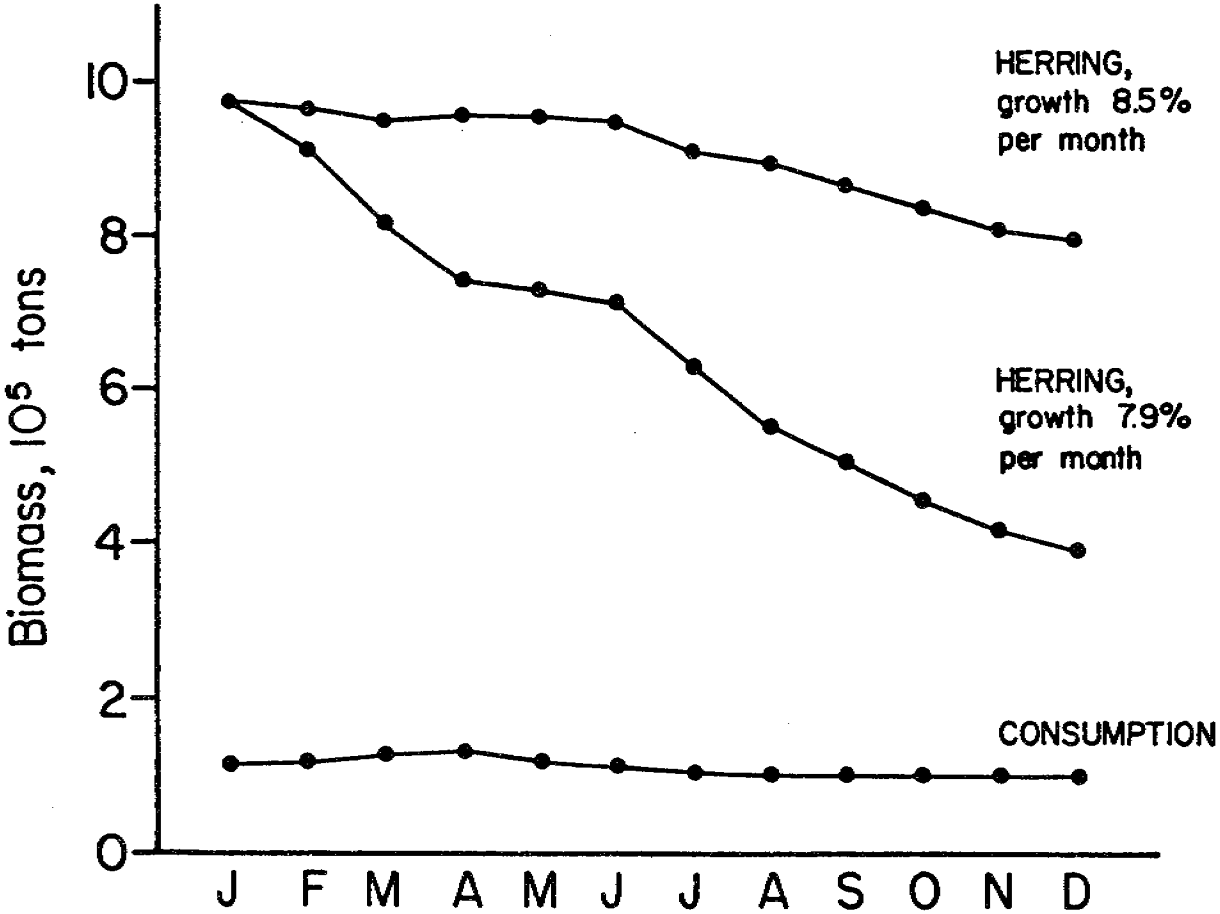


Figure 8.-Change of herring biomass throughout a year with two different growth coefficients.

Table 6.--Monthly total consumption of copepods, euphausids, herring, and pollock, in the Eastern Bering Sea, as computed with 8-component ecosystem submodel (in thousand tons).

Month	Consumption of Copepods	Euphausids	Herring	Pollock
January	2149	1705	112	173
February	2145	1704	114	176
March	2133	1700	180	115
April	2167	1710	187	119
May	2183	1706	122	192
June	2160	1657	118	194
July	2112	1606	116	225
August	2094	1564	108	216
September	2057	1529	103	204
October	2034	1520	101	199
November	2010	1509	99	178
December	2003	1502	96	157

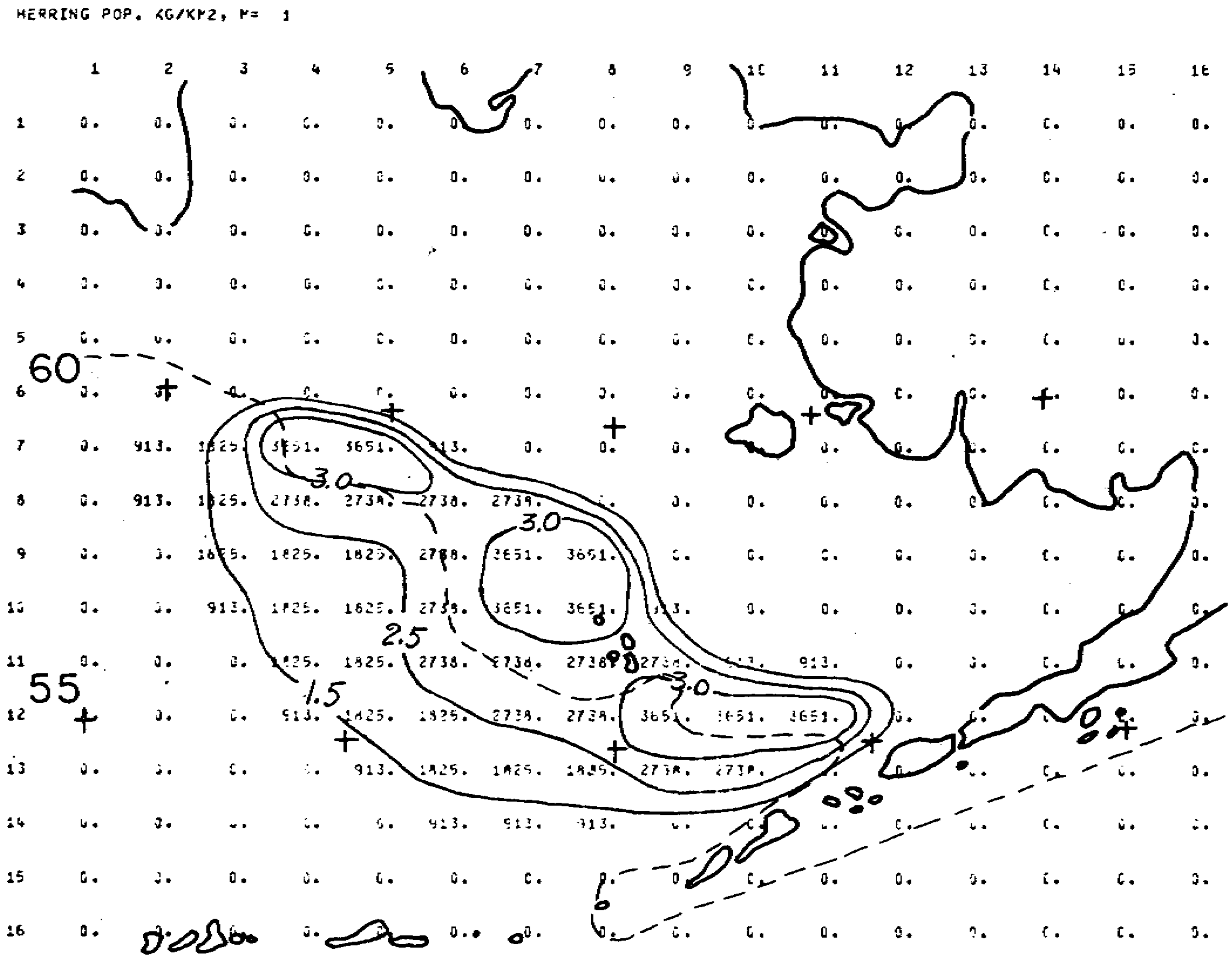


Figure 9.-Distribution of herring in January in the Eastern Bering Sea.

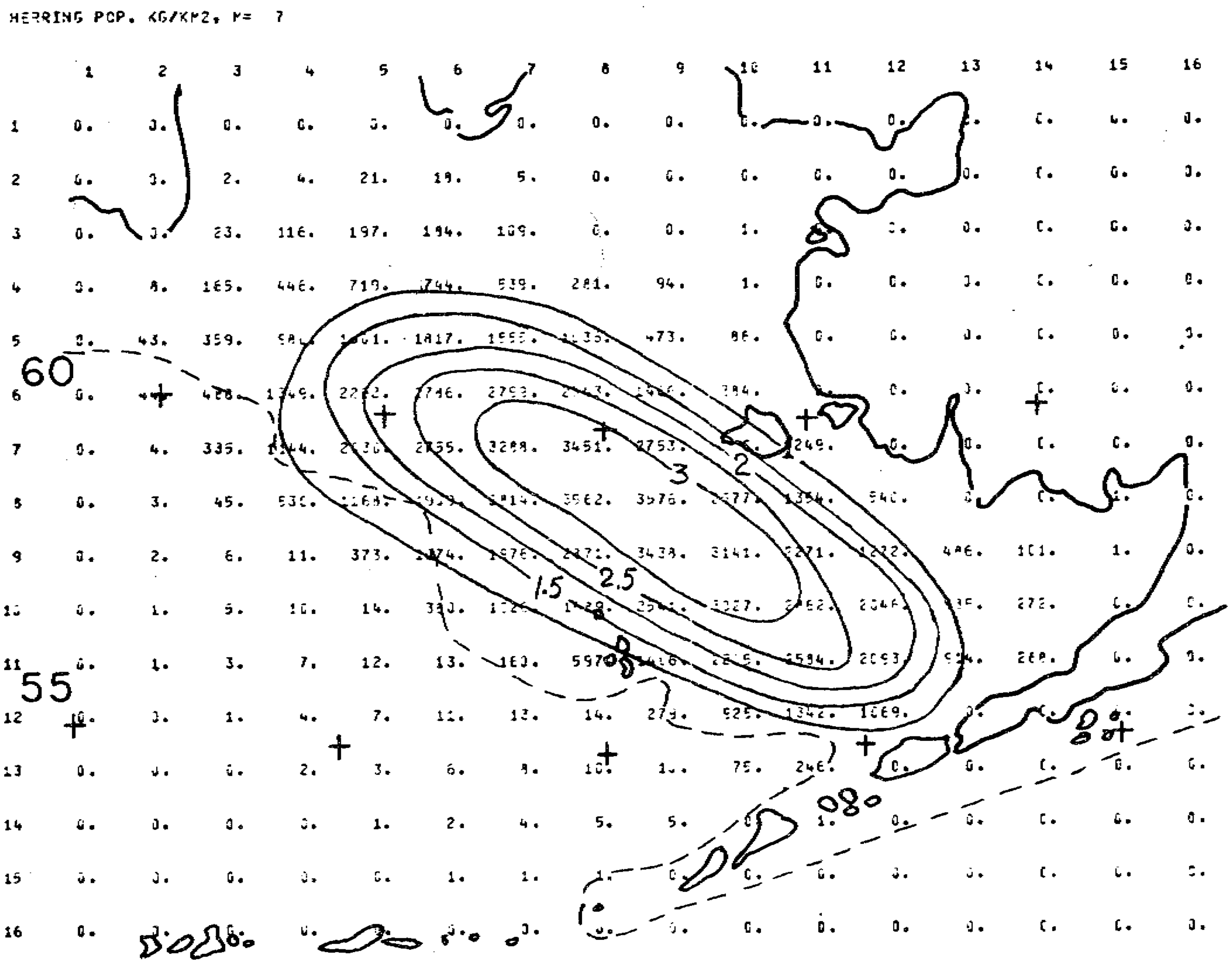


Figure 10.-Distribution of herring in July in the Eastern Bering Sea.

3. Pollock

In the last decade pollock has become the major exploited species in the Bering Sea, the total estimated annual catch having been over 1.5 million tons. In the last few years the pollock catches have, however, declined slightly, indicating possibly overfishing or changing phase of long-term fluctuations. Main concentrations of pollock occur near the continental slope (and partly over deep water) during winter (see Fig. 11), but move over the continental shelf during the summer.

In the present submodel, the pollock subroutine was programmed in greater detail than any other subroutine. First, the pollock biomass was divided into three size groups, necessitated by different composition of food, growth rates and effects of fishery (group 1-0 to 30 cm long, group 2-30 to 50 cm long and group 3- >50 cm long). Some of the basic data used in preliminary computation to find plausible standing stock of pollock are given in Tables 4 and 5. There are relatively little data available in literature on juvenile (pre-fishery) pollock. The growth rate given in Table 5 for this group might seem to be a little too high, which would mean that the minimum sustainable standing stock found with the model (ca. 5 million tons) is too low. This statement is derived from model logic: as consumption of pollock is largely determined by consumption of mammals and by cannibalism, which would not change considerably year by year, this consumption must be balanced by growth if a quasi-steady state exists. In addition, the plausible pollock standing stock figure above is low because sea lions, who consume adult pollock, were not included in this submodel. Here, however, the effects of sea lion grazing might be counteracted by decreased cannibalism (i.e. the larger pollock, who are most cannibalistic, are decimated by sea lions). It could be mentioned that sea lions might be principal consumers of adult salmon.

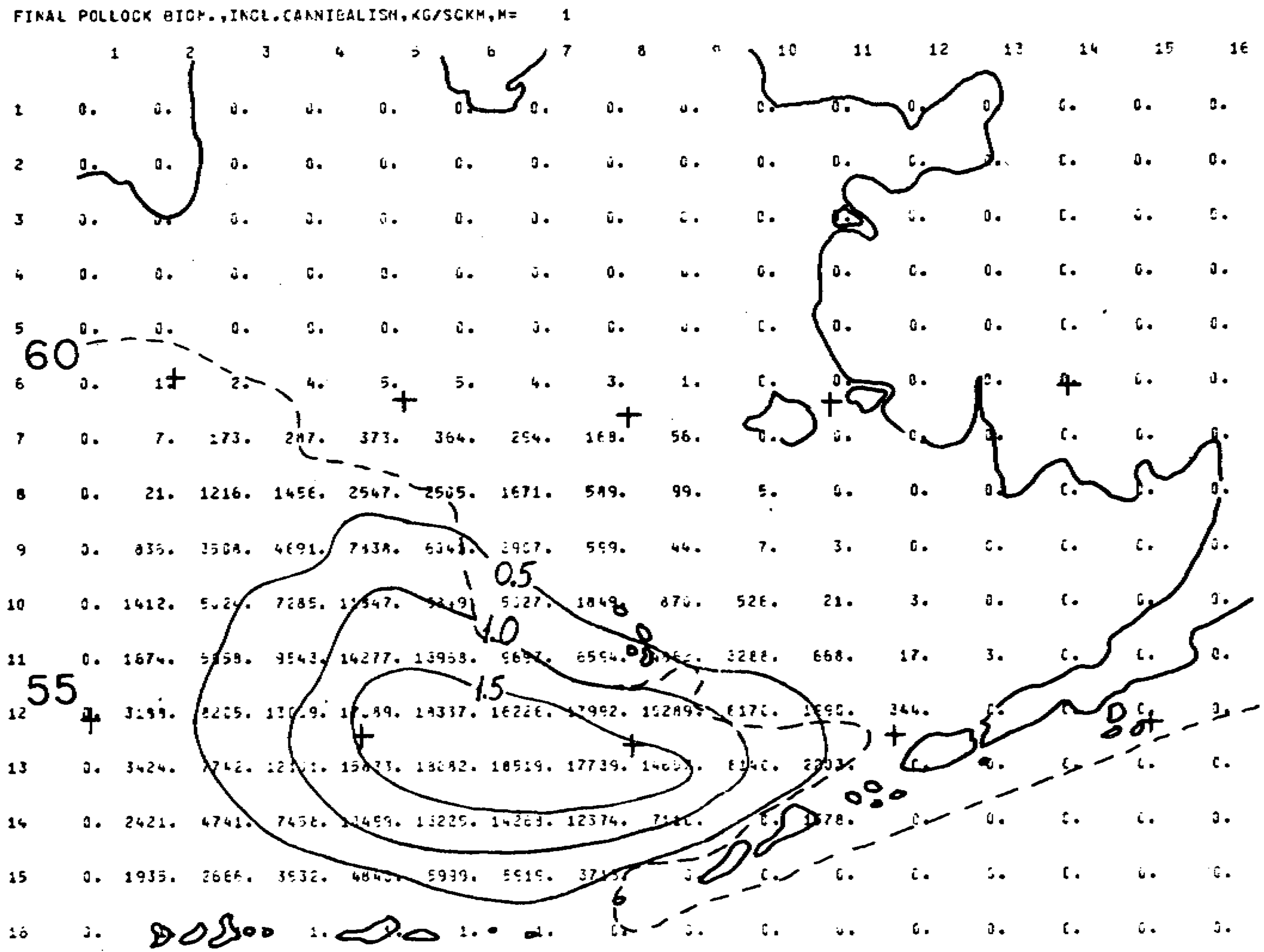


Figure 11.-Distribution of pollock in January in the Eastern Bering Sea.

The juvenile group of pollock is subject to greatest consumption pressure (i.e. cannibalism and fur seal consumes mainly pollock of ca 15 cm long). This means that the pollock year class strength, when they enter fishery, does not depend as much on the size of spawning population, as on the previous grazing on eggs, larvae, and specially juveniles by other predators.

The ecosystem internal consumption of pollock as shown in Tables 2 and 6 is considerably higher than the fishery. This consumption, together with bulk growth rates, determine the magnitude of plausible standing stock. Part of this ecosystem internal consumption is due to cannibalism, which is reported by several investigators to be at present rather high in older pollock. In present preliminary computer runs, the cannibalism was suppressed somewhat, as compared to some data (stomach analysis) in literature, which report that over 60% of stomach content of larger pollock (>50 cm) consist of other pollock, (Takahasi and Yamaguchi, 1972). Despite that the cannibalism in our submodel is low (8% in group 2, 34% in group 3 pollock); the total cannibalism is considerably higher than total fishery (Figure 7).

The interaction of cannibalism with other internal consumption and fishery is one of the main causes of long-term cycles of pollock population which were discovered in a preliminary study with the present submodel. Later several indirect observations by other fisheries scientists confirmed this observation as a distinct possibility. The plausible magnitudes and periods of these cycles will be investigated with next generation of the ecosystem model.

The annual cycle of the pollock biomass as computed with the preliminary submodel and with given initial biomass (5.25 million tons) and other data as given in Tables 4 and 5 and fishery (on Figure 7), is shown in Figure 12.

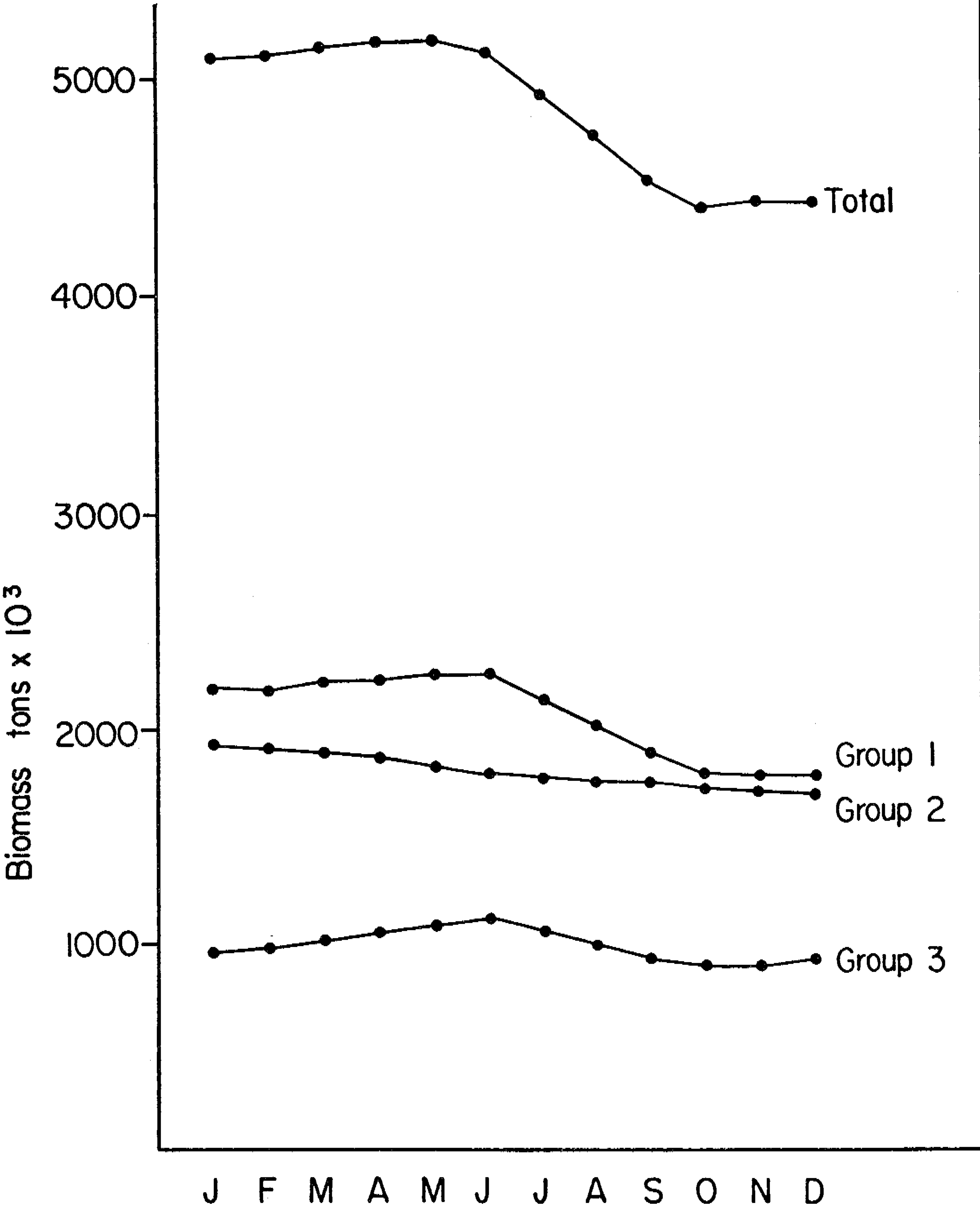


Figure 12.-Pollock biomass change within a year (assumptions see text).

As seen, this initial biomass is declining within the year, largest decline occurring during the summer, when fishery and consumption by fur seal is at maximum. The present submodel allows the migration of pollock (and other species) with a prescribed migration speed and direction. As a result the biomass at any given grid point changes with time. This information can be extracted with ease at desired locations and Figure 13 shows the change of group 2 pollock biomass at five locations as an example.

Figures 14 and 15 show the distribution of group 3 and group 2 pollock biomass respectively in August as computed with our submodel. Figure 14 shows two areas of higher concentration of older pollock, which are separated with an area of lower concentration. These higher concentration areas occur approximately where the more intensive fishery occurs in August and where higher concentrations of pollock are known to exist. Because of this separation of areas of higher concentrations of pollock which has been observed during past decade, it has been speculated that there might be two separate stocks in the Bering Sea. This separation, however, has come about by interaction between fishery, internal (to ecosystem) consumption and migration as our model indicates, and consequently there may be only one stock of pollock in the eastern Bering Sea. Figure 16 shows the distribution of group 1 pollock (juveniles in the same month as computed with our submodel. The higher concentrations of juveniles occur between the areas of high concentration of older pollock. This separation of generations is known to occur in many fish species elsewhere. It has a beneficial (saving) effect on juvenile pollock as cannibalism on juveniles is lower in areas of lower concentration of old pollock. Furthermore, this finding further demonstrates the sensitivity of the ecosystem and the necessity of inclusion of as many details as possible into an ecosystem model for reproduction of true conditions in the nature.

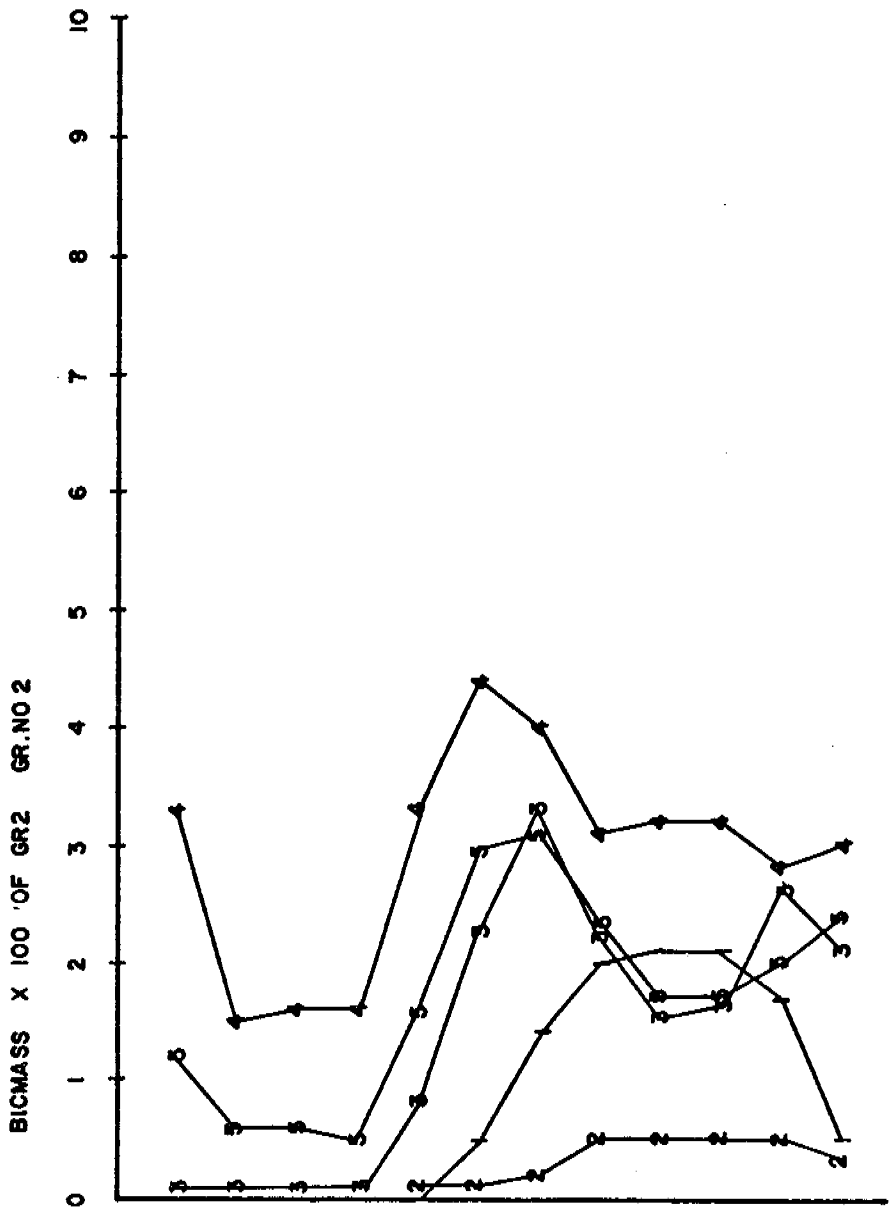


Figure 13.—Change of group 2 pollock biomass throughout a year at five locations in Bering Sea (1 - 58°0'N, 161°40'W; 2 - 57°15'N, 165°00'W; 3 - 56°30'N, 170°00'W; 4 - 55°30'N, 174°10'W; 5 - 55°30'N, 165°20'W).

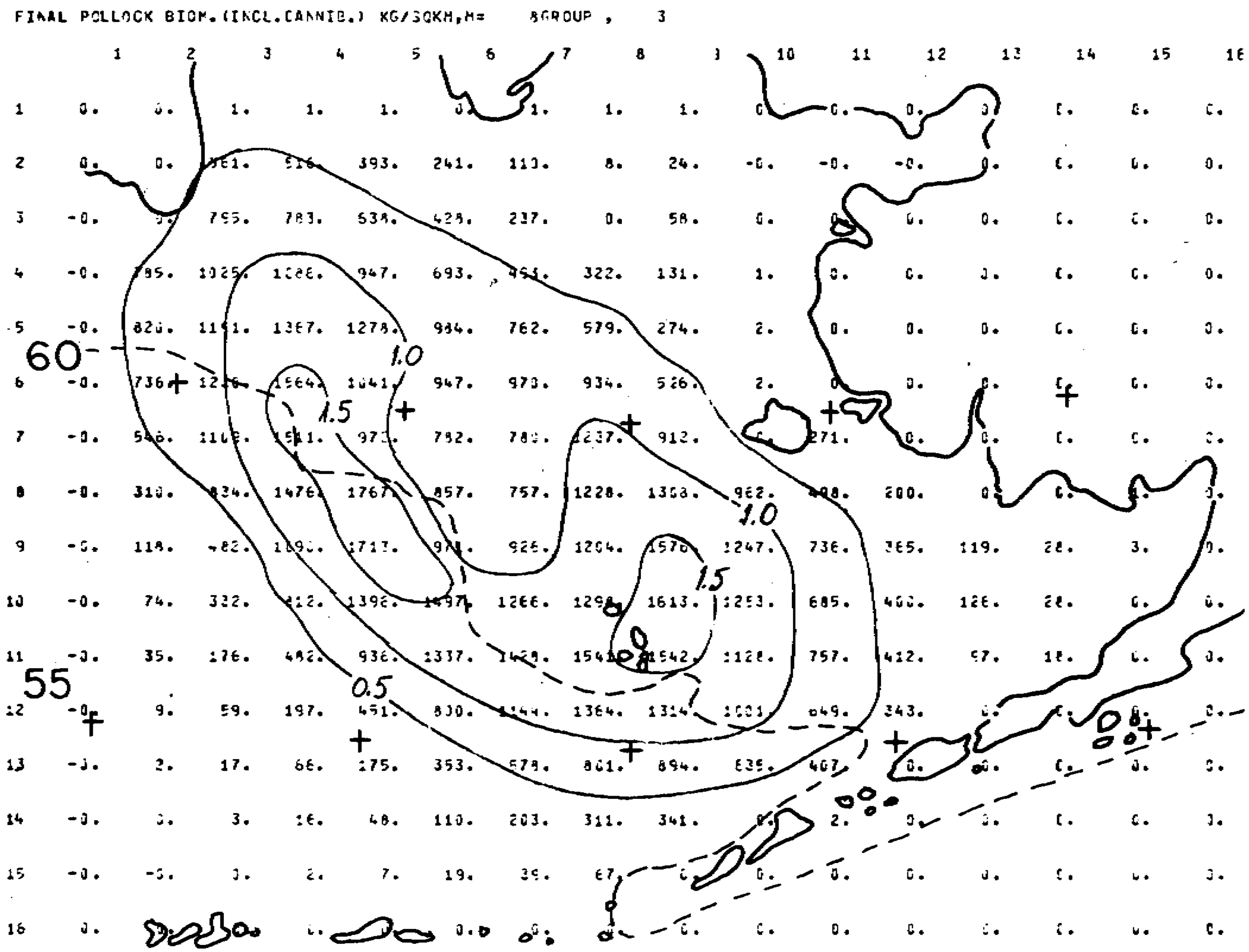
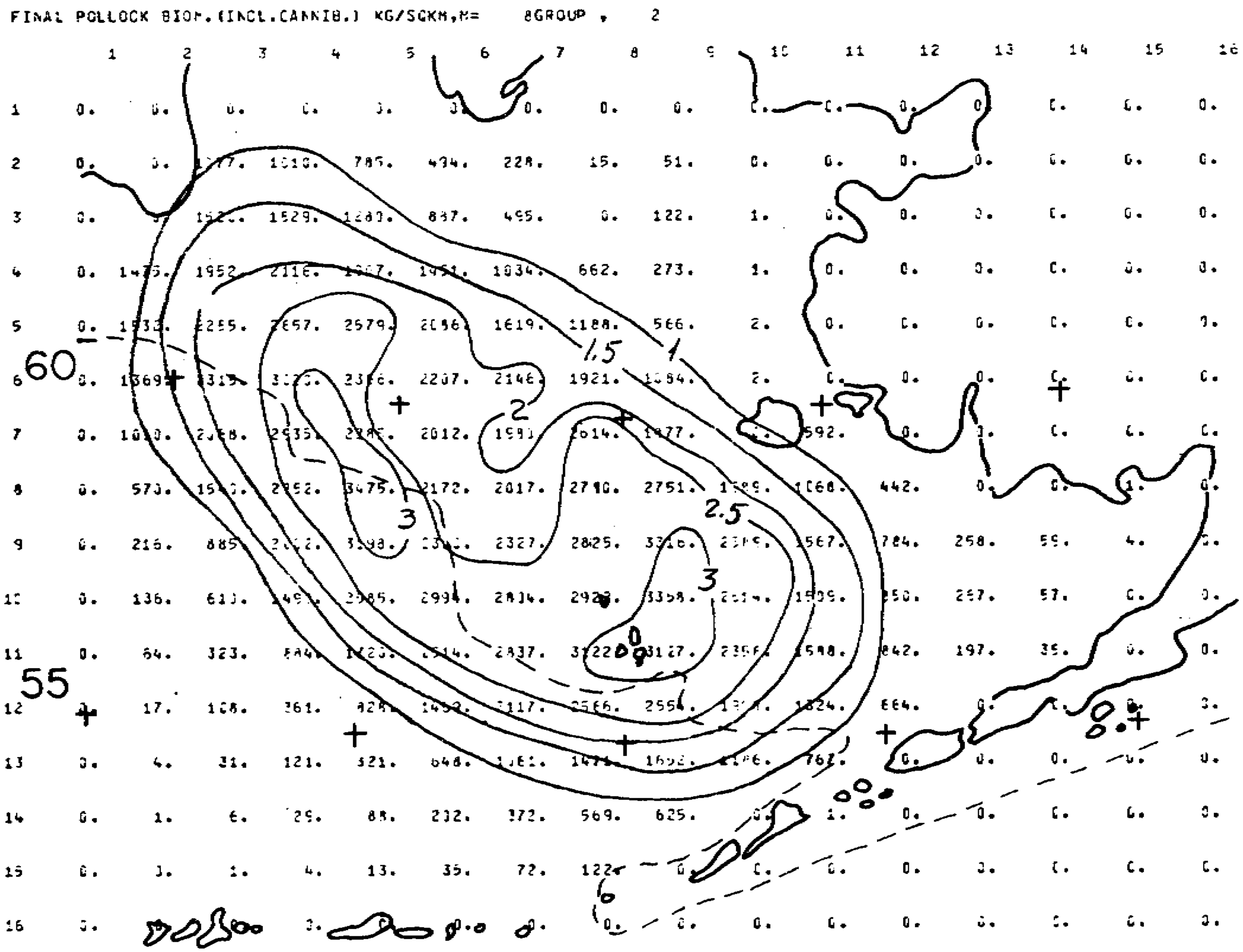


Figure 14.-Distribution of group 3 pollock (>50 cm long) in August.

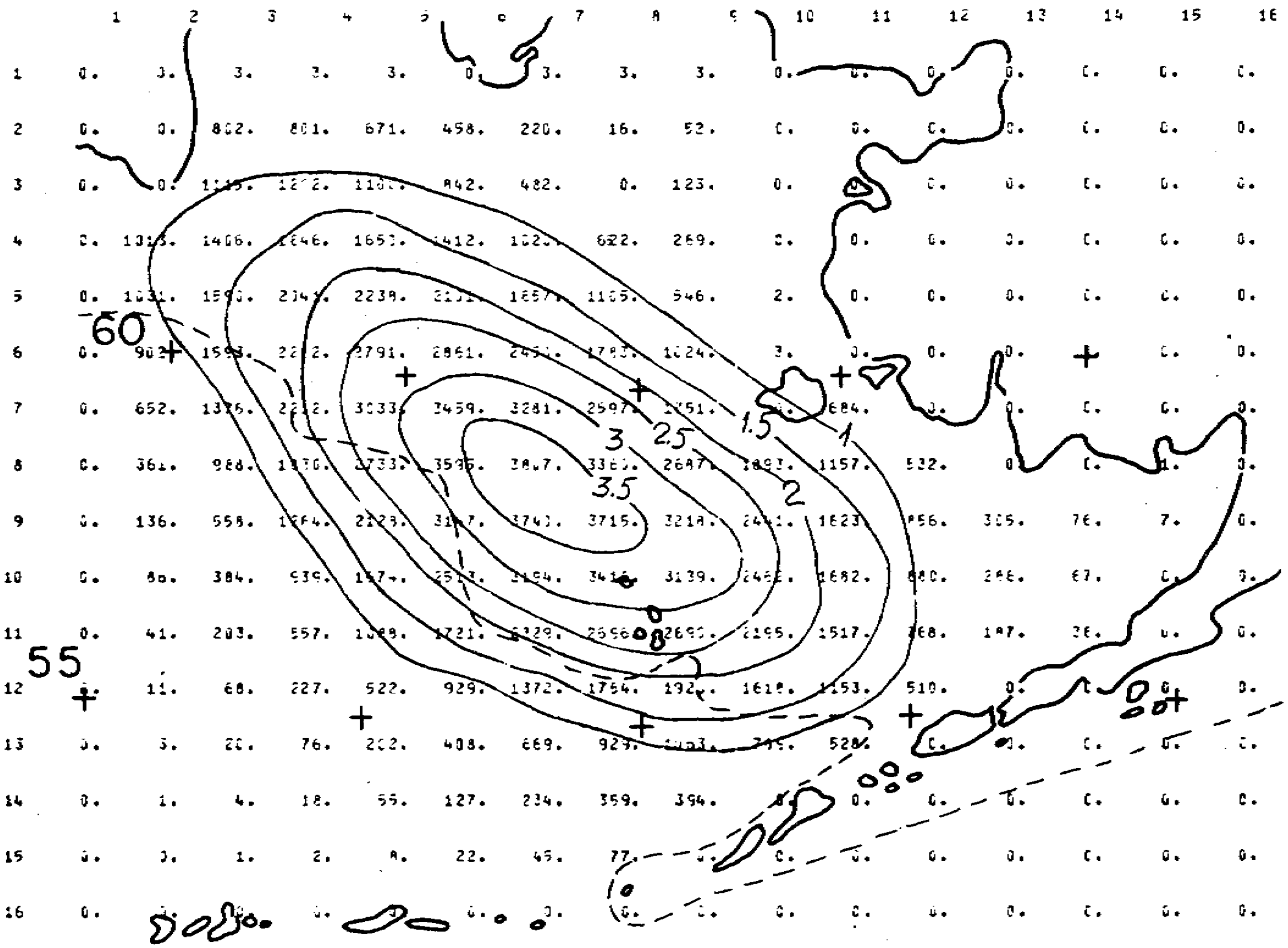


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.	0.	0.	0.	0.	[illegible]	0.	0.	0.	0.	0.	0.	0	0.	0.	0.
2	0.	0.	[illegible]	1010.	785.	434.	228.	15.	51.	0.	0.	0.	0.	0.	0.	0.
3	0.	[illegible]	[illegible]	1529.	1280.	837.	495.	0.	122.	1.	0.	0.	0.	0.	0.	0.
4	0.	[illegible]	1952.	2116.	[illegible]	[illegible]	1034.	662.	273.	1.	0.	0.	0.	0.	0.	0.
5	0.	[illegible]	2255.	2657.	2579.	2056.	1619.	1188.	566.	2.	0.	0.	0.	0.	0.	0.
6	0.	1369.	3319.	[illegible]	[illegible]	2207.	2146.	1921.	1084.	2.	0.	0.	0.	0.	0.	0.
7	0.	[illegible]	[illegible]	2935.	[illegible]	2012.	1991.	[illegible]	[illegible]	[illegible]	592.	0.	1.	0.	0.	0.
8	0.	570.	[illegible]	2952.	3475.	2172.	2017.	2710.	2751.	[illegible]	1068.	442.	0.	0.	1.	0.
9	0.	216.	885.	[illegible]	3198.	[illegible]	2327.	2825.	[illegible]	[illegible]	[illegible]	784.	258.	59.	4.	0.
10	0.	136.	610.	[illegible]	2985.	2994.	2834.	2923.	3358.	[illegible]	[illegible]	[illegible]	257.	57.	0.	0.
11	0.	64.	323.	844.	[illegible]	[illegible]	2837.	3122.	3127.	2356.	1598.	842.	197.	35.	0.	0.
12	0.	17.	108.	361.	[illegible]	1493.	[illegible]	2566.	2554.	[illegible]	1324.	664.	0.	0.	0.	0.
13	0.	4.	31.	121.	321.	648.	[illegible]	[illegible]	1692.	[illegible]	[illegible]	0.	0.	0.	0.	0.
14	0.	1.	6.	29.	85.	232.	372.	569.	625.	0.	1.	0.	0.	0.	0.	0.
15	0.	0.	1.	4.	13.	35.	72.	122.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	[illegible]	[illegible]	0.	[illegible]	[illegible]	[illegible]	0.	0.	0.	0.	0.	0.	0.	0.	0.

Figure 15.-Distribution of group 2 pollock (30-50 cm long) in August.

CP	8	2100.64	545.53	3032.52	2127.64	3740.06	305.04	1661.74	2698.02	522.20	1152.61
OS	8	2385.54	566.22	2295.07	3098.40	2326.76	257.77	1308.61	3122.13	828.23	1324.43
OH	8	983.51	274.10	972.32	1713.04	926.02	118.56	885.09	1541.04	451.28	648.56

FINAL POLLOCK BIOM.(INCL.CANNIB.) KG/SQKM,M= 8GROUP , 1



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.	3.	3.	3.	3.	0.	3.	3.	3.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	802.	801.	671.	458.	220.	16.	52.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	1115.	1212.	1100.	842.	482.	0.	123.	0.	0.	0.	0.	0.	0.	0.
4	0.	1313.	1406.	1646.	1653.	1412.	1020.	622.	269.	0.	0.	0.	0.	0.	0.	0.
5	0.	1031.	1590.	2041.	2239.	2101.	1657.	1105.	546.	2.	0.	0.	0.	0.	0.	0.
6	0.	902.	1593.	2212.	2791.	2861.	2451.	1783.	1024.	3.	0.	0.	0.	0.	0.	0.
7	0.	652.	1376.	2212.	3033.	3459.	3281.	2597.	1751.	0.	684.	0.	0.	0.	0.	0.
8	0.	361.	988.	1930.	2733.	3595.	3807.	3360.	2687.	1893.	1157.	532.	0.	0.	1.	0.
9	0.	136.	558.	1264.	2123.	3147.	3740.	3715.	3218.	2441.	1623.	856.	305.	76.	7.	0.
10	0.	86.	384.	939.	1574.	2513.	3194.	3416.	3139.	2462.	1682.	880.	266.	67.	0.	0.
11	0.	41.	203.	557.	1089.	1721.	2329.	2596.	2690.	2195.	1517.	768.	187.	36.	0.	0.
12	0.	11.	68.	227.	522.	929.	1372.	1754.	1920.	1618.	1153.	510.	0.	0.	0.	0.
13	0.	3.	20.	76.	202.	408.	669.	929.	1003.	745.	528.	0.	0.	0.	0.	0.
14	0.	1.	4.	18.	55.	127.	234.	359.	394.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	1.	2.	8.	22.	45.	77.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

Figure 16.-Distribution of group 1 pollock (juvenile) in August.

C. Zooplankton

1. Zooplankton in the Eastern Bering Sea

Numerous papers are available on zooplankton in the Bering Sea, produced mainly by fisheries scientists of the United States, Japan and Russia. However, the quantitative data reported in these papers are variable indeed, which are attributed mainly to two factors: the large spatial and temporal variability of zooplankton standing stock in general (patchiness) and the inadequacy of conventional sampling methods, specially in respect of catching more mobile species, such as euphausids. Thus, it is rather meaningless to summarize the zooplankton standing stock data other than in general terms: higher standing stock is reported in winter, spring and autumn in the vicinity of the continental slope. During the summer the standing stock is highest over the continental shelf, the time and location of maximum moving from southwest to northeast. Although the average standing stock is reported variably between 100 to 300 mg/m^3, higher concentrations (700 to 800 mg/m^3) in smaller areas are found in the upper 20 meter layers during late summer, the maximum patches reaching up to 2.5 g/m^3.

The data on zooplankton production is even less reliable than on standing stock, due to various indirect methods used for its estimation. The most frequently reported values of production are around 110 to 140 g/m^2, variably referred to as copepod production and total zooplankton production. This value is somewhat in disagreement with some earlier estimates of zooplankton production in the Atlantic (3 to 8% of standing stock daily; e.g. Riley, 1956, Cushing, 1955). Furthermore, these in literature reported quantitative data are not in full agreement with our computed values of consumption, as shown in next chapter.

The species composition of the zooplankton, as well as the frequency of occurrence of major species, is well agreed upon (see e.g. Motoda and Minoda 1974, Mesheryakova, 1970). However, the reproduction cycles are not well known; Heinrich (1962) reporting only one annual cycle in major species, which is in contrast to higher latitude Atlantic, where some species can have up to three generations per annum.

There are several summaries on standing stock (and production) of copepods in the Bering Sea, (Motoda and Minoda, 1974; Heinrich, 1962; Mesheryakova, 1964; and others). In general the authors report that 70 to 80% of the zooplankton in eastern Bering Sea consists of copepods, which might not be fully correct, as shown later. The average standing stock of copepods is reported between 0.2 to 0.7 g/m^3 or 20 to 70 g/m^2 (Heinrich, 1962).

Due to impracticability to obtain reasonable value of zooplankton standing stock at any given time and space, as described above, it is more advantageous for construction of ecosystem model to compute the plausible consumption (and demand) of zooplankton and to use only the relative zooplankton abundance for estimation of density dependent feeding. Therefore, the zooplankton standing stock is at present not directly used in our submodel, except for comparison of consumption. It will be used in the next generation of model for estimation of food availability (in case of grazing on zooplankton). An example of areal distribution of zooplankton standing stock as generated in our submodel for month of July, is shown in Figure 17. Known factors affecting the abundance and distribution of zooplankton were considered. One of the main objectives of the use of zooplankton subroutine in the present submodel was to investigate the spatial and temporal consumption of copepods and euphausids and to compare this consumption to availability. The monthly

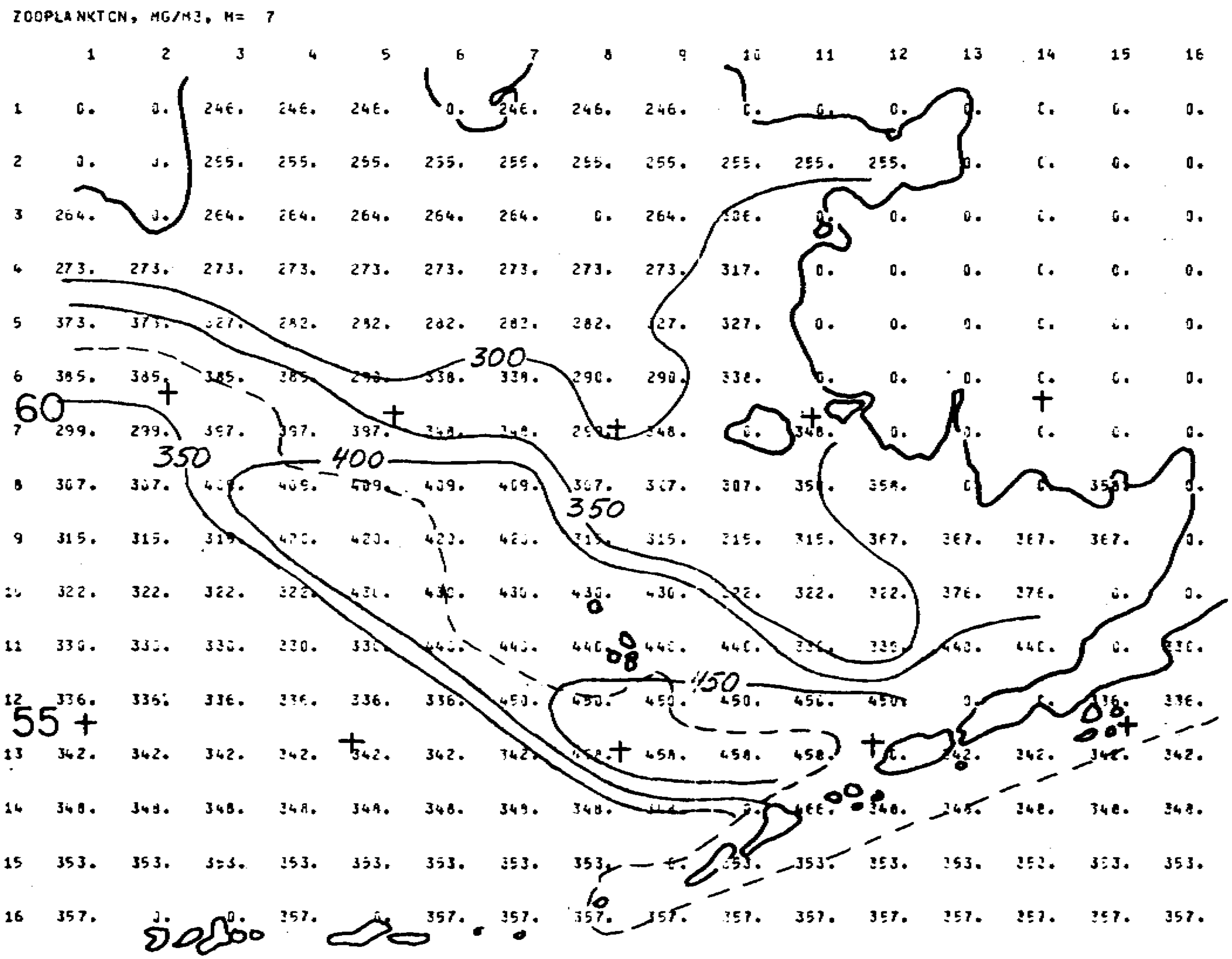


Figure 17.-Distribution of standing crop of zooplankton in the Eastern Bering Sea in July (mg/m^3).

consumption of copepods and euphausids was computed in other subroutines, in connection of food consumption computation of species feeding on plankton.

2. Consumption of total zooplankton and of copepods

The major consumers of copepods in our submodel are herring (and kindred species) and juvenile (pre-fishery) pollock (see Table 4). The total monthly amounts consumed are relatively constant throughout the year, decreasing with decreasing biomass of consumers (Table 6). The year-around constancy is caused by the fact that the present submodel did not account for food density dependent feeding, nor variation of food coefficient with temperature. An interesting observation from Table 6 is that the consumption of zooplankton and consumption of next lower link in food change is about 1:10 to 1:20 (these numbers will change with additional tuning of model), confirming indirectly the general "one order magnitude less" relation between various food chain links in the ocean. This relation is a result of the model rather than model input.

Examples of spatial distribution of monthly total zooplankton consumption (mg/m^3, assuming 50 m depth distribution) as computed with the submodel, are given in Figures 18 to 21. The highest consumption in January (Fig. 18) is off the continental shelf over deep water, where the bulk of herring and pollock biomass is located at this time. By April (Fig. 19) part of the higher consumption has moved over the edge of the continental shelf (herring has moved there) and by June (Fig. 20) the area of high consumption of zooplankton is over the central part of the continental shelf. By October (Fig. 21) the area of high zooplankton consumption is near the continental slope again, moving later off the continental slope.

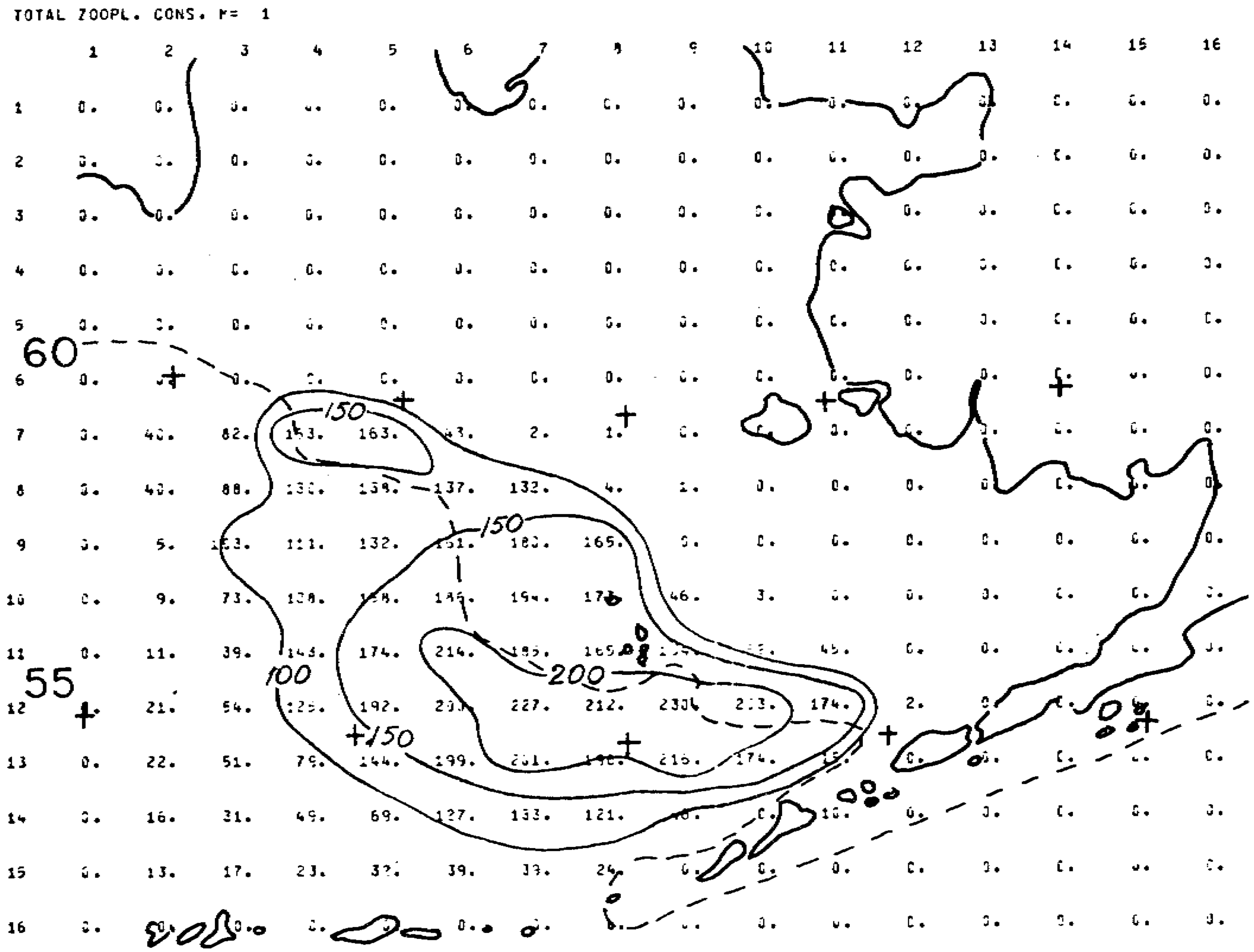


Figure 18.-Total zooplankton consumption in January (mg/m^3, assuming 50 m depth distribution).

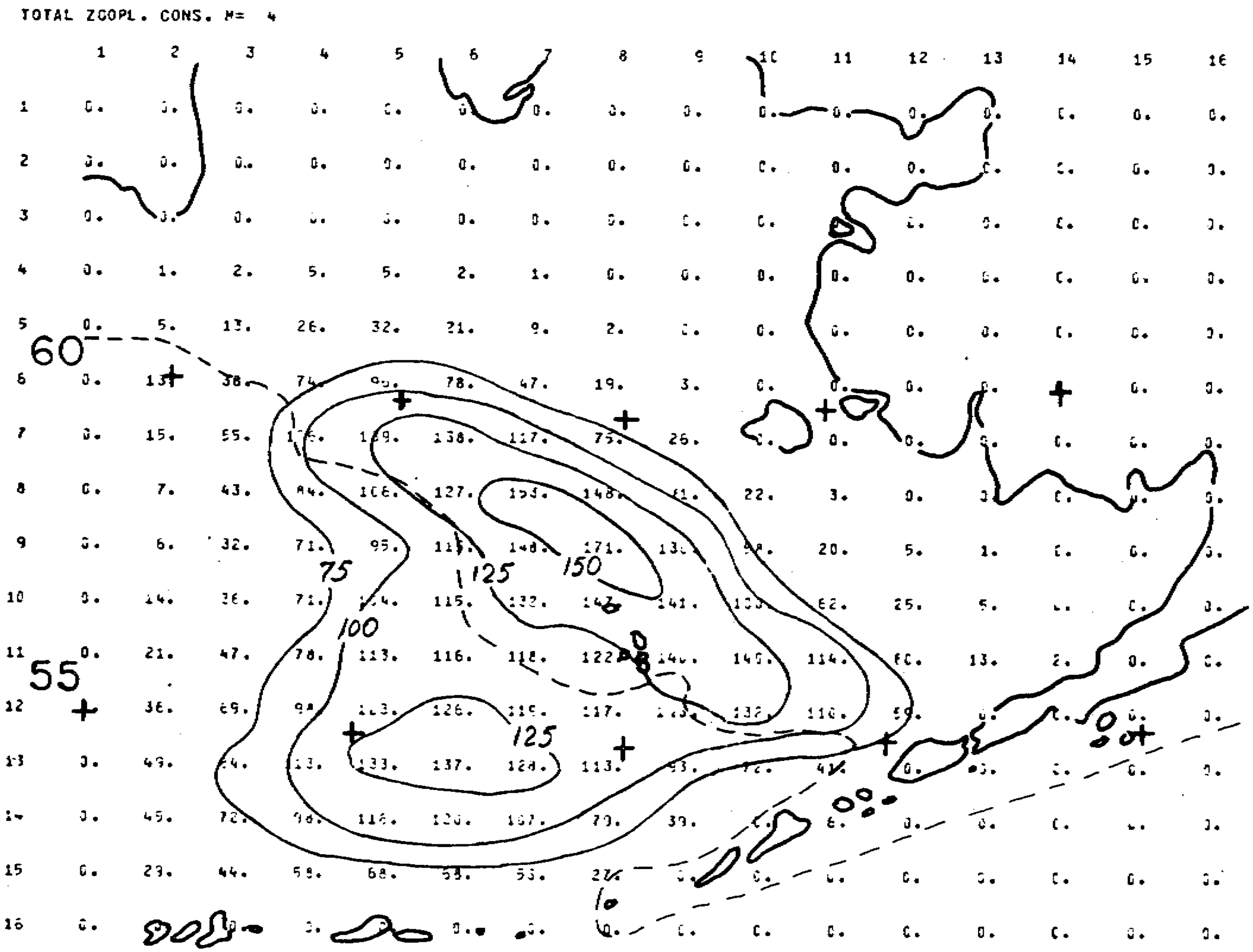


Figure 19.-Total zooplankton consumption in April (mg/m^3).

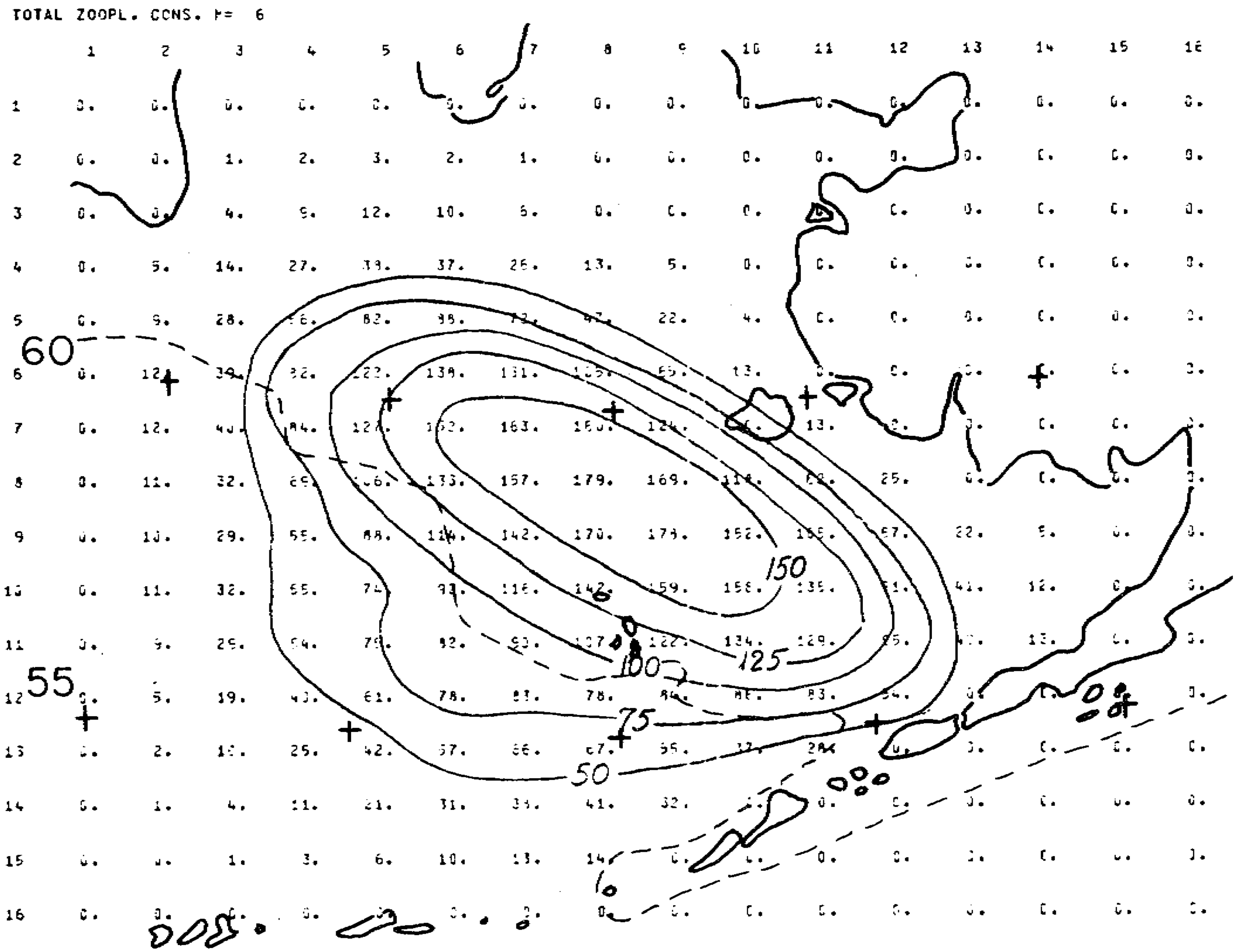


Figure 20.-Total zooplankton consumption in June (mg/m^3).

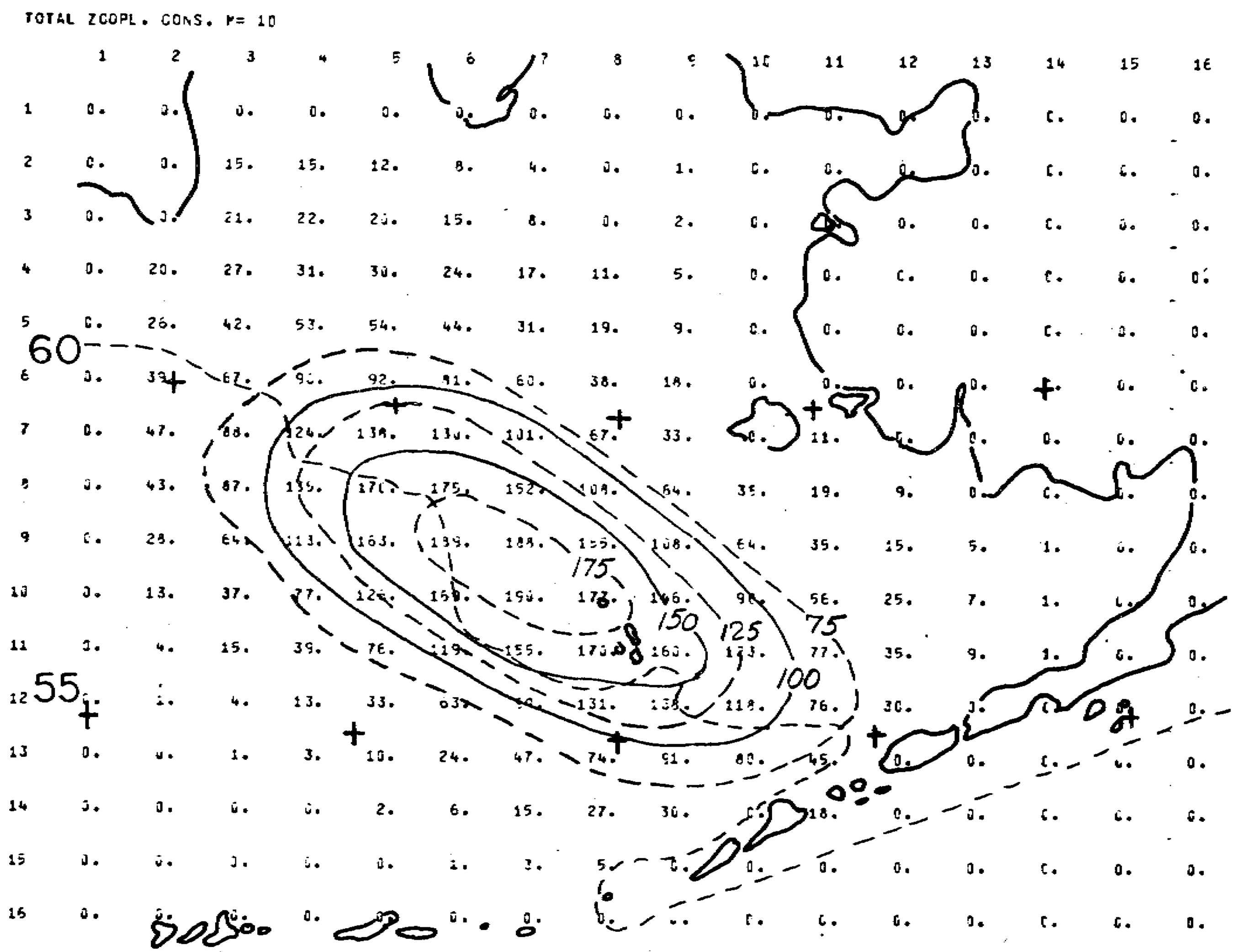


Figure 21.-Total zooplankton consumption in October (mg/m^3).

Two basic observations can be made from the above mentioned figures First, there are large areas in the northern part of the Bering Sea and also over deep water where zooplankton is little utilized. Secondly, the seasonal movement of areas of high utilization obviously enables the grazers to obtain the necessary food and this movement of areas of high consumption has a "saving" effect on possible reproduction and/or replenishment of zooplankton in previously heavily grazed areas. Serious, at present not fully explainable, discrepancy arises in the quantities of zooplankton consumed, in relation to reported standing stock and annual production. Our computations show relatively large areas where monthly consumption of copepods is in excess of 5 g/m^2. This would mean that in these rather extensive high-consumption areas, the greatest part of the reported standing stock and annual production is consumed. Questions thus arise: 1) Are the present methods adequate for measuring zooplankton standing stock and production? (Apparently not, as reported by numerous workers in literature.) 2) Is there an advection of zooplankton by currents into the areas of high consumption? 3) If zooplankton is grazed down to low level, does this cause a feeding migration in fish to new "feeding grounds" or does it cause partial starvation in fish, or does the composition of food change (i.e. does the stomach content reflect the availability of food)? These questions must be answered with carefully planned field work.

Another speculative observation can be made by considering Figures 18 to 21. It can be noted that the areas of higher zooplankton consumption do not coincide with known areas of more abundant occurrence of ichthyoplankton (fish eggs and larvae, the latter not shown on the figures). Thus the survival of larvae is enhanced, as these would otherwise be grazed in high zooplankton consumption area at least percentually as heavily (or more, due to some selectivity in most fish feeding) as zooplankton. In general the present model indicates, as noted already in case of pollock, that the year class strengths in many fish species with pelagic egg and larvae may greatly be determined by grazing on larvae and juvenile fish.

3. Euphausids (and ecologically kindred species)

Although most stomach content analyses indicate euphausids as a separate item, amphipods and at time even chaetognaths, are included in this group, and are considered so in our model computations. The quantitative knowledge on euphausids standing stock and production is meager indeed. Due to higher mobility than copepods, they are not included fully quantitatively in zooplankton catches and data, specially if this data is obtained with relatively small, fine-meshed nets.

The main consumers of euphausids in our model are pollock, shearwaters (not included among copepod consumers), and herring. The areas of higher consumption of euphausids, is in general similar, but not identical, to total zooplankton consumption. There are no reliable quantitative data - neither on euphausids standing stock nor on their production for comparison. It could only be mentioned that the total euphausids consumption is about two-thirds of copepod consumption (Table 6). It can be assumed that there is considerable substitution of both in the diet of consumers, depending on availability. The same questions regarding availability of euphausids in high consumption areas can be raised as done in the copepods section above.

D. Birds

1. Marine birds in the Eastern Bering Sea

Due to the high productivity of the Bering Sea, there is an abundance of marine birds who compete with other ecological groups for food. Partly due to the fact that marine birds have nearly no economic importance, nor do they form a food resource to other economically important species, the research on marine birds, and consequently the knowledge on them, is scant indeed. The basic data used in our model had been obtained from the summaries prepared by Sanger and King (1976) and direct contract work.

Only two species of birds were included into the present 8-component submodel: shearwaters and murres, the first being migratory birds occurring in the Bering Sea only during summer, and the second being local, breeding in the area. The total numbers of these birds present at any time is quite an uncertain estimate (see Fig. 22), thus the effects of the use of growth and mortality rates in present model would be entirely masked by the errors of the abundance estimates. Furthermore, the quantitative data on various causes of mortality of birds (starvation, storms, ice) is at present lacking. A conservative figure for food requirement (9% of body weight daily) has been used for both species in our submodel.

2. Murres

Common and thick-billed murres are among the most abundant pelagic bird species in the Bering Sea. These species, specially thick-billed murres, are highly pelagic during winter and spring. During the breeding season they are found in greater abundance near the costs and islands.

Murres can dive relatively deep, therefore, their food consists of 30% of benthos, 10% of herring, 30% of other smaller fish (including some juvenile pollock and salmon) and 30% of other, non-specific food items (such as squids).

The full ecological impact of murres will become apparent in complete ecosystem model, which will include ichthyoplankton and other species, as 60% of food consumed by murres falls within this group.

An example of at present prescribed monthly distribution of murres is given in Figure 23.

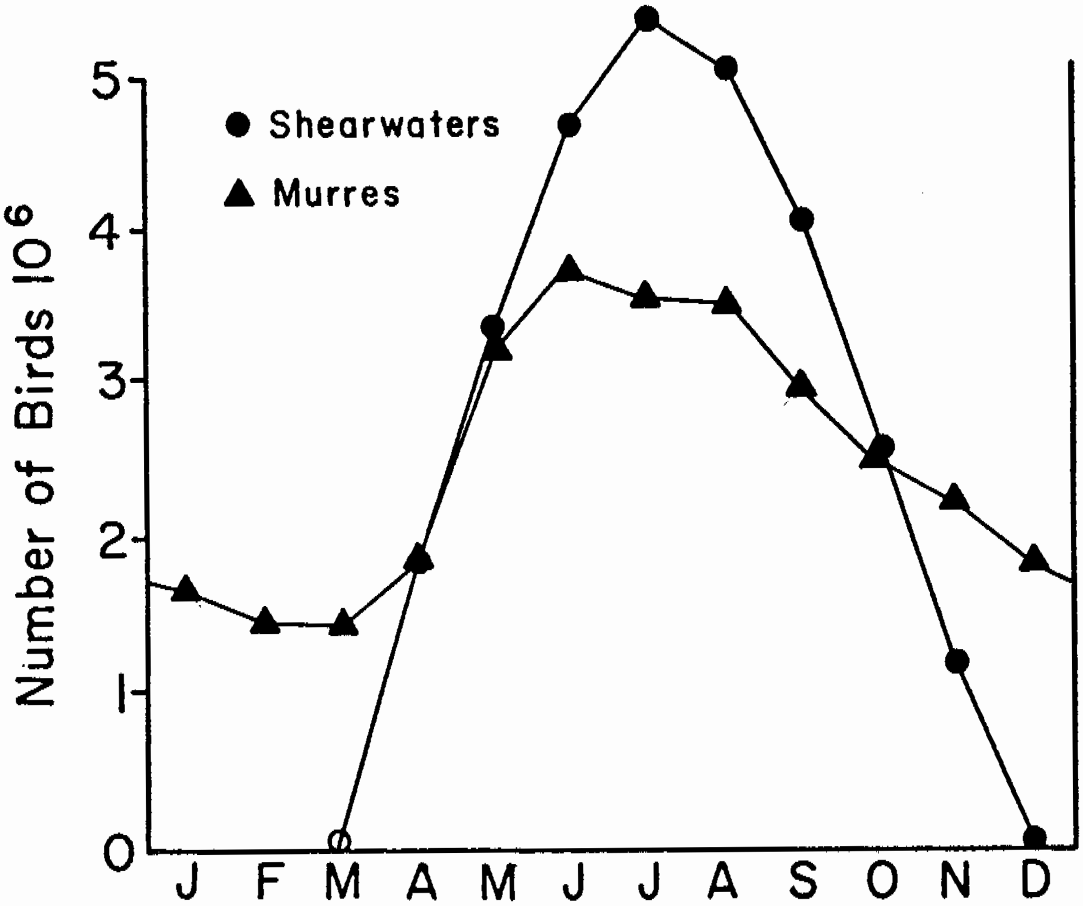


Figure 22.-Monthly abundance of shearwater and murres in Eastern Bering Sea.

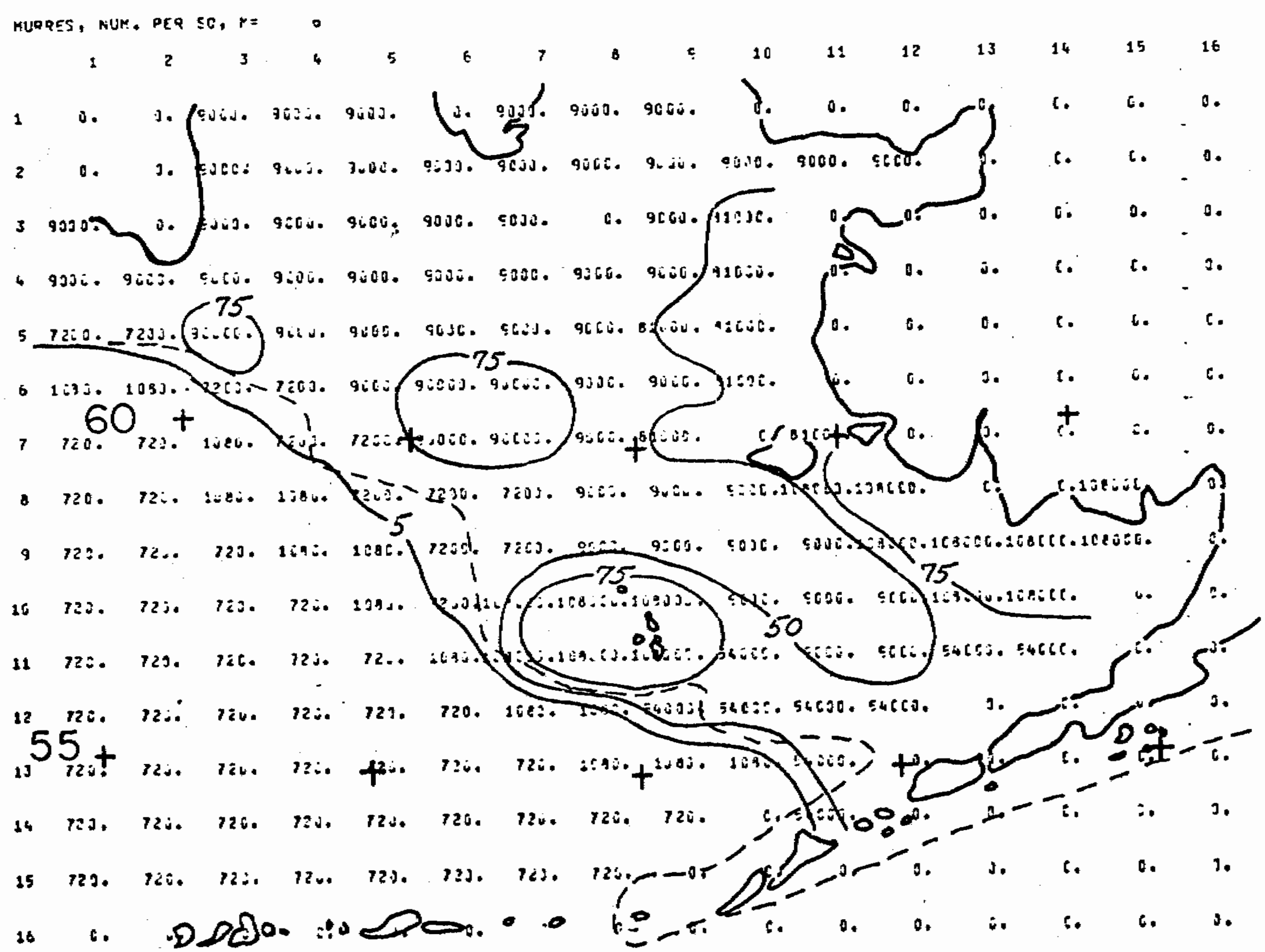


Figure 23.-Distribution of murres in June.

3. Shearwaters

Sooty and short-tailed shearwaters breed during northern winter in the southern hemisphere. They arrive in the Bering Sea in late spring and leave in autumn (see Fig. 22). During the summer months the shearwaters are numerically the most abundant bird species in the Bering Sea, and an example of the monthly distribution of shearwaters is given in Figure 24.

The composition of food of shearwaters is not well known, partly by lack of investigations, partly due to variability of composition of food and due to rapid digestion of some food (e.g. fish eggs and larvae). In our model the shearwater food composition is estimated to be: 10% herring, 10% small pollock, 30% of other unidentified small fish and 50% of euphausids and kindred species. Until more accurate information on distribution and food composition of shearwaters is obtained, detailed evaluation of the effects of shearwaters on marine ecosystem in the Bering Sea cannot be accurately ascertained.

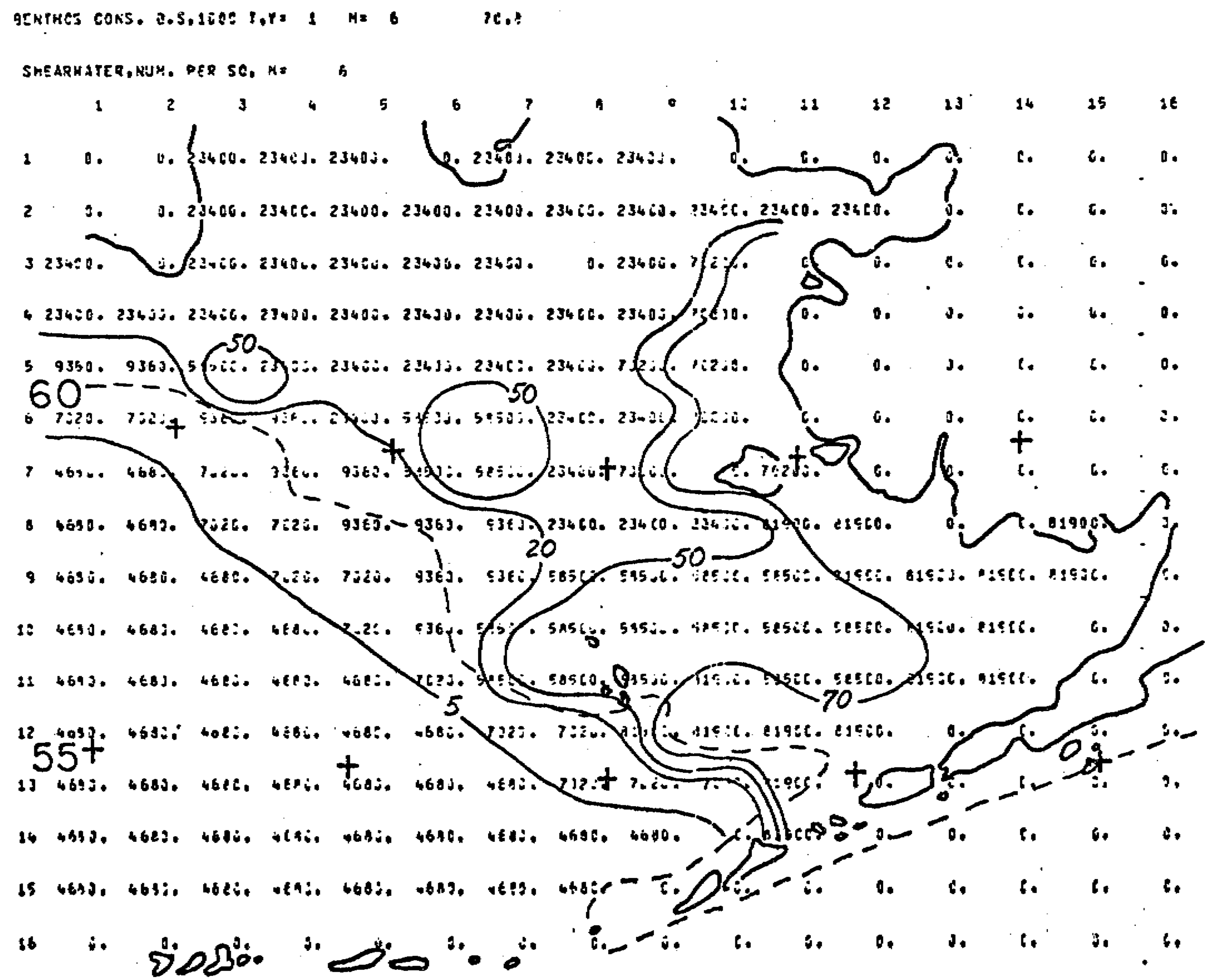


Figure 24.-Distribution of shearwaters in June.

IV. SUMMARY OF THE GENERAL RESULTS FROM 8-COMPONENT ECOSYSTEM SUBMODEL

A. Interactions and Interdependencies in Marine Ecosystem and the Need for Complete Ecosystem Model

The general interactions between species and groups of species (inter-species interactions) and between species and environment are shown in Figures 1 and 2. One of the most pronounced interspecies interactions is the food web, i.e. the grazing of one species upon another. The grazing involves also intraspecies interaction via cannibalism. In the present submodel the food coefficients (i.e. the food requirements for growth and maintenance) have been selected generally as lowest plausible values reported in literature. Furthermore, the composition of food has been kept constant throughout the year and in all locations (i.e. not a function of space and time). Furthermore, the submodel contains only eight major components of the ecosystem. Despite these limitations the model gives as a major conclusion that availability of food is a limiting factor for most components in marine ecosystem (i.e. limiting the possible population size, as well as growth and, indirectly, reproduction). Furthermore, from this conclusion follows, that a marine ecosystem model must include all components of this system as food sources and grazers in order to simulate real highly competitive conditions in the sea. Thus, the next steps in the completion of the ecosystem model at hand will be:

1) Inclusion of benthos and demersal fish subroutines.
2) Completion of the mammal subroutine with inclusion of sea lions and other seals in "bulk" form; inclusion of other pelagic species (e.g. capelin) to "herring" subroutine and other roundfish (semi-demersal) to pollock subroutine.

3) Inclusion of more environmental effects to all subroutines (such as the effects of cold bottom temperatures, effect of seasonal temperature changes and its anomalies on migrations, effect of temperature on feeding, growth, and spawning, effects of currents on transport of eggs and juveniles, etc.).

4) Refinements of feeding and growth computations by making (a) feeding rate dependent of availability of food (food concentration) and season (temperature effect, spawning), (b) making food composition a function of food availability in space and time (incl. preferred substitution), (c) making growth rate dependent on available food supply and temperature of the environment.

Many of the principal results of the interactions in marine ecosystem appear as computational results of the model, such as the separation of juvenile and adult pollock populations, described earlier. Furthermore, the abundance of herring in the present model is determined principally by interaction between consumption (mainly by pollock) and growth, whereas the abundance (and long-term fluctuations of abundance) of pollock is principally determined by consumption (mainly by mammals), fishery and cannibalism (determined by abundance of older pollock and availability of other food for them). The model is capable of depicting any desired interaction, which must be introduced (added) to the model with proper known quantitative process.

B. Further Research Topics as Indicated by the Ecosystem Model

The ecosystem model can be used to evaluate the priorities of future research. This is done mainly by evaluating the importance (and influence) of given parameters, processes and distributions on the results of the model outputs. The indicated research needs fall into three categories:

1) Literature search and testing and evaluating of data obtained (e.g. standing stocks and migrations; food requirements and composition, etc.).

2) Field work (verification of model results, such as abundance (distribution) of euphausids, under-ice distribution of plankton and fish, feeding under ice, hunger-dependent non-maturation, effects of environmental anomalies, etc.).

3) Laboratory work (food coefficients, cannibalism both in tanks and in field, stomach analysis, etc.).

Considering the need for various data for the numerical model, as well as ongoing research both in OCSEAP and outside it, a general list of major research tasks in relation to OCSEAP/PROBES objectives in Eastern Bering Sea is presented below. This list is arranged by large ecological groups and contains baseline-type research objectives (B) (i.e., abundance and distribution studies) as well as process-oriented research objectives (P). The suggested priorities are grouped into three categories (I to III).

1. Mammals

Priority		
I	1.1(B)	Estimation of abundance and distribution of all toothed whales. (Data on baleen whales is available to some extent, allowing some initial incorporation of this group into the model.)
I	1.2(P)	Food composition of toothed whales.
II	1.3(P)	Spatial and temporal changes of composition of food (stomach content analysis) of dominant mammal species (e.g. sea lions, fur seal, bearded seal and harbor seals) including better estimates on food requirements.

III 1.4(P) Quantitative evaluation of major factors affecting the mortality of adult seals and sea lions ("old age", starvation, disease, etc.).

2. Fish

I 2.1(B) Estimation of abundance, and distribution of presently "non-commercial" species, especially pelagic species (smelt, capelin, sand lance, etc.). Large gaps exist in the knowledge of abundance and distribution of surface schooling pelagic, bathypelagic, and near-shore components of fish populations. Additional knowledge on growth and food composition of sculpins and eel pouts is also required.

I 2.2(P) Study of composition of food, and growth rates of species in 2.1.

II 2.3(P) Study of growth rates of juvenile pollock (and other major species in juvenile stages).

II 2.4(B) Study of the differences in distribution of juveniles (and adult) of major species (pollock, groundfishes, herring, etc.).

3. Zooplankton and Nekton other than Fish

II 3.1(B) Distribution and abundance by season of squids.

II 3.2(B) Temporal and spatial variation of vertical distribution of copepods and euphausids (including patchiness).

III 3.3(P) Study of reproduction cycle of euphausids and its dependence on environmental factors.

4. Benthos

I. 4.1(B) Abundance and distribution of mobile epifauna.

II. 4.2(B) Improvement of the knowledge of spatial and temporal variation of the quantitative relations between predatory benthos (e.g., starfish) and "fish food" benthos (e.g., annelids, small bivalves). (Part of this knowledge might come from ongoing OCSEAP studies.)

5. Birds

I. 5.1(P) Behavior of birds during heavy storms and the effect of storms on mortality (present OCSEAP programs on marine birds are rather extensive but results are not available as yet).

V. POSSIBLE EFFECTS OF OIL EXPLORATION

A complete ecosystem model is a most useful tool to determine the possible effects of oil exploration in relation to "natural" changes (i.e. changes from natural causes) in an ecosystem, caused either by seasonal cycles or by environmental anomalies and catastrophic events, such as prolonged storms. These evaluations can be made with a complete ecosystem model posing the question and introducing proper magnitudes of natural and man-made events. Below are listed only a few plausible approaches, which need special evaluation with a complete ecosystem model and, thus, special reports of the results.

1) Comparison of man-made normal (e.g. fishery) or accidental effects with effects caused by Nature itself (e.g. seasonal cycles, anomalies, natural catastrophic events (e.g. heavy storms) in order to answer questions and criticism on oil exploration-exploitation and to

compare quantitatively the man-made and natural effects, locally as well as over large areas (e.g. effect of an oil spill on birds as compared to a heavy storm on birds' mortality).

2) Evaluation of local oil exploration effects in relation to regional marine ecosystem, (e.g. (a) effect of the drilling and traffic sound on possible aggregation/dispersal of mammals, birds, fish; (b) effect of drilling mud release on benthos communities and via them on demersal fish; (c) effects of surface traffic on birds and mammals (if any); (d) effects of oil spills on various ecosystem components, etc.).

3) Finally, it has to be borne in mind that a complete ecosystem model is a depository of our existing knowledge on the ecosystem in a condensed form. Thus, the model can be used for storage and for rapid extraction of any pertinent data on spatial and temporal distribution of species and/or groups of species and/or processes and interactions within the ecosystem itself.

The scope of the present contract neither required nor permitted the development of an ecosystem model beyond a conceptual framework. We feel that in spite of the recognized difficulties in modelling an ecosystem, considerable progress has been made along these lines in the eastern Bering Sea as a result of our efforts. With adequate support, the DYNUMES model could not only integrate the results of various OCSEAP units, but provide the best answers to the multitude of questions and problems associated with the real and potential effects of oil pollution in this area. In fact it seems to be the only integrative device to synthesize the interactions of the system in evaluating direct and indirect effects of petroleum exploration, extraction, and accidents.

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Appendix

Computer Program

of

8-component Ecosystem Submodel

for the Eastern Bering Sea

```
      PROGRAM BEMAP(TAPE3,TAPE4,INPUT,OUTPUT,PUNCH)
      DIMENSION ISL(16,16),CP1(16,16),CP2(16,16),CP3(16,16),
     1F1(16,16),F2(16,16),F3(16,16),F4(16,16),S1(16,16),S2(16,16),
     2S3(16,16),P1(16,16),P2(16,16),AS(16,16),AF(16,16),AP(16,16)
     3,IS(16,16),WA(12,10),WB(12,10),WC(12,10),IA(12)
     4,NS(10),MS(10),OP(10),OS(10),OH(10),OO(10)
     5,INDEX(301),WD(12,10),WE(12,10),WF(12,10),WG(12,10)
     6,POR(6),GR(6),TR(6),FF(6),FGF(6),FFM(6),CAN(6)
      COMMON ISL,CP1,CP2,CP3,
     2F1,F2,F3,F4,S1,S2,S3,P1,P2,AS,AF,AP
     3,IS,WA,WB,WC,IA,NS,MS,OP,OS,OH,OO,INDEX
     4,WD,WE,WF,WG
     5,POR,GR,TR,FF,FGF,FFM,CAN,HFC,HGR,POCC
      COMMON K,L,KK,LL,MM,NE,ME,NU,MJ,MJJ,MF,NMF,JA,MPF,NPF
     2,IPO1,IPO2,IPO3,IPO4,IPO5,IPO6,IPO7,IPO8,IPO9,IPO10,IPO11,IPO12
     3,IFS1,IFS2,IFS3,IFS4,IFS5,IFS6,IFS7,IFS8,IFS9,IFS10,IFS11,IFS12
     4,IBS1,IBS2,IBS3,IBS4,IBS5,IHE1,IHE2,IHE3
     5,IIC1,IIC2,IIC3,IIC4,IIC5,IIC6,IIC7,IIC8,IIC9,IIC10,IIC11,IIC12
     6,IFP1,IFP2,IFP3,IFP4,IFP5,IFP6,IFP7,IFP8,IFP9,IFP10,IFP11,IFP12
      COMMON IZO1,IZO2,IZO3,IZO4
     2,MON,IFSI,IFPI,IICI,IHEI,IPOI
      COMMON/1/IC(16,16)
      DATA IC/256*0.0/
C     ECS LOCATIONS
C     PO1-1     INITIAL POLLOCK                   1
C     PO2-257   POLLOCK GR. 1                     2
C     PO3-513   POLLOCK GR. 2                     3
C     PO4-769   POLLOCK GR. 3                     4
C     PO5-1025 POLLOCK CONSUMPTION       5
C     IBS3  POLLOCK CONSUMPTION BY MAMMALS
C     HE1-1537 INITIAL HERRING                    7
C     HE2-1793 COMPUTED HERRING FIELD             8
C     HE3-2049 HERRING CONSUMPTION                9
C     ZO1-2305 COPEPOD CONSUMPTION               10
C     Z/2-2561 EUPHAUSIDS CONSUMPTION            11
C     Z/3-2817 TOTAL ZOOPLANKTON CONSUMPTION       12
C     ZO4-3073 ZOOPALANKTON STANDING CROP FOR GIVEN MONTH 13
C     CONSUMPTION OF COPEPODS
C    1   JAN 60    FEB 61    MAR 62    APR 63    MAY 64    JUN 65
C    2   JUL 66    AUG 67    SEP 68    OCT 69    NOV 70    DEC 71
C     CONSUMTION OF EUPHAUSIDS
C    1   JAN 72    FEB 73    MAR 74    APR 75    MAY 76    JUN 77
C    2   JUL 78    AUG 79    SEP 80    OCT 81    NOV 82    DEC 83
C     CONSUMTION OF ZOOPLANKTON (TOTAL)
C    1   JAN 84    FEB 85    MAR 86    APR 87    MAY 88    JUN 89
C    2   JUL 90    AUG 91    SEP 92    OCT 93    NOV 94    DEC 95
C     CONSUMPTION OF HERRING
C    1   JAN 96    FEB 97    MAR 98    APR 99    MAY 100   JUN 101
C    2   JUL 102   AUG 103   SEP 104   OCT 105   NOV 106   DEC 107
C     CONSUMPTION OF POLLOCK
C    1   JAN 108   FEB 109   MAR 110   APR 111   MAY 112   JUN 113
C    2   JUL 114   AUG 115   SEP 116   OCT 117   NOV 118   DEC 119
C     CONSUMPTION OF OTHERS (UNSPECIFIED)
C    1   JAN 120   FEB 121   MAR 122   APR 123   MAY 124   JUN 125
C    2   JUL 126   AUG 127   SEP 128   OCT 129   NOV 130   DEC 131
C     CONSUMPTION OF BENTHOS (EXTERNEL)
C    1   JAN 132   FEB 133   MAR 134   APR 135   MAY 136   JUN 137
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C     2   JUL 138   AUG 139   SEP 140   OCT 141   NOV 142   DEC 143
C      FUR SEAL,KG/KM2, GRAPH                                144
C      POLLOCK CONSUMPTION BY FUR SEAL, KG/KM2, GRAPH 145
C      HERRING CONSUMPTION BY FUR SEAL, KG/KM2, GRAPH 146
C      SEA LION
C     1   JAN  51   FEB  52   MAR  53   APR  54   MAY  55   JUN  56
C     2   JUL  57   AUG  58   SEP  59   OCT 222   NOV 223   DEC 224
C      FUR SEAL
C     1   JAN  14   FEB  15   MAR  16   APR  17   MAY  18   JUN  19
C     2   JUL  20   AUG  21   SEP  22   OCT  23   NOV  24   DEC  25
C      ICE COVER
C     1   JAN  26   FEB  27   MAR  28   APR  29   MAY  30   JUN  31
C     2   JUL  32   AUG  33   SEP  34   OCT  35   NOV  36   DEC  37
C      POLLOCK FISHING  INTENSITY COEFFICIENTS
C     1   JAN  38   FEB  39   MAR  40  APR   41   MAY  42   JUN  43
C     2   JUL  44   AUG  45   SEP  46  OCT   47   NOV  48   DEC  49
C      POLLOCK CONSUMPTION BY MAMMALS  50
C      BEARDED SEAL
C     1   JAN 147   FEB 148   MAR 149   APR 150   MAY 151   JUN 152
C     2   JUL 153   AUG 154   SEP 155   OCT 156   NOV 157   DEC 158
C      SHEARWATERS
C     1   JAN 159   FEB 160   MAR 161   APR 162   MAY 163   JUN 164
C     2   JUL 165   AUG 166   SEP 167   OCT 168   NOV 169   DEC 170
C      MURRES
C     1   JAN 171   FEB 172   MAR 173   APR 174   MAY 175   JUN 176
C     2   JUL 177   AUG 178   SEP 179   OCT 180   NOV 181   DEC 182
C**************************************************************
C      TAPE 4
C      STANDING STOCK OF POLLOCK, GR1
C     1   JAN   1   FEB   2   MAR   3   APR   4   MAY   5   JUN   6
C     2   JUL   7   AUG   8   SEP   9   OCT  10   NOV  11   DEC  12
C      STANDING STOCK OF POLLOCK, GR2
C     1   JAN  13   FEB  14   MAR  15   APR  16   MAY  17   JUN  18
C     2   JUL  19   AUG  20   SEP  21   OCT  22   NOV  23   DEC  24
C      STANDING STOCK OF POLLOCK, GR3
C     1   JAN  25   FEB  26   MAR  27   APR  28   MAY  29   JUN  30
C     2   JUL  31   AUG  32   SEP  33   OCT  34   NOV  35   DEC  36
C      MONTHLY CATCHES OF POLLOCK
C     1   JAN  37   FEB  38   MAR  39   APR  40   MAY  41   JUN  42
C     2   JUL  43   AUG  44   SEP  45   OCT  46   NOV  47   DEC  48
C      SANDING STOCK OF POLLOCK
C     1   JAN  49   FEB  50   MAR  51   APR  52   MAY  53   JUN  54
C     2   JUL  55   AUG  56   SEP  57   OCT  58   NOV  59   DEC  60
C      POLLOCK BIOMASS, SIZE GROUP 1, GRAPH 61
C      POLLOCK BIOMASS, SIZE GROUP 2, GRAPH 62
C      POLLOCK BIOMASS, SIZE GROUP 3, GRAPH 63
C      ZOOPLANKTON GRAPH 64
C      MONTHLY DISTRIBUTION OF HERRING
C     1   JAN  65   FEB  66   MAR  67   APR  68   MAY  69   JUN  70
C     2   JUL  71   AUG  72   SEP  73   OCT  74   NOV  75   DEC  76
C      MJ-INDICATOR, 1 SINGEL MONTH, 2 SEVERAL MONTHS,3 FULL YEAR
C      MJJ-NUMBER OF MONTHS TO BE COMPUTED
C      MF-FIRST MONTH TO BE COMPUTED
C      NU-NUMBER OF SPECIAL OUTPUT POINTS
C      MON-MONTS COUNT (ACTUAL MONTH BEING COMPUTED)
C      NMF- INDICATO ON THE CHANGE OF FISHING MORTALITY
C      NFF NUMBER OF POINTS WHERE FISHING MORTALITY IS CHANGED
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C     ISL- 1=OPEN SEA,CEEPER THAN 200 M, 2=SEA,CONT. SHELF,3=LAND
C     NS,MS  N AND M OF SPECIAL OUTPUT POINTS
C     JA- JA=0 NO INITIALIZATION,  JA=1-INITIALIZE
      CALL OPENMS(3,INDEX,226,0)
      DO 10 M=1,225
      CALL WRITMS(3,IC,256,M)
   10 CONTINUE
      CALL OPENMS(4,INDEX,201,0)
      DO 19 M=1,200
      CALL WRITMS(4,IC,256,M)
   19 CONTINUE
      SU=0.
      SLM=0.
      MCN=0
      READ   30,MJ,MJJ,MF,NU,NMF,NPF,MPF,JA,NE,ME
      READ   30,(NS(I),MS(I),I=1,NU)
      READ 11,HGC,HGR,PCCC,FMO
      PRINT 12,HGC,HGR,POCO,FMO
C     HFC - HERRING FISHING COEFFICIENT
C     HGR - HERRING GROWTH COEFFICIENT
C     POCO - HERRING POPULATION SIZE ADJUSTING COEFFICIENT
C     FMO  - OLD AGE MORTALITY COEFFICIENT FOR POLLOCK
      READ 11,(POR(I),I=1,6)
C     POR   - POLLOCK PROPORTIONING COEFFICIENT
   11 FORMAT(6F6.4)
      PRINT 12,(POR(I),I=1,6)
      READ 11,(GR(I),I=1,6)
C     GR    - MONTHLY BULK GROWTH COEFFICIENTS FOR POLLOCK
      PRINT 12,(GR(I),I=1,6)
   12 FORMAT (6F10.4)
      READ 11,(TR(I),I=1,6)
C     TR    - MONTHLY PERCENTAGE OF POLLOCK BIOM. TRANSFERRED
C                FROM ONE SIZE GROUP TO ANOTHER
      PRINT 12,(TR(I),I=1,6)
      READ 11,(FF(I),I=1,6)
C     FF    - FISHING INTENSITY ADJUSTING FACTOR (FOR DIFFERENT
C                SIZE  GROUPS)
      PRINT 12,(FF(I),I=1,6)
      READ 11,(FGF(I),I=1,6)
C     FGF  - FOOD COEFFICIENT FOR GROWTH (POLLOCK)
      PRINT 12,(FGF(I),I=1,6)
      READ 11,(FFM(I),I=1,6)
C     FFM  - MONTHLY FOOD COEFFICIENT FOR MAINTENANCE (POLLOCK)
      READ 11,(CAN(I),I=1,6)
C     CAN  - PERCENTAGE OF FOOD AQUIRED THROUGH CANNIBALISM
      PRINT 12,(FFM(I),I=1,6)
      PRINT 12,(CAN(I),I=1,6)
      READ   31,((ISL(N,M),M=1,16),N=1,16)
   30 FORMAT (24I3)
   31 FORMAT (12I6)
   32 FORMAT(5X,14HSEA-LAND TABLE//9X,16I7)
   33 FORMAT (//I7,16I7)
   34 FORMAT (5X,8I6)
   35 FORMAT(//5X,22HCOORD. OF SPEC. POINTS,//5X,10(1H(,I2,1H,,I2,1H),2
     2,))
      PRINT 30,MJ,MJJ,MF,NU,NMF,NPF,MPF,JA,NE,ME
      PRINT 32,(N,N=1,16)
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      PRINT 33,(N,(ISL(N,M),M=1,16),N=1,16)
      PRINT 35,(NS(I),MS(I),I=1,NU)
      K=MF
   37 FORMAT (12F6.0)
   51 READ 31,((IS(N,M),M=1,16),N=1,16)
   52 PRINT 40,(N,N=1,16)
   40 FORMAT(1H1,5X,21HSPECIAL INDICES FIELD,//9X,16I7)
      PRINT 33,(N,(IS(N,M),M=1,16),N=1,16)
   50 READ 31,((IC(N,M),M=1,16),N=1,16)
   22 PRINT 36,K,(N,N=1,16)
   36 FORMAT (5X,11HICE COVER   ,I6//9X,16I7)
      PRINT 33,(N,(IC(N,M),M=1,16),N=1,16)
  121 GO TO (61,62,63,64,65,66,67,68,69,70,71,72),K
   61 CALL WRITMS(3,IC,256,26,1)
      GO TO 75
   62 CALL WRITMS(3,IC,256,27,1)
      GO TO 75
   63 CALL WRITMS(3,IC,256,28,1)
      GO TO 75
   64 CALL WRITMS(3,IC,256,29,1)
      GO TO 75
   65 CALL WRITMS(3,IC,256,30,1)
      GO TO 75
   66 CALL WRITMS(3,IC,256,31,1)
      GO TO 75
   67 CALL WRITMS(3,IC,256,32,1)
      GO TO 75
   68 CALL WRITMS(3,IC,256,33,1)
      GO TO 75
   69 CALL WRITMS(3,IC,256,34,1)
      GO TO 75
   70 CALL WRITMS(3,IC,256,35,1)
      GO TO 75
   71 CALL WRITMS(3,IC,256,36,1)
      GO TO 75
   72 CALL WRITMS(3,IC,256,37,1)
   75 CONTINUE
      K=K+1
      IF(K-3)50,22,55
   55 IF(K-5)50,50,79
   79 IF(K-11)23,50,24
   23 DO 25 N=1,NE
      DO 25 M=1,ME
      IC(N,M)=ISL(N,M)
   25 CONTINUE
      GO TO 22
   24  IF(K-12)50,50,41
   41 CONTINUE
      K=MF
   76 READ  37,((CP1(N,M),M=1,16),N=1,16)
      DO 120 N=1,NE
      DO 120 M=1,MF
  763 SL=SL+(CP1(N,M)*9.0726)/1000.
  120 CONTINUE
      PRINT 38,K
   38 FORMAT(1H1,5X,23HPOLLOCK, KG/SQKM, MONTH,I6//)
      CALL PRIFLD (CP1,1)
```

```
 39 FORMAT(//I7,16F7.1)
    PRINT 350,K,SU
350 FORMAT(//5X,27HTOTAL POLLOCK,1000 TONS, M=,I4,F9.1)
    SU=0.
 78 CALL WRITMS(3,CP1,256,1,1)
 42 CONTINUE
130 READ 1371,((CP1(N,M),M=1,16),N=1,16)
1371 FORMAT(12F6.2)
    READ 1371,((CP2(N,M),M=1,16),N=1,16)
 43 SU=0.
    GO TO(133,134,135,136,137,138,139,140,141,142,143,144),K
133 CALL WRITMS(3,CP1,256,14,1)
    CALL WRITMS(3,CP2,256,51,1)
    GO TO 146
134 CALL WRITMS(3,CP1,256,15,1)
    CALL WRITMS(3,CP2,256,52,1)
    GO TO 146
135 CALL WRITMS(3,CP1,256,16,1)
    CALL WRITMS(3,CP2,256,53,1)
    GO TO 146
136 CALL WRITMS(3,CP1,256,17,1)
    CALL WRITMS(3,CP2,256,54,1)
    GO TO 146
137 CALL WRITMS(3,CP1,256,18,1)
    CALL WRITMS(3,CP2,256,55,1)
    GO TO 146
138 CALL WRITMS(3,CP1,256,19,1)
    CALL WRITMS(3,CP2,256,56,1)
    GO TO 146
139 CALL WRITMS(3,CP1,256,20,1)
    CALL WRITMS(3,CP2,256,57,1)
    GO TO 146
140 CALL WRITMS(3,CP1,256,21,1)
    CALL WRITMS(3,CP2,256,58,1)
    GO TO 146
141 CALL WRITMS(3,CP1,256,22,1)
    CALL WRITMS(3,CP2,256,59,1)
    GO TO 146
142 CALL WRITMS(3,CP1,256,23,1)
    CALL WRITMS(3,CP2,256,222,1)
    GO TO 146
143 CALL WRITMS(3,CP1,256,24,1)
    CALL WRITMS(3,CP2,256,223,1)
    GO TO 146
144 CALL WRITMS(3,CP1,256,25,1)
    CALL WRITMS(3,CP2,256,224,1)
146 CONTINUE
    PRINT 132,K
132 FORMAT(1H1,5X,24HFUR SEAL, KG/SQKM  ,MONTH,I6//)
    CALL PRIFLD(CP1,1)
351 FORMAT(//5X,28HTOTAL FUR SEAL, THOUSANS, M=,I4,F8.0)
    K=K+1
 53 IF(K-12)130,130,148
148 CONTINUE
    SU=0.
    K=MF
149 READ 37,((CP1(N,M),M=1,16),N=1,16)
```

```
      DO 150 N=1,NE
      DO 150 M=1,ME
      SU=SU+(CP1(N,M)*9.0726)/1000.
  150 CONTINUE
      PRINT 151,K
  151 FORMAT(1H1,5X,17HHERRING, KG/SQKM ,I6//)
      CALL PRIFLD(CP1,1)
      SU=0.
      CALL WRITMS(3,CP1,256,7,1)
  166 CONTINUE
  167 READ 1372,((CP1(N,M),M=1,16),N=1,16)
 1372 FORMAT(12F6.3)
      DO 168 N=1,NE
      DO 168 M=1,ME
      CP1(N,M)=CP1(N,M)*0.01
  168 CONTINUE
 1154 PRINT 169,K,(N,N=1,16)
  169 FORMAT(1H1,5X,33HFISHING MORTALITY COEFF.(MONTHLY,I6//9X,16I7)
      PRINT 170,(N,(CP1(N,M),M=1,16),N=1,16)
  170 FORMAT (//I7,16F7.3)
      GO TO(171,172,173,174,175,176,177,178,179,180,181,182),K
  171 CALL WRITMS(3,CP1,256,38,1)
      GO TO 183
  172 CALL WRITMS(3,CP1,256,39,1)
      GO TO 183
  173 CALL WRITMS(3,CP1,256,40,1)
      GO TO 183
  174 CALL WRITMS(3,CP1,256,41,1)
      GO TO 183
  175 CALL WRITMS(3,CP1,256,42,1)
      GO TO 183
  176 CALL WRITMS(3,CP1,256,43,1)
      GO TO 183
  177 CALL WRITMS(3,CP1,256,44,1)
      GO TO 183
  178 CALL WRITMS(3,CP1,256,45,1)
      GO TO 183
  179 CALL WRITMS(3,CP1,256,46,1)
      GO TO 183
  180 CALL WRITMS(3,CP1,256,47,1)
      GO TO 183
  181 CALL WRITMS(3,CP1,256,48,1)
      GO TO 183
  182 CALL WRITMS(3,CP1,256,49,1)
  183 CONTINUE
  113 K=K+1
   59 IF(K-12)167,167,185
  185 CONTINUE
      K=MF
      DO 520 I=1,12
      READ 1371,((CP1(N,M),M=1,16),N=1,16)
      READ 37,((CP2(N,M),M=1,16),N=1,16)
      READ 37,((CP3(N,M),M=1,16),N=1,16)
      GO TO (501,502,503,504,505,506,507,508,509,510,511,512),K
  501 CALL WRITMS(3,CP1,256,147,1)
      CALL WRITMS(3,CP2,256,159,1)
      CALL WRITMS(3,CP3,256,171,1)
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```
      GO TO 520
  502 CALL WRITMS(3,CP1,256,148,1)
      CALL WRITMS(3,CP2,256,160,1)
      CALL WRITMS(3,CP3,256,172,1)
      GO TO 520
  503 CALL WRITMS(3,CP1,256,149,1)
      CALL WRITMS(3,CP2,256,161,1)
      CALL WRITMS(3,CP3,256,173,1)
      GO TO 520
  504 CALL WRITMS(3,CP1,256,150,1)
      CALL WRITMS(3,CP2,256,162,1)
      CALL WRITMS(3,CP3,256,174,1)
      GO TO 520
  505 CALL WRITMS(3,CP1,256,151,1)
      CALL WRITMS(3,CP2,256,163,1)
      CALL WRITMS(3,CP3,256,175,1)
      GO TO 520
  506 CALL WRITMS(3,CP1,256,152,1)
      CALL WRITMS(3,CP2,256,164,1)
      CALL WRITMS(3,CP3,256,176,1)
      GO TO 520
  507 CALL WRITMS(3,CP1,256,153,1)
      CALL WRITMS(3,CP2,256,165,1)
      CALL WRITMS(3,CP3,256,177,1)
      GO TO 520
  508 CALL WRITMS(3,CP1,256,154,1)
      CALL WRITMS(3,CP2,256,166,1)
      CALL WRITMS(3,CP3,256,178,1)
      GO TO 520
  509 CALL WRITMS(3,CP1,256,155,1)
      CALL WRITMS(3,CP2,256,167,1)
      CALL WRITMS(3,CP3,256,179,1)
      GO TO 520
  510 CALL WRITMS(3,CP1,256,156,1)
      CALL WRITMS(3,CP2,256,168,1)
      CALL WRITMS(3,CP3,256,180,1)
      GO TO 520
  511 CALL WRITMS(3,CP1,256,157,1)
      CALL WRITMS(3,CP2,256,169,1)
      CALL WRITMS(3,CP3,256,181,1)
      GO TO 520
  512 CALL WRITMS(3,CP1,256,158,1)
      CALL WRITMS(3,CP2,256,170,1)
      CALL WRITMS(3,CP3,256,182,1)
  520 CONTINUE
      K=1
  210 CONTINUE
      DO 211 N=1,12
      DO 211 M=1,10
      WA(N,M)=0.
      WB(N,M)=0.
      WC(N,M)=0.
  211 CONTINUE
      LL=1
  215 K=MF
      DO 251 N=1,NF
      DO 251 M=1,MF
```

```
      CP1(N,M)=0.
      CP2(N,M)=0.
      CP3(N,M)=0.
      F1(N,M)=0.
      F2(N,M)=0.
  251 CONTINUE
      CALL WRITMS(3,CP1,256,10,1)
      CALL WRITMS(3,CP2,256,11,1)
      CALL WRITMS(3,CP3,256,12,1)
      CALL WRITMS(3,CP3,256,13,1)
      CALL WRITMS(3,F1,256,9,1)
      CALL WRITMS(3,F2,256,5,1)
      CALL WRITMS (3,F2,256,6,1)
  212 CALL SEALPO
      CALL BIRDPC
      CALL POLLPO
      CALL ZOOPPO
      CALL HERRPO
      CALL READMS(3,CP1,256,10)
      CALL READMS(3,CP2,256,11)
      CALL READMS(3,CP3,256,12)
      CALL READMS(3,F1,256,9)
      CALL READMS(3,F2,256,5)
      SU=SUM=SUU=SUMM=SSU=0.
      DO 252 N=1,NE
      DO 252 M=1,ME
      SU=SU+(CP1(N,M)*9.0726)/1000.
      SUM=SUM+(CP2(N,M)*9.0726)/1000.
      SUU=SUU+(CP3(N,M)*9.0726)/1000.
      SUMM=SUMM+(F1(N,M)*9.0726)/1000.
      SSU=SSU+(F2(N,M)*9.0726)/1000.
  252 CONTINUE
  610 GO TO (253,263,263,263,253,263,263,263,263,253),LL
  253 PRINT 254,K
  254 FORMAT(1H1,5X,30HMONTHLY COPEPOD CONS.KG/KM2,M=,I3/)
      CALL PRIFLD(CP1,1)
      PRINT 255,K
  255 FORMAT(1H1,5X,33HMONTHLY EUPHAUSIDS CONS.KG/KM2,M=,I3/)
      CALL PRIFLD(CP2,1)
      PRINT 256,K
  256 FORMAT(1H1,5X,33HMONTHLY TOT.ZOOPL. CONS.KG/KM2,M=,I3/)
      CALL PRIFLD(CP3,1)
      PRINT 257,K
  257 FORMAT(1H1,5X,31HMONTHLY HERRING CONS. KG/KM2,M=,I3/)
      CALL PRIFLD(F1,1)
      PRINT 258,K
  258 FORMAT(1H1,5X,31HMONTHLY POLLOCK CONS. KG/KM2,M=,I3/)
      CALL PRIFLD(F2,1)
      GO TO (301,302,303,304,305,306,307,308,309,310,311,312),K
  301 CALL WRITMS (3,CP1,256,60,1)
      CALL WRITMS (3,CP2,256,72,1).
      CALL WRITMS (3,CP3,256,84,1)
      CALL WRITMS (3,F1,256,96,1)
      CALL WRITMS (3,F2,256,108,1)
      GO TO 263
  302 CALL WRITMS (3,CP1,256,61,1)
      CALL WRITMS (3,CP2,256,73,1)
```

```
      CALL WRITMS (3,CP3,256,85,1)
      CALL WRITMS (3,F1,256,97,1)
      CALL WRITMS (3,F2,256,109,1)
      GO TO 263
  303 CALL WRITMS (3,CP1,256,62,1)
      CALL WRITMS (3,CP2,256,74,1)
      CALL WRITMS (3,CP3,256,86,1)
      CALL WRITMS (3,F1,256,98,1)
      CALL WRITMS (3,F2,256,110,1)
      GO TO 263
  304 CALL WRITMS (3,CP1,256,63,1)
      CALL WRITMS (3,CP2,256,75,1)
      CALL WRITMS (3,CP3,256,87,1)
      CALL WRITMS (3,F1,256,99,1)
      CALL WRITMS (3,F2,256,111,1)
      GO TO 263
  305 CALL WRITMS (3,CP1,256,64,1)
      CALL WRITMS (3,CP2,256,76,1)
      CALL WRITMS (3,CP3,256,88,1)
      CALL WRITMS (3,F1,256,100,1)
      CALL WRITMS (3,F2,256,112,1)
      GO TO 263
  306 CALL WRITMS (3,CP1,256,65,1)
      CALL WRITMS (3,CP2,256,77,1)
      CALL WRITMS (3,CP3,256,89,1)
      CALL WRITMS (3,F1,256,101,1)
      CALL WRITMS (3,F2,256,113,1)
      GO TO 263
  307 CALL WRITMS (3,CP1,256,66,1)
      CALL WRITMS (3,CP2,256,78,1)
      CALL WRITMS (3,CP3,256,90,1)
      CALL WRITMS (3,F1,256,102,1)
      CALL WRITMS (3,F2,256,114,1)
      GO TO 263
  308 CALL WRITMS (3,CP1,256,67,1)
      CALL WRITMS (3,CP2,256,79,1)
      CALL WRITMS (3,CP3,256,91,1)
      CALL WRITMS (3,F1,256,103,1)
      CALL WRITMS (3,F2,256,115,1)
      GO TO 263
  309 CALL WRITMS (3,CP1,256,68,1)
      CALL WRITMS (3,CP2,256,80,1)
      CALL WRITMS (3,CP3,256,92,1)
      CALL WRITMS (3,F1,256,104,1)
      CALL WRITMS (3,F2,256,116,1)
      GO TO 263
  310 CALL WRITMS (3,CP1,256,69,1)
      CALL WRITMS (3,CP2,256,81,1)
      CALL WRITMS (3,CP3,256,93,1)
      CALL WRITMS (3,F1,256,105,1)
      CALL WRITMS (3,F2,256,117,1)
      GO TO 263
  311 CALL WRITMS (3,CP1,256,70,1)
      CALL WRITMS (3,CP2,256,82,1)
      CALL WRITMS (3,CP3,256,94,1)
      CALL WRITMS (3,F1,256,106,1)
      CALL WRITMS (3,F2,256,118,1)
```

```
      GC TO 263
  312 CALL WRITMS (3,CP1,256,71,1)
      CALL WRITMS (3,CP2,256,83,1)
      CALL WRITMS (3,CP3,256,95,1)
      CALL WRITMS (3,F1,256,107,1)
      CALL WRITMS (3,F2,256,119,1)
  263 PRINT 264,LL,K,SL
  264 FCRMAT(//5X,32HMCNTHLY COPEPOD CONS.1000TCNS,Y=,I3,3X,2HM=,I3,F9.1
     2)
      PRINT 265,LL,K,SLM
  265 FCRMAT(/5X,32HMONTHLY EUPHAUS.CONS.1000TONS,Y=,I3,3X,2HM=,I3,F9.1)
      PRINT 266,LL,K,SLL
  266 FCRMAT(/5X,31HMONTHLY TOT.ZOOPL.CONS.1000T,Y=,I3,3X,2HM=,I3,F9.1)
      PRINT 267,LL,K,SLMM
  267 FCRMAT(/5X,32HMONTHLY HERRING CONS.1000TONS,Y=,I3,3X,2HM=,I3,F9.1)
      PRINT 268,LL,K,SSU
  268 FORMAT(/5X,32HMONTHLY POLLOCK CONS.1000TONS,Y=,I3,3X,2HM=,I3,F9.1)
  602 DO 269 N=1,NE
      DC 269 M=1,ME
      CP1(N,M)=0.
      CP2(N,M)=0.
      CP3(N,M)=0.
      F2(N,M)=0.
      F1(N,M)=0.
  269 CONTINUE
      CALL WRITMS(3,CP1,256,10,1)
      CALL WRITMS(3,CP2,256,11,1)
      CALL WRITMS(3,CP3,256,12,1)
      CALL WRITMS(3,F1,256,9,1)
      CALL WRITMS(3,F2,256,5,1)
      K=K+1
      IF(K-12)212,212,214
  213 CCNTINUE
  214 LL=LL+1
0     IF(LL-2)215,216,216
  216 STOP
      END
```

A-10

```
      SUBROUTINE SEALPC
      DIMENSION ISL(16,16),CP1(16,16),CP2(16,16),CP3(16,16),
     1F1(16,16),F2(16,16),F3(16,16),F4(16,16),S1(16,16),S2(16,16),
     2S3(16,16),P1(16,16),P2(16,16),AS(16,16),AF(16,16),AP(16,16)
     3,IS(16,16),WA(12,10),WB(12,10),WC(12,10),IA(12)
     4,NS(10),MS(10),OP(10),CS(10),OH(10),OO(10)
     5,INDEX(301),WD(12,10),WE(12,10),WF(12,10),WG(12,10)
     6,POR(6),GR(6),TR(6),FF(6),FGF(6),FFM(6),CAN(6)
      COMMON ISL,CP1,CP2,CP3,
     2F1,F2,F3,F4,S1,S2,S3,P1,P2,AS,AF,AP
     3,IS,WA,WB,WC,IA,NS,MS,OP,CS,OH,OO,INDEX
     4,WD,WE,WF,WG
     5,POR,GR,TR,FF,FGF,FFM,CAN,HFC,HGR,PCCC
      COMMON K,L,KK,LL,MM,NE,ME,NU,MJ,MJJ,MF,NMF,JA,MPF,NPF
     2,IPO1,IPO2,IPO3,IPO4,IPO5,IPO6,IPO7,IPO8,IPO9,IPO10,IPO11,IPO12
     3,IFS1,IFS2,IFS3,IFS4,IFS5,IFS6,IFS7,IFS8,IFS9,IFS10,IFS11,IFS12
     4,IBS1,IBS2,IBS3,IBS4,IBS5,IHE1,IHE2,IHE3
     5,IIC1,IIC2,IIC3,IIC4,IIC5,IIC6,IIC7,IIC8,IIC9,IIC10,IIC11,IIC12
     6,IFP1,IFP2,IFP3,IFP4,IFP5,IFP6,IFP7,IFP8,IFP9,IFP10,IFP11,IFP12
      COMMON IZO1,IZO2,IZO3,IZO4
     2,MON,IFSI,IFPI,IICI,IHEI,IPOI
      COMMON/1/IC(16,16)
      INTEGER AH
      GRF=-0.045
      OMF=-0.048
      SL=0.
      SLM=0.
C     ASSUMING FOOD CONSUMPTION 4 PER CENT BODY WEIGHT DAILY
  262 GO TO (101,102,103,104,105,106,107,108,109,110,111,112),K
  101 CALL READMS(3,CP1,256,14)
      GO TO 115
  102 CALL READMS(3,CP1,256,15)
        GO TO 115
  103 CALL READMS(3,CP1,256,16)
        GO TO 115
  104 CALL READMS(3,CP1,256,17)
        GO TO 115
  105 CALL READMS(3,CP1,256,18)
        GO TO 115
  106 CALL READMS(3,CP1,256,19)
        GO TO 115
  107 CALL READMS(3,CP1,256,20)
        GO TO 115
  108 CALL READMS(3,CP1,256,21)
        GO TO 115
  109 CALL READMS(3,CP1,256,22)
        GO TO 115
  110 CALL READMS(3,CP1,256,23)
        GO TO 115
  111 CALL READMS(3,CP1,256,24)
         GO TO 115
  112 CALL READMS(3,CP1,256,25)
  115 DO 250 N=1,NE
      DO 250 M=1,ME
      CP1(N,M)=(CP1(N,M)*65.)/9.0726
      CP1(N,M)=CP1(N,M)*(2.-EXP(GRF))*EXP(OMF)
      FOOF=CP1(N,M)*1.2
```

```
      P1(N,M)=0.77*FOOF
      P2(N,M)=0.05*FOOF
      SU=SU+(P1(N,M)*9.0726)/1000.
      SUM=SUM+(P2(N,M)*9.0726)/1000.
  250 CONTINUE
      CALL READMS(3,F1,256,9)
      CALL READMS(3,F2,256,5)
      DO 274 N=1,NE
      DO 274 M=1,ME
      F1(N,M)=F1(N,M)+P2(N,M)
      F2(N,M)=F2(N,M)+F1(N,M)
  274 CONTINUE
      CALL WRITMS(3,F1,256,9,1)
      CALL WRITMS(3,F2,256,5,1)
      CALL WRITMS(3,F2,256,50,1)
C     P1-CONS. OF POLLOCK, P2-CONS. OF HERRING
      IF(MON-1)276,276,277
  276 GO TO (272,273,273,273,272,273,273,273,273,273),LL
  272 PRINT 251,K
  251 FORMAT(1H1,5X,29HFUR SEAL, (COMP.),KG/SQKM, M=,I6//)
      CALL PRIFLD (CP1,2)
  252 FORMAT (//I7,16F7.2)
      PRINT 253, K
  253 FORMAT(1H1,5X,34HPOLLOCK CONS. BY FUR SEAL, KG/SQKM,I6//)
      CALL PRIFLD (P1,2)
      PRINT 254,K
  254 FORMAT(1H1,5X,34HHERRING CONS. BY FUR SEAL. KG/SQKM,I6//)
      CALL PRIFLD (P2,2)
  277 CONTINUE
  273 PRINT 270,K,SU
  270 FORMAT(//5X,45HTOTAL POLLOCK CONS. BY FUR SEAL, 1000 TONS,M=,I5,F9
     2.2)
      PRINT 271,K,SUM
  271 FORMAT(//5X,45HTOTAL HERING CONS. BY FUR SEAL, 1000 TONS, M=,I5,F9
     2.2)
      SU=0.
      SUM=0.
      SUU=0.
C     BEARDED SEAL
      GO TO (117,118,119,120,121,122,123,124,125,126,127,128),K
  117 CALL READMS(3,S1,256,147)
      GO TO 116
  118 CALL READMS(3,S1,256,148)
      GO TO 116
  119 CALL READMS(3,S1,256,149)
      GO TO 116
  120 CALL READMS(3,S1,256,150)
      GO TO 116
  121 CALL READMS(3,S1,256,151)
      GO TO 116
  122 CALL READMS(3,S1,256,152)
      GO TO 116
  123 CALL READMS(3,S1,256,153)
      GO TO 116
  124 CALL READMS(3,S1,256,154)
      GO TO 116
  125 CALL READMS(3,S1,256,155)
```

```
      GO TO 116
  126 CALL READMS(3,S1,256,156)
      GO TO 116
  127 CALL READMS(3,S1,256,157)
      GO TO 116
  128 CALL READMS(3,S1,256,158)
  116 DO 22 N=1,NE
      DO 22 M=1,ME
  304 SL=SU+S1(N,M)
      S2(N,M)=(S1(N,M)*240.)/9.0726
   22 CONTINUE
  499 SUMM=0.
C       SEA LION
      GO TO (448,449,450,451,452,453,454,455,456,457,458,459),K
  448 CALL READMS (3,AP,256,51,1)
      GO TO 461
  449 CALL READMS (3,AP,256,52,1)
      GO TO 461
  450 CALL READMS (3,AP,256,53,1)
      GO TO 461
  451 CALL READMS (3,AP,256,54,1)
      GO TO 461
  452 CALL READMS (3,AP,256,55,1)
      GO TO 461
  453 CALL READMS (3,AP,256,56,1)
      GO TO 461
  454 CALL READMS (3,AP,256,57,1)
      GO TO 461
  455 CALL READMS (3,AP,256,58,1)
      GO TO 461
  456 CALL READMS (3,AP,256,59,1)
      GO TO 461
  457 CALL READMS (3,AP,256,222,1)
      GO TO 461
  458 CALL READMS (3,AP,256,223,1)
      GO TO 461
  459 CALL READMS (3,AP,256,224,1)
  461 CONTINUE
  370 FORMAT (12F6.2)
      PRINT 462,K
  462 FORMAT(//5X,23HSEA LION, THOUSANDS, M=,I6//)
      CALL PRIFLD (AP,1)
      APS=0.
      DO 1460 N=1,NE
      DO 1460 M=1,ME
 1460 APS=APS + AP(N,M)
      PRINT 1461,K,APS
 1461 FORMAT(//5X,23HSEA LION, THOUSANDS, M=,I6,F8.1)
C       SEA LION FOOD -75 PC POLLOCK, 5 PC HERRING, 25 PC OTHER FISH
      DO 465 N=1,NE
      DO 465 M=1,ME
      AP(N,M)=AP(N,M)*400.
      FOOSL=AP(N,M)*1.4/9.0726
      CP1(N,M)=FOOSL*0.75
      CP2(N,M)=FOOSL*0.05
  465 CONTINUE
      CALL READMS (3,AS,256,5)
```

```
      CALL READMS (3,AF,256,9)
      CALL READMS (3,CP3,256,50)
      DO 463 N=1,NE
      DO 463 M=1,ME
      AS(N,M)=AS(N,M)+CP1(N,M)
      CP3(N,M)=CP3(N,M)+CP1(N,M)
      AF(N,M)=AF(N,M)+CP2(N,M)
  463 CONTINUE
      CALL WRITMS (3,AS,256,5,1)
      CALL WRITMS (3,AF,256,9,1)
      CALL WRITMS (3,CP3,256,50,1)
      SUMM=0.
C     BEARDED SEAL FOOD CONSUMPTION
C     8 PC POLLOCK, 8 PC HERRING,MACKEREL ETC, 70 PC BENTHOS
C     F2 POLLOCK CONS. BY BEARDED SEAL
C     F3 HERRING ETC CONS.
C     F4 BENTHOS CONS.
      DO 80 N=1,NE
      DO 80 M=1,ME
   90 F1(N,M)=S2(N,M)*1.35
       F2(N,M)=F1(N,M)*0.04
      F3(N,M)=F1(N,M)*0.08
      F4(N,M)=F1(N,M)*0.70
      SUM=SUM+(F2(N,M)*9.0726)/1000.
      SUMM=SUMM+(F3(N,M)*9.0726)/1000.
      SUU=SUU+(F4(N,M)*9.0726)/1000.
   80 CONTINUE
C     SUM THESE CONS. FIELDS BEFORE STORAGE
      CALL READMS (3,CP1,256,9)
      CALL READMS (3,CP2,256,5)
      CALL READMS(3,CP3,256,50)
      DO 275 N=1,NE
      DO 275 M=1,ME
      CP1(N,M)=CP1(N,M)+F3(N,M)
      CP2(N,M)=CP2(N,M)+F2(N,M)
      CP3(N,M)=CP3(N,M)+F2(N,M)
  275 CONTINUE
      CALL WRITMS (3,CP1,256,9,1)
      CALL WRITMS (3,CP2,256,5,1)
      CALL WRITMS(3,CP3,256,50,1)
   93 GO TO (91,92,92,92,91,92,92,92,92,91),LL
   91 PRINT 81,LL,K
   81 FORMAT(1H1,5X,24HBEARDED SEAL, KG/KM2, Y=,I3,3X,2HM=,I3,//)
      CALL PRIFLD(S2,1)
      IF(MON-1)92,92,278
  278 PRINT 82,LL,K
   82 FORMAT(1H1,5X,27HPOLLOCK CONS. BY B.SEAL, Y=,I3,3X,2HM=,I3,//)
      CALL PRIFLD(F2,1)
      PRINT 83,LL,K
   83 FORMAT(1H1,5X,28HHERR.+OTH.CONS.BY B.SEAL, Y=,I3,3X,2HM=,I3,//)
      CALL PRIFLD(F3,1)
      PRINT 84,LL,K
   84 FORMAT(1H1,5X,27HBENTHOS CONS. BY B.SEAL, Y=,I3,3X,2HM=,I3,//)
      CALL PRIFLD(F4,1)
   92 PRINT 85,LL,K,SU
   85 FORMAT(//5X,27HTOTAL,BEARDED SEAL,1000, Y=,I3,3X,2HM=,I3,3X,F9.1)
      PRINT 86,LL,K,SUM
```

```
 86 FORMAT(//5X,27HPOLLOCK CONS. P.S.1000 T,Y=,I3,3X,2HM=,I3,3X,F9.1)
    PRINT 87,LL,K,SUMM
 87 FORMAT(//5X,27HHER.ETC CONS. P.S.1000 T,Y=,I3,3X,2HM=,I3,3X,F9.1)
    PRINT 88,LL,K,SUL
 88 FORMAT(//5X,27HBENTHOS CONS. P.S.1000 T,Y=,I3,3X,2HM=,I3,3X,F9.1)
    SU=0.
    SUU=0.
    SUM=0.
    SUMM=0.
264 RETURN
    END
```

```
      SUBROUTINE BIRDPC
      DIMENSION ISL(16,16),CP1(16,16),CP2(16,16),CP3(16,16),
     1F1(16,16),F2(16,16),F3(16,16),F4(16,16),S1(16,16),S2(16,16),
     2S3(16,16),P1(16,16),P2(16,16),AS(16,16),AF(16,16),AP(16,16)
     3,IS(16,16),WA(12,10),WB(12,10),WC(12,10),IA(12)
     4,NS(10),MS(10),DP(10),CS(10),DH(10),DD(10)
     5,INDEX(301),WD(12,10),WE(12,10),WF(12,10),WG(12,10)
     6,POR(6),GR(6),TR(6),FF(6),FGF(6),FFM(6),CAN(6)
      COMMON ISL,CP1,CP2,CP3,
     2F1,F2,F3,F4,S1,S2,S3,P1,P2,AS,AF,AP
     3,IS,WA,WB,WC,IA,NS,MS,DP,CS,DH,DD,INDEX
     4,WD,WE,WF,WG
     5,POR,GR,TR,FF,FGF,FFM,CAN,HEC,HGR,POCD
      COMMON K,L,KK,LL,MM,NE,ME,NU,MJ,MJJ,MF,NMF,JA,MPF,NPF
     2,IPO1,IPO2,IPO3,IPO4,IPO5,IPO6,IPO7,IPO8,IPO9,IPO10,IPO11,IPO12
     3,IFS1,IFS2,IFS3,IFS4,IFS5,IFS6,IFS7,IFS8,IFS9,IFS10,IFS11,IFS12
     4,IBS1,IBS2,IBS3,IBS4,IBS5,IHE1,IHE2,IHE3
     5,IIC1,IIC2,IIC3,IIC4,IIC5,IIC6,IIC7,IIC8,IIC9,IIC10,IIC11,IIC12
     6,IFP1,IFP2,IFP3,IFP4,IFP5,IFP6,IFP7,IFP8,IFP9,IFP10,IFP11,IFP12
      COMMON IZ01,IZ02,IZ03,IZ04
     2,MON,IFSI,IFPI,IICI,IHEI,IPOI
      COMMON/1/IC(16,16)
C       AS   SHEARWATER
C       AF   MURRES
      GO TO (201,202,203,204,205,206,207,208,209,210,211,212),K
  201 CALL READMS(3,AS,256,159)
      CALL READMS(3,AF,256,171)
      GO TO 220
  202 CALL READMS(3,AS,256,160)
      CALL READMS(3,AF,256,172)
      GO TO 220
  203 CALL READMS(3,AS,256,161)
      CALL READMS(3,AF,256,173)
      GO TO 220
  204 CALL READMS(3,AS,256,162)
      CALL READMS(3,AF,256,174)
      GO TO 220
  205 CALL READMS(3,AS,256,163)
      CALL READMS(3,AF,256,175)
      GO TO 220
  206 CALL READMS(3,AS,256,164)
      CALL READMS(3,AF,256,176)
      GO TO 220
  207 CALL READMS(3,AS,256,165)
      CALL READMS(3,AF,256,177)
      GO TO 220
  208 CALL READMS(3,AS,256,166)
      CALL READMS(3,AF,256,178)
      GO TO 220
  209 CALL READMS(3,AS,256,167)
      CALL READMS(3,AF,256,179)
      GO TO 220
  210 CALL READMS(3,AS,256,168)
      CALL READMS(3,AF,256,180)
      GO TO 220
  211 CALL READMS(3,AS,256,169)
      CALL READMS(3,AF,256,181)
```

```
      GO TO 220
  212 CALL READMS(3,AS,256,170)
      CALL READMS(3,AF,256,182)
  220 CONTINUE
      DO 90 N=1,NE
      DO 90 M=1,ME
      IF(ISL(N,M)-3)32,31,32
   31 AS(N,M)=0.
      AF(N,M)=0.
      GO TO 90
   32 P1(N,M)=(AS(N,M)*WTS)/9072.6
      P2(N,M)=(AF(N,M)*WTM)/9072.6
   90 CONTINUE
      GO TO (131,132,132,132,131,132,132,132,132,131),LL
  131 PRINT 100,K
  100 FORMAT(1H1,5X,26HSHEARWATER,NUM. PER SQ. M=,I6/)
      CALL PRIFLD(AS,1)
      PRINT 101,K
  101 FORMAT(1H1,5X,23HMURRES, NUM. PER SQ. M=,I6/)
      CALL PRIFLD(AF,1)
  132 PRINT 102,K,SU
  102 FORMAT(15X,37HTOTAL NUMBER OF SHEARWATER IN 1000,M=,I3,3X,F9.1)
      PRINT 103,K,SUM
  103 FORMAT(15X,33HTOTAL NUMBER OF MURRES IN 1000,M=,I3,3X,F9.1/)
      SU=SUM=SUU=SUMM=SM=0.
C     FOOD CONSUMPTION
C     F1 EUPHAUSIDS, SHERW 50 PC
C     F2 SMALL FISH FISH, SHERW 40 PC, MURRES 30 PC
C     F3 HERRING6, SHERW 10 PC, MURRES 10 PC
C     AP SMALL POLLOCK, SHERW,30 PC
C     F4 BENTHOS, MURRES 30 PC
C     FOOD CONS. 9 PC BODY W. DAILY, CONS GIVEN KG/KM2
      CALL READMS (3,S1,256,11)
      CALL READMS(3,S2,256,9)
      CALL READMS (3,S3,256,5)
      CALL READMS (3,AF,256,12)
      ARE=9.0726/1000.
  104 DO 120 N=1,NE
      DO 120 M=1,ME
      CP1(N,M)=P1(N,M)*3.6
      CP2(N,M)=P2(N,M)*3.6
      F1(N,M)=CP1(N,M)*0.5
      F2(N,M)=CP1(N,M)*0.3+CP2(N,M)*0.3
      F3(N,M)=CP1(N,M)*0.1+CP2(N,M)*0.1
      AP(N,M)=CP1(N,M)*0.1
      F4(N,M)=CP2(N,M)*0.3
      SU=SU+F1(N,M)*ARE
      SUM=SUM+F2(N,M)*ARE
      SUU=SUU+F3(N,M)*ARE
      SUMM=SUMM+AP(N,M)*ARE
      SM=SM+F4(N,M)*ARE
      S1(N,M)=S1(N,M)+F1(N,M)
      S2(N,M)=S2(N,M)+F3(N,M)
      S3(N,M)=S3(N,M)+AP(N,M)
      AF(N,M)=AF(N,M)+F1(N,M)
  120 CONTINUE
      CALL WRITMS (3,S1,256,11,1)
```

```
      CALL WRITMS(3,S2,256,9,1)
      CALL WRITMS (3,S3,256,5,1)
      CALL WRITMS (3,AF,256,12,1)
      IF(MON-1)141,141,140
140   GO TO (133,134,134,134,133,134,134,134,134,133),LL
133   PRINT 121,K
121   FORMAT(1H1,5X,36HEUPHAUSIDS CONS. BY BIRDS, KG/KM2.M=,I3/)
      CALL PRIFLD(F1,2)
      PRINT 122,K
122   FORMAT(1H1,5X,36HSMALL FISH CONS. BY BIRDS, KG/KM2,M=,I3/)
      CALL PRIFLD(F2,2)
      PRINT 123,K
123   FORMAT(1H1,5X,34HHERRING CONS. BY BIRDS, KG/KM2. M=,I3/)
      CALL PRIFLD(F3,2)
      PRINT 124,K
124   FORMAT(1H1,5X,40HSMALL POLLOCK CONS. BY BIRDS. KG/KM2, M=,I3/)
      CALL PRIFLD(AP,2)
      PRINT 125,K
125   FORMAT(1H1,5X,34HBENTHOS CONS. BY BIRDS. KG/KM2, M=,I3/)
      CALL PRIFLD(F4,2)
134   PRINT 126,K,SU
126   FORMAT(/5X,40HTOTAL EUFHAUS. CONS.BY BIRDS 1000TONS,M=,I3,3X,F9.1)
      PRINT 127,K,SUM
127   FORMAT(/5X,40HTOTAL SML.FISH.CONS.BY BIRDS 1000TONS,M=,I3,3X,F9.1)
      PRINT 128,K,SUU
128   FORMAT(/5X,40HTOTAL HERRING  CONS.BY BIRDS 1000TONS,M=,I3,3X,F9.1)
      PRINT 129,K,SUMM
129   FORMAT(/5X,40HTOTAL SML.POLL.CONS.BY BIRDS 1000TONS,M=,I3,3X,F9.1)
      PRINT 130,K,SM
130   FORMAT(/5X,39HTOTAL BENTHOS CONS.BY BIRDS 1000TONS,M=,I3,3X,F9.1)
141   RETURN
      END
```

```
      SUBROUTINE POLLPO
      DIMENSION ISL(16,16),CP1(16,16),CP2(16,16),CP3(16,16),
     1F1(16,16),F2(16,16),F3(16,16),F4(16,16),S1(16,16),S2(16,16),
     2S3(16,16),P1(16,16),P2(16,16),AS(16,16),AF(16,16),AP(16,16)
     3,IS(16,16),WA(12,10),WB(12,10),WC(12,10),IA(12)
     4,NS(10),MS(10),OP(10),OS(10),OH(10),OO(10)
     5,INDEX(301),WD(12,10),WE(12,10),WF(12,10),WG(12,10)
     6,POR(6),GR(6),TR(6),FF(6),FGF(6),FFM(6),CAN(6)
      COMMON ISL,CP1,CP2,CP3,
     2F1,F2,F3,F4,S1,S2,S3,P1,P2,AS,AF,AP
     3,IS,WA,WB,WC,IA,NS,MS,OP,OS,OH,OO,INDEX
     4,WD,WE,WF,WG
     5,POR,GR,TR,FF,FGF,FFM,CAN,HFC,HGR,POCO
      COMMON K,L,KK,LL,MM,NE,ME,NU,MJ,MJJ,MF,NMF,JA,MPF,NPF
     2,IPO1,IPO2,IPO3,IPO4,IPO5,IPO6,IPO7,IPO8,IPO9,IPO10,IPO11,IPO12
     3,IFS1,IFS2,IFS3,IFS4,IFS5,IFS6,IFS7,IFS8,IFS9,IFS10,IFS11,IFS12
     4,IBS1,IBS2,IBS3,IBS4,IBS5,IHE1,IHE2,IHE3
     5,IIC1,IIC2,IIC3,IIC4,IIC5,IIC6,IIC7,IIC8,IIC9,IIC10,IIC11,IIC12
     6,IFP1,IFP2,IFP3,IFP4,IFP5,IFP6,IFP7,IFP8,IFP9,IFP10,IFP11,IFP12
      COMMON IZO1,IZO2,IZO3,IZO4
     2,MON,IFSI,IFPI,IICI,IHEI,IPOT
      COMMON/1/IC(16,16)
      IF(LL-1)324,201,501
  201 IF(K-1)324,270,501
  270 CALL READMS(3,CP1,256,1)
      CALL READMS(3,P1,256,50)
      GO TO 343
  358 SU=0.
      SUM=0.
      SSL=SLU=C.
C     INITIALIZATION, DEVIDE INTO 3 SIZE GROUPS
      DO 301 N=1,NE
      DO 301 M=1,ME
  435 S1(N,M)=POR(1)*CP1(N,M)
      S2(N,M)=POR(2)*CP1(N,M)
      S3(N,M)=POR(3)*CP1(N,M)
  301 CONTINUE
      GO TO 203
  501 CONTINUE
      SUU=0.
      SU=0.
      SLM=0.
      SSU=0.
      CALL READMS(3,S1,256,2)
      CALL READMS(3,S2,256,3)
      CALL READMS(3,S3,256,4)
      CALL READMS(3,P1,256,50)
  343 GO TO (344,345,346,347,348,349,350,351,352,353,354,355),K
  344 CALL READMS(3,F1,256,38)
      GO TO 356
  345 CALL READMS(3,F1,256,39)
      GO TO 356
  346 CALL READMS(3,F1,256,40)
      GO TO 356
  347 CALL READMS(3,F1,256,41)
      GO TO 356
  348 CALL READMS(3,F1,256,42)
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```
      GC TO 356
  349 CALL READMS(3,F1,256,43)
      GC TO 356
  350 CALL READMS(3,F1,256,44)
      GO TO 356
  351 CALL READMS(3,F1,256,45)
      GC TO 356
  352 CALL READMS(3,F1,256,46)
      GO TO 356
  353 CALL READMS(3,F1,256,47)
      GC TO 356
  354 CALL READMS(3,F1,256,48)
      GC TO 356
  355 CALL READMS(3,F1,256,49)
  356 IF(LL-1)324,357,203
  357 IF(K-1)324,358,203
  203 AL=30.*0.0174533
      PKA=185.*0.0174533
      DO 202 N=1,NF
      DO 202 M=1,ME
      AU=(9-N)*0.75
      AV=2.5+(4.-0.25*N)
      IF(K-3)208,752,205
  205 IF(K-4)208,752,206
  206 IF(K-9)208,752,207
  207 IF(K-10)208,752,208
  208 IF(N-9)215,211,209
  209 IF(N-10)215,211,210
  210 IF(N-11)215,211,215
  211 IF(K-5)213,214,212
  212 IF(K-8)214,214,213
  213 AF(N,M)=-1.2
      GO TO 216
  214 AF(N,M)=1.2
      GC TO 216
  215 AF(N,M)=-AL*COS(AL*K+PKA)
  216 AS(N,M)= AV*COS(AL*K+PKA)
      GO TO 202
  217 AF(N,M)=0.
      AS(N,M)=0.
  202 CONTINUE
C     COMPUTATION OF MIGRATION
      SU=SSU=SUU=US=USS=USU=C.
      KK=1
      TD=7
      ALS=0.5
      B1=95.25*95.25
      B2=(2.*TD*AUS)/B1
      B5=(AUS*TD)/B1
      DL=92.25
  254 DO 260 N=2,15
      DO 260 M=2,15
      SU=SU+S1(N,M)/1000.
      SSU=SSU+S2(N,M)/1000.
      SUU=SUU+S3(N,M)/1000.
      IF(ISL(N,M)-3)221,260,221
  221 IF(AF(N,M))225,225,231
```

```
225  SH=(S1(N,M)-S1(N,M+1))/DL
     SHH=(S2(N,M)-S2(N,M+1))/DL
     SSH=(S3(N,M)-S3(N,M+1))/DL
     GO TO 232
231  SH=(S1(N,M)-S1(N,M-1))/DL
     SHH=(S2(N,M)-S2(N,M-1))/DL
     SSH=(S3(N,M)-S3(N,M-1))/DL
232  IF(AS(N,M))233,233,234
233  SV=(S1(N,M)-S1(N-1,M))/DL
     SVV=(S2(N,M)-S2(N-1,M))/DL
     SSV=(S3(N,M)-S3(N-1,M))/DL
     GO TO 235
234  SV=(S1(N,M)-S1(N+1,M))/DL
     SVV=(S2(N,M)-S2(N+1,M))/DL
     SSV=(S3(N,M)-S3(N+1,M))/DL
235  F2(N,M)=S1(N,M)-B2*S1(N,M)+B5*(S1(N-1,M)+S1(N+1,M)+S1(N,M-1)+
    2S1(N,M+1)-4.*S1(N,M))
    3-(TD*ABS(AF(N,M))*SH)-(TD*ABS(AS(N,M))*SV)
    4+B5*(S1(N-1,M-1)+S1(N-1,M+1)+S1(N+1,M-1)+S1(N+1,M+1))
     F3(N,M)=S2(N,M)-B2*S2(N,M)+B5*(S2(N-1,M)+S2(N+1,M)+S2(N,M-1)+
    2S2(N,M+1)-4.*S2(N,M))
    3-(TD*ABS(AF(N,M))*SHH)-(TD*ABS(AS(N,M))*SVV)
    4+B5*(S2(N-1,M-1)+S2(N-1,M+1)+S2(N+1,M-1)+S2(N+1,M+1))
     F4(N,M)=S3(N,M)-B2*S3(N,M)+B5*(S3(N-1,M)+S3(N+1,M)+S3(N,M-1)+
    2S3(N,M+1)-4.*S3(N,M))
    3-(TD*ABS(AF(N,M))*SSH)-(TD*ABS(AS(N,M))*SSV)
    4+B5*(S3(N-1,M-1)+S3(N-1,M+1)+S3(N+1,M-1)+S3(N+1,M+1))
     US=US+F2(N,M)/1000.
     USS=USS+F3(N,M)/1000.
     USU=USU+F4(N,M)/1000.
260  CONTINUE
     U1=SU/US
     U2=SSU/USS
     U3=SUU/USU
     DO 751 N=1,NE
     DO 751 M=1,ME
     S1(N,M)=F2(N,M)*U1
     S2(N,M)=F3(N,M)*U2
     S3(N,M)=F4(N,M)*U3
     IF(S1(N,M)-0.1)716,717,717
716  S1(N,M)=0.
717  IF(S2(N,M)-0.1)718,719,719
718  S2(N,M)=0.
719  IF(S3(N,M)-0.1)720,722,722
720  S3(N,M)=0.
722  IF(ISL(N,M)-3)751,251,251
251  S1(N,M)=0.
     S2(N,M)=0.
     S3(N,M)=0.
751  CONTINUE
     SU=SSU=SUU=US=USS=USU=0.
     KK=KK+1
     IF(KK-4)254,254,255
255  KK=0
752  SU=SSU=SUU=US=USS=USU=0.
     DO 740 N=1,NE
     S1(N,1)=0.
```

```
      S2(N,1)=0.
      S3(N,1)=0.
  740 CONTINUE
      IF(MON-1)261,261,258
  258 GO TO (259,261,261,261,259,261,261,261,261,259),LL
  259 PRINT 256,K
  256 FORMAT(1H1,5X,27HU COMP. OF MIGR. KM/DAY, M=,I3//9X,16I7)
      CALL PRIFLD(AF,2)
      PRINT 257,K
  257 FORMAT(1H1,5X,27HV COMP. OF MIGR. KM/DAY, M=,I3//9X,16I7)
      CALL PRIFLD(AS,2)
  261 DO 503 N=1,NE
      DO 503 M=1,ME
      SUU=SUU+(S1(N,M)*9.0726)/1000.
      SSU=SSU+(S2(N,M)*9.0726)/1000.
      SUM=SUM+(S3(N,M)*9.0726)/1000.
      SU=SU+((S1(N,M)+S2(N,M)+S3(N,M))*9.0726)/1000.
  503 CONTINUE
      PRINT 504,LL,K,SUU
  504 FORMAT(//5X,33HTOTAL POLLOCK,GROUP 1,1000TONS,Y=,I3,2HM=,I3,F9.1)
      PRINT 505,LL,K,SSU
  505 FORMAT(//5X,33HTOTAL POLLOCK,GROUP 2,1000TONS,Y=,I3,2HM=,I3,F9.1)
      PRINT 506,LL,K,SUM
  506 FORMAT(//5X,33HTOTAL POLLOCK,GROUP 3,1000TONS,Y=,I3,2HM=,I3,F9.1)
      SSU=0.
      SUU=0.
      SUM=0.
  502 PRINT 441,K,SU
  441 FORMAT(//5X,27HTOTAL POLLOCK,1000 TONS, M=,I4,F9.1)
      SU=0.
C     COMP. OF GROWTH MORTALITY AND CONSUMPTION BY SEALS
      DO 302  N=1,NE
      DO 302  M=1,ME
      IF(S1(N,M)-0.35*P1(N,M))731,732,732
  731 S1(N,M)=0.35*P1(N,M)
  732 IF(S2(N,M)-0.40*P1(N,M))733,734,734
  733 S2(N,M)=0.40*P1(N,M)
      IF(S3(N,M)-0.25*P1(N,M))1733,734,734
 1733 S3(N,M)=0.25*P1(N,M)
  734 CP1(N,M)=S1(N,M)*(2.-EXP(-GR(1)))-S1(N,M)*TR(1)
     1-0.35*P1(N,M)
      CP2(N,M)=(S2(N,M)*(2.-EXP(-GR(2))))*EXP(FF(1)*(-F1(N,M)))
     1+S1(N,M)*TR(1)-S2(N,M)*TR(2)-0.40*P1(N,M)
      CP3(N,M)=(S3(N,M)*(2.-EXP(-GR(3))))*EXP(-FMO)
     1*EXP(FF(2)*(-F1(N,M)))+S2(N,M)*TR(2)-0.25*P1(N,M)
  302 CONTINUE
  329 L=1
      SU=0.
      SUM=0.
C     COMPUTATION AND SUMMATION OF FISHING MORTALITY
      DO 460 N=1,NE
      DO 460 M=1,ME
      F2(N,M)=CP2(N,M)-CP2(N,M)*EXP(FF(1)*(-F1(N,M)))
      F3(N,M)=CP3(N,M)-CP3(N,M)*EXP(FF(2)*(-F1(N,M)))
      F4(N,M)=F2(N,M)+F3(N,M)
      SUM=SUM+(F4(N,M)*9.0726)/1000.
  460 CONTINUE
```

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 631 GO TO (465,466,466,466,465,466,466,466,466,465),LL
 465 PRINT 461,K,(N,N=1,16)
 461 FORMAT(1H1,5X,28HPOLLOCK CATCHES, KG/KM2, M=,I6//9X,16I7)
     PRINT 402,(N,(F4(N,M),M=1,16),N=1,16)
 402 FORMAT(//I7,16F7.0)
 466 PRINT 462,K,SUM
 462 FORMAT(//5X,37HTOTAL CATCH OF POLLOCK, 1000 TONS, M=,I4,F9.1)
     GO TO (360,361,362,363,364,365,366,367,368,369,370,371),K
 360 CALL WRITMS(4,F4,256,37,1)
     GO TO 372
 361 CALL WRITMS(4,F4,256,38,1)
     GO TO 372
 362 CALL WRITMS(4,F4,256,39,1)
     GO TO 372
 363 CALL WRITMS(4,F4,256,40,1)
     GO TO 372
 364 CALL WRITMS(4,F4,256,41,1)
     GO TO 372
 365 CALL WRITMS(4,F4,256,42,1)
     GO TO 372
 366 CALL WRITMS(4,F4,256,43,1)
     GO TO 372
 367 CALL WRITMS(4,F4,256,44,1)
     GO TO 372
 368 CALL WRITMS(4,F4,256,45,1)
     GO TO 372
 369 CALL WRITMS(4,F4,256,46,1)
     GO TO 372
 370 CALL WRITMS(4,F4,257,47,1)
     GO TO 372
 371 CALL WRITMS(4,F4,258,48,1)
 372 SU=0.
     SUM=0.
     DO 305 N=1,NE
     DO 305 M=1,ME
     F2(N,M)=S1(N,M)+S2(N,M)+S3(N,M)
     F3(N,M)=CP1(N,M)+CP2(N,M)+CP3(N,M)
     F4(N,M)=F3(N,M)-F2(N,M)
     SU=SU+(F3(N,M)*9.0726)/1000.
 305 CONTINUE
C    F2-OLD, F3-NEW,F4-NEW-OLD BIOMASS
     IF(MON-1)446,446,432
 432 GO TO (445,446,446,446,445,446,446,446,446,445),LL
 445 PRINT 403,K,(N,N=1,16)
 403 FORMAT(1H1,5X,61HCHANGE OF TOT. POLLOCK BIOM.(WITHOUT CANNIB.)(-LO
    2SS,+GAIN, M=,I5//9X,16I7)
     PRINT 402,(N,(F4(N,M),M=1,16),N=1,16)
     PRINT 404,K,(N,N=1,16)
 404 FORMAT(1H1,5X,24HPOLLOCK(NEW) KG/SQKM, M=,I6//9X,16I7)
     PRINT 402,(N,(F3(N,M),M=1,16),N=1,16)
 446 PRINT 442,K,SU
 442 FORMAT(//5X,32HNEW TOTAL POLLOCK ,1000 TONS, M=,I4,F9.1)
 436 FORMAT(12F6.0)
     SU=0.
     SUM=0.
C    FOOD CONSUMPTION
 448 DO 315 N=1,NE
```

```
      DO 315 M=1,MF
      S1(N,M)=(CP1(N,M)*(2.-EXP(-GF(1)))-CP1(N,M))*FGF(1) +
     1 CP1(N,M)*FFM(1)
      S2(N,M)=(CP2(N,M)*(2.-EXP(-GR(2)))-CP2(N,M))*FGF(2) +
     1 CP2(N,M)*FFM(2)
      S3(N,M)=(CP3(N,M)*(2.-EXP(-GR(3)))-CP3(N,M))*FGF(3) +
     1 CP3(N,M)*FFM(3)
  315 CONTINUE
C     CANNIBALISM
      DO 316 N=1,NF
      DO 316 M=1,MF
      CP1(N,M)=CP1(N,M)-S2(N,M)*CAN(1)-S3(N,M)*CAN(2)
      IF(CP1(N,M))753,754,754
  753 CP1(N,M)=0.
  754 CP2(N,M)=CP2(N,M)-S3(N,M)*CAN(3)
      IF(CP2(N,M))755,756,756
  755 CP2(N,M)=0.
  756 F2(N,M)=CP1(N,M)+CP2(N,M)+CP3(N,M)
      F4(N,M)=F3(N,M)-F2(N,M)
      SU=SU+(F4(N,M)*9.0726)/1000.
      SUM=SUM+(F2(N,M)*9.0726)/1000.
  316 CONTINUE
      GO TO (449,450,450,450,449,450,450,450,450,449),LL
  449 PRINT 405,K,(N,N=1,16)
  405 FORMAT(1H1,5X,47HFINAL POLLOCK BIOM.,INCL.CANNIBALISM,KG/SQKM,M=,I
     25//9X,16I7)
      PRINT 402,(N,(F2(N,M),M=1,16),N=1,16)
      GO TO (373,374,375,376,377,378,379,380,381,382,383,384),K
  373 CALL WRITMS(4,F2,256,49,1)
      CALL WRITMS(4,CP1,256,1,1)
      CALL WRITMS(4,CP2,256,13,1)
      CALL WRITMS(4,CP3,256,25,1)
      GO TO 385
  374 CALL WRITMS(4,F2,256,50,1)
      CALL WRITMS(4,CP1,256,2,1)
      CALL WRITMS(4,CP2,256,14,1)
      CALL WRITMS(4,CP3,256,26,1)
      GO TO 385
  375 CALL WRITMS(4,F2,256,51,1)
      CALL WRITMS(4,CP1,256,3,1)
      CALL WRITMS(4,CP2,256,15,1)
      CALL WRITMS(4,CP3,256,27,1)
      GO TO 385
  376 CALL WRITMS(4,F2,256,52,1)
      CALL WRITMS(4,CP1,256,4,1)
      CALL WRITMS(4,CP2,256,16,1)
      CALL WRITMS(4,CP3,256,28,1)
      GO TO 385
  377 CALL WRITMS(4,F2,256,53,1)
      CALL WRITMS(4,CP1,256,5,1)
      CALL WRITMS(4,CP2,256,17,1)
      CALL WRITMS(4,CP3,256,29,1)
      GO TO 385
  378 CALL WRITMS(4,F2,256,54,1)
      CALL WRITMS(4,CP1,256,6,1)
      CALL WRITMS(4,CP2,256,18,1)
      CALL WRITMS(4,CP3,256,30,1)
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      GO TO 385
  379 CALL WRITMS(4,F2,256,55,1)
      CALL WRITMS(4,CP1,256,7,1)
      CALL WRITMS(4,CP2,256,19,1)
      CALL WRITMS(4,CP3,256,31,1)
      GO TO 385
  380 CALL WRITMS(4,F2,256,56,1)
      CALL WRITMS(4,CP1,256,8,1)
      CALL WRITMS(4,CP2,256,20,1)
      CALL WRITMS(4,CP3,256,32,1)
      GO TO 385
  381 CALL WRITMS(4,F2,256,57,1)
      CALL WRITMS(4,CP1,256,9,1)
      CALL WRITMS(4,CP2,256,21,1)
      CALL WRITMS(4,CP3,256,33,1)
      GO TO 385
  382 CALL WRITMS(4,F2,256,58,1)
      CALL WRITMS(4,CP1,256,10,1)
      CALL WRITMS(4,CP2,256,22,1)
      CALL WRITMS(4,CP3,256,34,1)
      GO TO 385
  383 CALL WRITMS(4,F2,256,59,1)
      CALL WRITMS(4,CP1,256,11,1)
      CALL WRITMS(4,CP2,256,23,1)
      CALL WRITMS(4,CP3,256,35,1)
      GO TO 385
  384 CALL WRITMS(4,F2,256,60,1)
      CALL WRITMS(4,CP1,256,12,1)
      CALL WRITMS(4,CP2,256,24,1)
      CALL WRITMS(4,CP3,256,36,1)
  385 IF(MON-1) 450,450,634
  634 PRINT 406,K,(N,N=1,16)
  406 FORMAT(1H1,5X,50HCHANGE OF POL.BIOM.CAUSED BY CANNIBALISM,KG/KM2,M
     2=,I5//9X,16I7)
      PRINT 402,(N,(F4(N,M),M=1,16),N=1,16)
  450 PRINT 443,K,SU
  443 FORMAT(//5X,55HTOTAL POLLOCK LOSS DUE TO CANNIBALISM, IN 1000 TONS
     2, M=,I4,F9.1)
      PRINT 481,K,SUM
  481 FORMAT(//5X,38HFINAL POLLOCK BIOMASS IN 1000 TONS, M=,I4,F9.1)
      SUM=0.
      SU=0.
      GO TO (451,452,452,452,451,452,452,452,452,451),LL
  451 DO 317 I=1,NU
      N=NS(I)
      M=MS(I)
      OF(I)=CP1(N,M)
      OS(I)=CP2(N,M)
      OH(I)=CP3(N,M)
      WA(K,I)=CP1(N,M)
      WB(K,I)=CP2(N,M)
      WC(K,I)=CP3(N,M)
  317 CONTINUE
      IF(K-12) 387,386,386
  386 CALL WRITMS(4,WA,120,61,1)
      CALL WRITMS(4,WB,120,62,1)
      CALL WRITMS(4,WC,120,63,1)
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  387 CONTINUE
  318 L=1
  319 PRINT 420,K,L,(N,N=1,16)
  420 FORMAT(1H1,5X,44HFINAL POLLOCK BIOM.(INCL.CANNIB.) KG/SQKM,M=,I5,7
     2HGROUP ,I5//9X,16I7)
      PRINT 402,(N,(CP1(N,M),M=1,16),N=1,16)
      L=2
      PRINT 420,K,L,(N,N=1,16)
      PRINT 402,(N,(CP2(N,M),M=1,16),N=1,16)
      L=3
      PRINT 420,K,L,(N,N=1,16)
      PRINT 402,(N,(CP3(N,M),M=1,16),N=1,16)
  452 L=1
      CALL WRITMS(3,CP1,256,2,1)
      CALL WRITMS(3,CP2,256,3,1)
      CALL WRITMS(3,CP3,256,4,1)
C     CP1  ZOPLANKTON (COPEPODS) COSUMPTION
C     CP2 MACROPLANKTON (EUPHAUSIDS) CONSUMPTION
C     CP3 TOTAL  ZOPLANKTON CONSUMPTION
C     F4 HERRING CONSUMPTION
C     F1 SMALL POLLOCK CONSUMPTION
C     F2 MEDIUM POLLOCK CONSUMPTION
C     F3 TOTAL POLLOCK CANNIBALISM
C     P1 BENTHOS COMSUMPTION
      DO 320 N=1,NE
      DO 320 M=1,ME
      CP1(N,M)=S1(N,M)*0.30+S2(N,M)*0.18+S3(N,M)*0.05
      CP2(N,M)=S1(N,M)*0.70+S2(N,M)*0.56+S3(N,M)*0.30
      CP3(N,M)=CP1(N,M)+CP2(N,M)
      F4(N,M)=S2(N,M)*0.10+S3(N,M)*0.10
      F1(N,M)=S2(N,M)*0.08+S3(N,M)*0.24
      F2(N,M)=S3(N,M)*0.10
      F3(N,M)=F1(N,M)+F2(N,M)
      P1(N,M)=S2(N,M)*0.06+S3(N,M)*0.16
  320 CONTINUE
      CALL READMS(3,S1,256,10)
      CALL READMS(3,S2,256,11)
      CALL READMS(3,S3,256,12)
      CALL READMS(3,AS,256,9)
      CALL READMS(3,AF,256,5)
      DO 276 N=1,NE
      DO 276 M=1,ME
      S1(N,M)=S1(N,M)+CP1(N,M)
      S2(N,M)=S2(N,M)+CP2(N,M)
      S3(N,M)=S3(N,M)+CP3(N,M)
      AS(N,M)=AS(N,M)+F4(N,M)
      AF(N,M)=AF(N,M)+F3(N,M)
  276 CONTINUE
      CALL WRITMS(3,S1,256,10,1)
      CALL WRITMS(3,S2,256,11,1)
      CALL WRITMS(3,S3,256,12,1)
      CALL WRITMS(3,AS,256,9,1)
      CALL WRITMS(3,AF,256,5,1)
      IF(MON-1)454,454,635
  635 GO TO (453,454,454,454,453,454,454,454,454,453),LL
  453 PRINT 407,K,(N,N=1,16)
  407 FORMAT(1H1,5X,38H ZOPLANKTON CONSUM. BY POL. KG/KM2, M=,I6//9X,16I
```

```
  27)
      PRINT 402,(N,(CP1(N,M),M=1,16),N=1,16)
      PRINT 408,K,(N,N=1,16)
  408 FORMAT(1H1,5X,33HMACROPL. CONS. BY POL. KG/KM2, M=,I6//9X,16I7)
      PRINT 402,(N,(CP2(N,M),M=1,16),N=1,16)
      PRINT 409,K,(N,N=1,16)
  409 FORMAT(1H1,5X,35HTOT. ZOPL. CONS. BY POL. KG/KM2, M=16//9X,16I7)
      PRINT 402,(N,(CP3(N,M),M=1,16),N=1,16)
      PRINT 410,K,(N,N=1,16)
  410 FORMAT(1H1,5X,31HHERRING CONS. BY POL. KG/KM2,M=,I6//9X,16I7)
      PRINT 402,(N,(F4(N,M),M=1,16),N=1,16)
      PRINT 411,K,(N,N=1,16)
  411 FORMAT(1H1,5X,35HSMALL POL. CONS. BY POL. KG/KM2, M=,I6//9X,16I7)
      PRINT 402,(N,(F1(N,M),M=1,16),N=1,16)
      PRINT 412,K,(N,N=1,16)
  412 FORMAT(1H1,5X,34HMED. POL. CONS. BY POL. KG/KM2, M=,I6//9X,16I7)
      PRINT 402,(N,(F2(N,M),M=1,16),N=1,16)
      PRINT 413,K,(N,N=1,16)
  413 FORMAT(1H1,5X,34HTOT. POL. CONS. BY POL. KG/KM2, M=,I6//9X,16I7)
      PRINT 402,(N,(F3(N,M),M=1,16),N=1,16)
      PRINT 414,K,(N,N=1,16)
  414 FORMAT(1H1,5X,33HBENTHOS CONS. BY POL. KG/KM2), M=,I6//9X,16I7)
      PRINT 402,(N,(P1(N,M),M=1,16),N=1,16)
      DO 415 N=1,NF
      DO 415 M=1,MF
      CP3(N,M)=CP3(N,M)/50.
  415 CONTINUE
      PRINT 416,K,(N,N=1,16)
  416 FORMAT(1H1,5X,35HZOOPLANKTON CONS. BY POL. MG/M3, M=,I6//9X,16I7)
      PRINT 402,(N,(CP3(N,M),M=1,16),N=1,16)
  454 CONTINUE
  324 RETURN
      END
```

```
      SUBROUTINE HERRPC
      DIMENSION ISL(16,16),CP1(16,16),CP2(16,16),CP3(16,16),
     1F1(16,16),F2(16,16),F3(16,16),F4(16,16),S1(16,16),S2(16,16),
     2S3(16,16),P1(16,16),P2(16,16),AS(16,16),AF(16,16),AP(16,16)
     3,IS(16,16),WA(12,10),WB(12,10),WC(12,10),IA(12)
     4,NS(10),MS(10),OP(10),OS(10),OH(10),OD(10)
     5,INDEX(301),WD(12,10),WE(12,10),WF(12,10),WG(12,10)
     6,POR(6),GR(6),TR(6),FF(6),FGF(6),FFM(6),CAN(6)
      COMMON ISL,CP1,CP2,CP3,
     2F1,F2,F3,F4,S1,S2,S3,P1,P2,AS,AF,AP
     3,IS,WA,WB,WC,IA,NS,MS,OP,OS,OH,OD,INDEX
     4,WD,WE,WF,WG
     5,POR,GR,TR,FF,FGF,FFM,CAN,HFC,HGR,POCO
      COMMON K,L,KK,LL,MM,NE,ME,NU,MJ,MJJ,MF,NMF,JA,MPF,NPF
     2,IPO1,IPO2,IPO3,IPO4,IPO5,IPO6,IPO7,IPO8,IPO9,IPO10,IPO11,IPO12
     3,IFS1,IFS2,IFS3,IFS4,IFS5,IFS6,IFS7,IFS8,IFS9,IFS10,IFS11,IFS12
     4,IBS1,IBS2,IBS3,IBS4,IBS5,IHE1,IHE2,IHE3
     5,IIC1,IIC2,IIC3,IIC4,IIC5,IIC6,IIC7,IIC8,IIC9,IIC10,IIC11,IIC12
     6,IFP1,IFP2,IFP3,IFP4,IFP5,IFP6,IFP7,IFP8,IFP9,IFP10,IFP11,IFP12
      COMMON IZ01,IZ02,IZ03,IZ04
     2,MON,IFSI,IFPI,IICI,IHEI,IPOI
      COMMON/1/IC(16,16)
      IF(LL-1)80,11,14
   11 IF(K-1)80,12,14
   12 CALL READMS(3,CP3,256,7)
      DO 71 N=1,NE
      DO 71 M=1,ME
      CP2(N,M)=0.
   71 CONTINUE
      SU=0.
      SUD=0.
      SUF=0.
      GO TO 15
   14 CALL READMS(3,CP1,256,8)
      CALL READMS(3,CP2,256,9)
      CALL READMS(3,CP3,256,7)
      SU=0.
      SUD=0.
      SUF=0.
      GO TO 20
   15 DO 16 N=1,NE
      DO 16 M=1,ME
      CP1(N,M)=CP3(N,M)*POCO
      SU=SU+(CP1(N,M)*9.0726)/1000.
   16 CONTINUE
      PRINT 17,SU
   17 FORMAT(//5X,35HTOTAL INITIAL HERRING POP.1000 TONS,F9.1)
      SU=0.
   20 DO 121 N=1,NE
      DO 121 M=1,ME
      IF(CP1(N,M)-CP2(N,M))107,108,108
  107 CP1(N,M)=CP2(N,M)
      SUD=SUD+((CP2(N,M)-CP1(N,M))*9.0726)/1000.
  108 CP1(N,M)=CP1(N,M)*(2.-EXP(-HGR))-CP2(N,M)
      SU=SU+(CP1(N,M)*9.0726)/1000.
      IF(K-3)22,22,23
   23 IF(K-6)121,22,24
```

```
   24 IF(K-7)121,22,121
   22 CP1(N,M)=CP1(N,M)*EXP(-HFC)
      F4(N,M)=CP1(N,M)-(CP1(N,M)*EXP(-HFC))
      SUF=SUF+F4(N,M)/1000.
  121 CONTINUE
      U4=(SU-SUD)/SU
      DO 123 N=1,NE
      DO 123 M=1,MF
      CP1(N,M)=CP1(N,M)*U4
  123 CONTINUE
      PRINT 25,K,SU
   25 FORMAT(//5X,42HTOTAL HERRING POP.BEFORE MIGR.1000 TONS,K=,I3,3X,F9
     2.1)
      SU=0.
      IF(K-3)122,122,30
   30 IF(K-6)40,122,31
   31 IF(K-7)122,122,36
   36 IF(K-10)41,122,122
   40 U=2.8
      V=2.8
C     KM PER DAY
      GO TO 50
   41 U=-2.8
      V=-2.8
   50 KK=1
      TD=7
      AUS=0.5
      B1=95.25*95.25
      B2=(2.0*TD*AUS)/B1
      B5=(AUS*TD)/B1
      DL=92.25
      SUSS=USUU=0.
   57 DO 51 N=2,15
      DO 51 M=2,15
      SUSS=SUSS+CP1(N,M)/1000.
      IF(ISL(N,M)-3)42,51,51
   42 IF(U)43,43,49
   43 SH=(CP1(N,M)-CP1(N,M+1))/DL
      GO TO 52
   49 SH=(CP1(N,M)-CP1(N,M-1))/DL
   52 IF(V)53,53,54
   53 SV=(CP1(N,M)-CP1(N-1,M))/DL
      GO TO 55
   54 SV=(CP1(N,M)-CP1(N+1,M))/DL
   55 S1(N,M) =CP1(N,M)-B2*CP1(N,M)+B5*(CP1(N-1,M)+CP1(N+1,M)+CP1(N,M-1)
     2+CP1(N,M+1)-4.*CP1(N,M))
     3-(TD*ABS(U)*SH)-(TD*ABS(V)*SV)
     4+B5*(CP1(N-1,M-1)+CP1(N-1,M+1)+CP1(N+1,M-1)+CP1(N+1,M+1))
      USUU=USUU+S1(N,M)/1000.
   51 CONTINUE
      U1=SUSS/USUU
      DO 751 N=1,NE
      DO 751 M=1,MF
      CP1(N,M)=S1(N,M)*U1
      IF(K-4)751,124,751
  124 SU=SU+(CP1(N,M)*S.0726)/1000.
  751 CONTINUE
```

```
      SUSS=USUU=0.
      KK=KK+1
      IF(KK-4)57,57,58
   58 KK=0
      DO 106 N=1,NE
      CP1(N,1)=0.
  106 CONTINUE
      PRINT 56,K,SU
   56 FORMAT(//5X,40HTOTAL HERRING POP.AFTER MIGR,1000TONS,M=,I3,3X,F9.1
     2)
  122 SU=0.
      PRINT 77,K,SUF
   77 FORMAT(//5X,29HHERRING CATCH, 1000 TONS, M=,I3,3X,F9.2)
  104 GO TO (72,60,60,60,72,60,60,60,60,72),LL
   72 PRINT 61,K
   61 FORMAT(1H1,5X,23HHERRING POP. KG/KM2, M=,I3//)
      CALL PRIFLD(CP1,1)
      GO TO (81,82,83,84,85,86,87,88,89,90,91,92),K
   81 CALL WRITMS(4,CP1,256,65,1)
      GO TO 60
   82 CALL WRITMS(4,CP1,256,66,1)
      GO TO 60
   83 CALL WRITMS(4,CP1,256,67,1)
      GO TO 60
   84 CALL WRITMS(4,CP1,256,68,1)
      GO TO 60
   85 CALL WRITMS(4,CP1,256,69,1)
      GO TO 60
   86 CALL WRITMS(4,CP1,256,70,1)
      GO TO 60
   87 CALL WRITMS(4,CP1,256,71,1)
      GO TO 60
   88 CALL WRITMS(4,CP1,256,72,1)
      GO TO 60
   89 CALL WRITMS(4,CP1,256,73,1)
      GO TO 60
   90 CALL WRITMS(4,CP1,256,74,1)
      GO TO 60
   91 CALL WRITMS(4,CP1,256,75,1)
      GO TO 60
   92 CALL WRITMS(4,CP1,257,76,1)
C     HERRING FEEDING, F2 COPEPODS,F3 EUPHAUSIDS
C     HERRING GROWTH
   60 CONTINUE
      DO 70 N=1,NE
      DO 70 M=1,ME
      F1(N,M)=(CP1(N,M)*(2.-EXP(-HGR)))*2.+CP1(N,M)*0.30
      IF(F1(N,M)-0.1)102,102,103
  102 F1(N,M)=0.
  103 F2(N,M)=F1(N,M)*0.70
      F3(N,M)=F1(N,M)*0.20
      SU=SU+(F1(N,M)*9.0726)/1000.
   70 CONTINUE
      IF(MON-1)74,74,105
  105 GO TO (73,74,74,74,73,74,74,74,74,73),LL
   73 PRINT 62,K
   62 FORMAT(1H1,5X,37HTOTAL HERRING (+GRO.-GRAZ.) KG/KM2,M=,I3//)
```

```
      CALL PRIFLD(CP1,1)
      PRINT 63,K
   63 FORMAT(1H1,5X,35HCOPEPODS CONS.BY HERRING, KG/KM2,M=, I3//)
      CALL PRIFLD(F2,2)
      PRINT 64,K
   64 FORMAT(1H1,5X,35HEUPHAUS. CONS BY HERRING, KG/KM2,M= ,I3//)
      CALL PRIFLD(F3,2)
   74 SU=0.
      CALL WRITMS(3,CP1,256,6,1)
      CALL READMS(3,CP1,256,10)
      CALL READMS(3,CP2,256,11)
      CALL READMS(3,CP3,256,12)
      DO 76 N=1,NE
      DO 76 M=1,ME
      AF(N,M)=F2(N,M) + F3(N,M)
      F1(N,M)=CP1(N,M)+F2(N,M)
      F2(N,M)=CP2(N,M)+F3(N,M)
      F4(N,M)=CP3(N,M) + AF(N,M)
   76 CONTINUE
      CALL WRITMS(3,F1,256,10,1)
      CALL WRITMS(3,F2,256,11,1)
      CALL WRITMS(3,F4,256,12,1)
   80 RETURN
      END
```

```
      SUBROUTINE ZOOPPD
      DIMENSION ISL(16,16),CP1(16,16),CP2(16,16),CP3(16,16),
     1F1(16,16),F2(16,16),F3(16,16),F4(16,16),S1(16,16),S2(16,16),
     2S3(16,16),P1(16,16),P2(16,16),AS(16,16),AF(16,16),AP(16,16)
     3,IS(16,16),WA(12,10),WB(12,10),WC(12,10),IA(12)
     4,NS(10),MS(10),OP(10),CS(10),OH(10),OO(10)
     5,INDEX(30)),WD(12,10),WE(12,10),WF(12,10),WG(12,10)
     6,POR(6),GR(6),TR(6),FF(6),FGF(6),FFM(6),CAN(6)
      COMMON ISL,CP1,CP2,CP3,
     2F1,F2,F3,F4,S1,S2,S3,P1,P2,AS,AF,AP
     3,IS,WA,WB,WC,IA,NS,MS,OP,CS,OH,OO,INDEX
     4,WD,WE,WF,WG
     5,POR,GR,TR,FF,FGF,FFM,CAN,HFC,HGR,PCCC
      COMMON K,L,KK,LI,MM,NE,ME,NJ,MJ,MJJ,MF,NMF,JA,MPF,NPF
     2,IPO1,IPO2,IPO3,IPO4,IPO5,IPO6,IPO7,IPO8,IPO9,IPO10,IPO11,IPO12
     3,IFS1,IFS2,IFS3,IFS4,IFS5,IFS6,IFS7,IFS8,IFS9,IFS10,IFS11,IFS12
     4,IBS1,IBS2,IBS3,IBS4,IBS5,IHF1,IHF2,IHF3
     5,IIC1,IIC2,IIC3,IIC4,IIC5,IIC6,IIC7,IIC8,IIC9,IIC10,IIC11,IIC12
     6,IFP1,IFP2,IFP3,IFP4,IFP5,IFP6,IFP7,IFP8,IFP9,IFP10,IFP11,IFP12
      COMMON IZO1,IZO2,IZO3,IZO4
     2,MON,IFSI,IFPI,IICI,IHFI,IPOI
      COMMON/1/IC(16,16)
      INTEGER AH
      RAD=0.0174533
      ALP=30.*RAD
      ALPP=60.*RAD
      ZKAPP=120.*RAD
      ZO=220.
      ZOS=40.
      ZSC=5.
      DO 90 N=1,NE
      DO 90 M=1,ME
      ZOM=ZO+4.*N
      ZOMS=ZOS+0.7*N
      PKAP=(3.+0.20*N)*30.*RAD
      IF(IS(N,M)-2)51,11,12
   12 IF(IS(N,M)-3)51,11,13
   13 IF(IS(N,M)-4)51,11,14
   14 IF(IS(N,M)-6)51,11,51
   11 ZOM=1.4*ZOM
      ZOMS=1.4*ZOMS
      GO TO 52
   51 IF(IS(N,M)-5)52,15,16
   16 IF(IS(N,M)-8)52,15,17
   17 IF(IS(N,M)-9)52,15,52
   15 ZOM=1.2*ZOM
      ZOMS=1.2*ZOMS
   52 F1(N,M)=ZOM+ZOMS*COS(ALP*K-PKAP)+ZSC*COS(ALPP*K-ZKAPP)
      IF(ISL(N,M)-3)90,53,90
   53 F1(N,M)=0.
   90 CONTINUE
   82 PRINT 61,K
   61 FORMAT(1H1,5X,22HZOOPLANKTON, MG/M3, K=,I3/)
      CALL PRIFLO(F1,1)
   81 CALL WRITMS(3,F1,256,13,1)
      CALL READMS(3,F2,256,10)
      CALL READMS(3,F3,256,11)
```

```
C     IZ01 COPEPOD CONS. IZ02 EUPHAUSID CONS. IZ03 TOT.ZOOPL.CONS.
C     REDUCE ZOOPLANKTON WITH A GRAZING FACTOR
      DO 20 N=1,NE
      DO 20 M=1,ME
  666 S1(N,M)=(F2(N,M)+F3(N,M))/50.
      F1(N,M)=F1(N,M)-S1(N,M)
   20 CONTINUE
   84 PRINT 21,K
   21 FORMAT(1H1,5X,42HZOOPL STAND. STOCK,CORR.FOR GRAZ. MG/M3,M=,I3/)
      CALL PRIFLO(F1,1)
      PRINT 22,K
   22 FORMAT(1H1,5X,21HTOTAL ZOOPL. CONS. M=,I3/)
      CALL PRIFLO(S1,1)
   83 DO 30 N=1,NE
      DO 30 M=1,ME
      F1(N,M)=F1(N,M)*50.
      F4(N,M)=F2(N,M)+F3(N,M)
   30 CONTINUE
      DO 72 I=1,NU
      N=NS(I)
      M=MS(I)
      WG(K,I)=F4(N,M)
   72 CONTINUE
      IF(K-12)102,101,101
  101 CALL WRITMS(4,WG,120,64,1)
  102 CONTINUE
  560 PRINT 31,K
   31 FORMAT(1H1,5X,29HTOTAL ZOOPL. CONS. KG/KM2, M=,I3/)
      CALL PRIFLO(F4,1)
   99 RETURN
      END
```

```
      SUBROUTINE GRAPHF(WW,AH,NG)
      DIMENSION WW(12,10),LINE(110)
      INTEGER AH
      MLM=K
      NLG=1
   10 PMA=0.
      DO 20 N=1,12
      DO 20 M=1,5
      PMA=AMAX1(WW(N,M),PMA)
   20 CONTINUE
   23 IF(PMA-100.)24,24,25
   24 IN1=1
      GO TO 30
   25 IF(PMA-1000.)26,26,27
   26 IN1=10
      GO TO 30
   27 IF(PMA-10000.)28,28,29
   28 IN1=100
      GO TO 30
   29 IN1=1000
   30 PRINT 31,IN1,AH,NG
   31 FORMAT(1H1,20X,10HBIOMASS  Y,I6,3X,3HOF ,A6,6HGR. NO,I3//)
      PRINT 32
   32 FORMAT(15X,1H0,9X,1H1,9X,1H2,9X,1H3,9X,1H4,9X,1H5,9X,1H6,9X,1H7,9X
     2,1H8,9X,1H9,8X,2H10/)
      IBLANK=1H
      IP=1H+
      IM=1H-
      IV=1HI
      I1=1H1
      I2=1H2
      I3=1H3
      I4=1H4
      I5=1H5
      DO 33 I=1,100
   33 LINE(I)=IM
      DO 34 I=10,100,10
   34 LINE(I)=IP
      PRINT 101,(LINE(I),I=1,100)
  101 FORMAT(15X,1H+,100A1)
      K=1
   42 L=1
   39 DO 35 I=1,100
   35 LINE(I)=IBLANK
   37 PRINT 36,(LINE(I),I=1,99)
   36 FORMAT(15X,1H+,99A1)
      L=L+1
      IF(L-2)37,37,38
   38 IF(K-12)40,40,90
   40 DO 102 N=1,12
      DO 102 M=1,5
      IK=IFIX(WW(N,M))/IN1
      IF(IK-1)103,102,102
  103 WW(N,M)=IN1
  102 CONTINUE
      J=IFIX(WW(K,1))/IN1
      LINE(J)=I1
```

```
      J=IFIX(WW(K,2))/IN1
      LINE(J)=I2
      J=IFIX(WW(K,3))/IN1
      LINE(J)=I3
      J=IFIX(WW(K,4))/IN1
      LINE(J)=I4
      J=IFIX(WW(K,5))/IN1
      LINE(J)=I5
      PRINT 41,(LINE(I),I=1,99)
   41 FORMAT(15X,1H+,99A1)
      K=K+1
      GO TO 42
   90 IF(NUG-2)91,95,95
   91 DO 60 N=1,12
      DO 60 M=1,5
      I=5+M
      WW(N,M)=WW(N,I)
   60 CONTINUE
      NUG=2.
      GO TO 10
   95 K=MLM
      RETURN
      END

      SUBROUTINE PRIFLD (FLD,KM)
      DIMENSION FLD(16,16)
      NE=16
      ME=16
      PRINT 500, (N,N=1,16)
  500 FORMAT(7X,16I7)
      IF (KM-1)504,502,503
  503 PRINT 501,(N,(FLD(N,M),M=1,16),N=1,16)
  501 FORMAT(//I7,16F7.1)
      GO TO 506
  502 PRINT 505,(N,(FLD(N,M),M=1,16),N=1,16)
  505 FORMAT(//I7,16F7.0)
      GO TO 506
  504 PRINT 507, KM
  507 FORMAT(5X,22HERROR IN PRINTFLD, KM=,I3)
  506 RETURN
      END
```

```
      SUBROUTINE PRIPNT (NS,MS,PU,PK,PT,K,KP,KK)
      DIMENSION NS(10),MS(10),PU(10),PK(10),PT(10),PN(10),KK(3)
C     NS,MS N AND M OF SPECIAL POINTS
C     PU,PK,PT 3 SETS OF VALUES AT SPECIAL POINTS
C     KP NUMBER OF SPECIAL POINT SETS (UP TO 3)
C     K  MONTH
C     KK ABREVIATIONS OF SUBJECT
      NU=10
      PRINT 11,(NS(I),MS(I),I=1,NU)
   11 FORMAT(//13X,10(2X,I3,1H,,I3)//)
   12 FORMAT(5X,A2,I6,10F9.2)
      PRINT 12,KK(1),K,(PU(I),I=1,NU)
      IF(KP-2)15,13,13
   13 PRINT 12,KK(2),K,(PK(I),I=1,NU)
      IF(KP-3)15,14,14
   14 PRINT 12,KK(3),K,(PT(I),I=1,NU)
   15 RETURN
      END
```

6th Quarterly Report

Contract # 03-5-022-72
Research Unit 83
Reporting Period 1 July -
30 September 197

9 pages

Reproductive Ecology of Pribilof Island Seabirds

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1 October 1976

I. Task Objectives

The task objectives for the 6th quarter were:

a) To determine the phenology of seabirds nesting on St. Paul and St. George Islands.
b) To evaluate reproductive success of seabirds nesting on St. Paul and St. George Islands.
c) To determine food habits of Pribilof Island seabirds.
d) To conduct radial transects by ship in the vicinity of St. Paul and St. George Islands.
e) To aid Dr. Hickey's group in the estimation of population size of Pribilof Island seabirds.

II. Field Activities

A. Ship and Field Trip Schedule

1 July 1976	- Doug Causey depart St. Paul Island
7-12 July 1976	- George Hunt and Zoe Eppley on R/V Moana Wave
7 July 1976	- Molly Hunt to St. Paul Is. from St. George Is.
10 July 1976	- Barbara Mayer to St. Paul Is.
1 August 1976	- George Hunt departs St. Paul Is.
4 August 1976	- Molly Hunt to St. George Is. from St. Paul Is.
15 September 1976	- Doug Schwartz and Zoe Eppley depart St. Paul Is.
22 September 1976	- Barbara Mayer departs St. Paul Is.
29 September 1976	- Molly Hunt departs St. George Is.

B. Scientific Party

George L. Hunt, Jr., Associate Professor, University of California, Irvine, Principal Investigator.

Molly Warner Hunt, Assistant Specialist, University of California, Irvine, Project Leader, St. George Is.

Barbara Mayer, Assistant Specialist, University of California, Irvine, Project Leader, St. Paul Is.

S.D.L. Causey, Research Assistant, University of California, Irvine, Field Observer.

Zoe Eppley, Laboratory Assistant, University of California, Irvine, Field Observer.

Doug Schwartz, Laboratory Assistant, University of California, Irvine, Field Observer.

C. Methods

For task objectives a-d please see Annual Report 1975.

e) We participated in censusing efforts by making all-day counts in two locations on St. Paul to obtain data on daily rhythms of colony-occupancy. We made two photographic surveys of the cliff-nesting species on St. Paul Is. Approximately 300 frames of black and white film were exposed. Additionally we walked the beach from the Northwest Point at Tsammana to the middle of the high bluffs at Rush Hill and obtained detailed counts of all Red-faced Cormorant and Red-legged Kittiwake nests.

D. Sampling Localities

1) Radial transects to survey for marine birds at sea are presented in Figure 1.

2) Studies of Reproductive Ecology were conducted on St. Paul and St. George Islands.

E. Data Collected

1) Radial transect surveys of birds at sea: on our 7-12 July cruise, 121 transect segments were counted during 1,658 minutes of observation. This amounts to over 502 km of surveying for a total of 201 km^2 of ocean censused. Coding and analysis of this material has yet to begin.

2) Studies of Reproductive Ecology

a) Reproductive Success: studies of laying dates, numbers of eggs laid, hatching and fledging success are being completed as listed below.

	St. Paul		St. George	
Species	# sites	# nests	# sites	# nests
Northern Fulmar	2	9	-	-
Red-faced Cormorant	7	82	2	52
Black-legged Kittiwake	5	140	2	27
Red-legged Kittiwake	5	82	3	89
Common Murre	5	91	1	10
Thick-billed Murre	8	114	1	40
Parakeet Auklet	2	7	-	-
Least Auklet	1	2	-	-
Horned Puffin	2	21	-	-

b) Data on growth rates of young have been obtained as follows:

	St. Paul	St. George
Species	young weighed	young weighed
Red-faced Cormorant	17	11
Black-legged Kittiwake	35	18
Red-legged Kittiwake	5	32
Common Murre	10	8
Thick-billed Murre	29	23
Parakeet Auklet	1	-
Horned Puffin	10	-

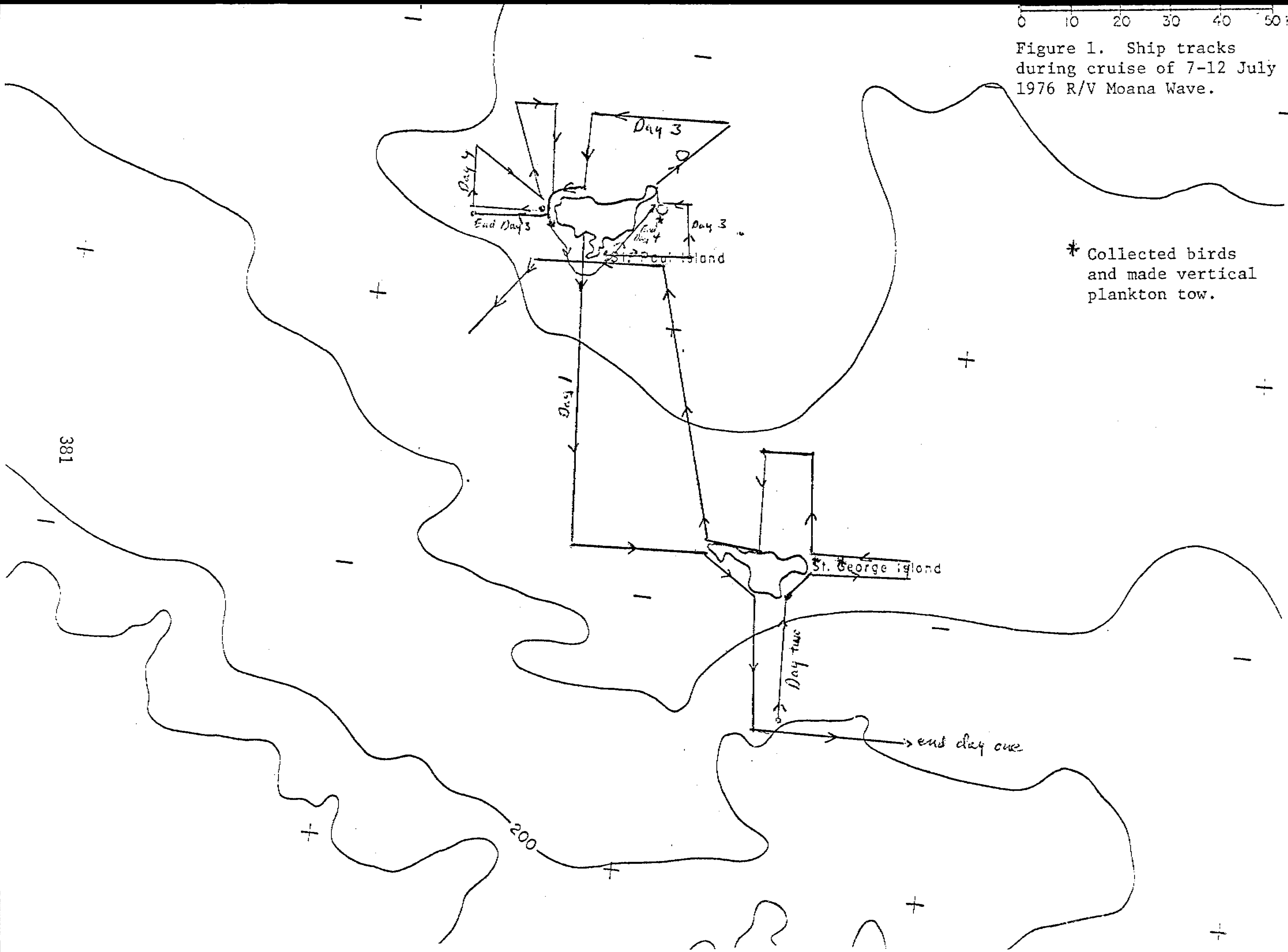

Figure 1. Ship tracks during cruise of 7-12 July 1976 R/V Moana Wave.

c) Data on foods were obtained by shooting adults and by taking samples from young as listed below.

Species	St. Paul samples up to 2 September	St. George samples up to 30 August
Northern Fulmar	0	0
Red-faced Cormorant	30	20
Black-legged Kittiwake	73	27
Red-legged Kittiwake	16	35
Common Murre	15	1
Thick-billed Murre	17	7
Murre sp.	18	6
Parakeet Auklet	18	0
Crested Auklet	10	0
Least Auklet	93	0
Horned Puffin	9	0
Tufted Puffin	5	0
Total	304	84
Grand total to the end of August		388

By the end of September we will have obtained 100-150 more samples than we had expected to get.

Summary of Effort 1975-1976

Reproductive Success (number of nests studied)

Species	St. Paul 1975	St. Paul 1976	St. George 1975	St. George 1976
Northern Fulmar	6	9	0	0
Red-faced Cormorant	88	82	0	52
Black-legged Kittiwake	185	140	0	27
Red-legged Kittiwake	51	82	28	89
Common Murre	18	91	0	10
Thick-billed Murre	66	114	0	40
Parakeet Auklet	0	7	0	0
Least Auklet	0	2	0	0
Horned Puffin	11	21	0	0
Total	425	548	28	218

Growth Rate Studies (numbers of chicks weighed)

Species	St. Paul 1975	St. Paul 1976	St. George 1975	St. George 1976
Red-faced Cormorant	8	17	0	11
Black-legged Kittiwake	34	35	0	18
Red-legged Kittiwake	0	5	18	32
Common Murre	0	10	0	8
Thick-billed Murre	7	29	0	23
Parakeet Auklet	0	1	0	0
Horned Puffin	8	10	0	0
Total	57	107	18	92

Food Samples Collected

Species	St. Paul 1975	St. Paul 1976	St. George 1975	St. George 1976	Total both years both islands
Northern Fulmar	1	0	0	0	1
Red-faced Cormorant	37	30	0	20	87
Black-legged Kittiwake	123	73	0	27	223
Red-legged Kittiwake	0	16	10	35	61
Common Murre	21	15	0	1	37
Thick-billed Murre	20	17	0	7	44
Parakeet Auklet	8	18	0	0	26
Crested Auklet	6	10	0	0	16
Least Auklet	52	93	0	0	145
Horned Puffin	4	9	0	0	13
Tufted Puffin	2	5	0	0	7
Total	274	286	10	90	660

II. & IV. Results and Interpretation

At this point virtually all of the second year's data have been gathered, although summaries are available only up to the beginning of September. Our success, and the quality and quantity of data gathered in 1976 have significantly increased over 1975. Of particular importance, we now have the beginnings of a data base for St. George Island and we have more and better quality at-sea observations. Data reduction and interpretation will begin in early October.

Phenology:

Our data for both kittiwakes and for both murres are excellent for 1975 and 1976. This year the birds appear to be about a week to ten days later than they were last year. Although definite statements on this matter will have to wait until the 1976 data are plotted, it appears that

Black-legged Kittiwakes, which had pretty much fledged their chicks at St. Paul Is. by 10-16 September last year, still had many of their chicks in the nests by mid-September 1976. In 1976 the winter was unusually cold and according to Captain Stanford C. Balmforth of the U.S. Navy Fleet Weather Service, Ice Department, the ice pack extended further south in the Bering Sea than ever before (in lit.). The apparent late start of the birds therefore, may have been related to this past winter's severe ice conditions. It will be most important to the OCSEP program to know the normal extremes of shifts in nesting caused by different ice conditions, if the effects of the impacts of oil development are to be assessed.

Reproductive Success:

We have good data for Red-faced Cormorants, both kittiwakes and both murres for 1975 and 1976. We have yet to analyze our results for reproductive success in 1976. My impression is that our results will not differ greatly from last year. Comparison of growth rates of young in 1975 and 1976 may allow us to separate effects on reproduction steming from a late ice break up from effects related to changes in food availability.

This year we have found that in Black-legged Kittiwake nests the older chick invariably kills the younger chick. Within a week to ten days after the hatching of the younger chick, only the first hatched chick remained. In other areas (England for instance) more than one chick may be fledged by a pair of Black-legged Kittiwakes. In attempting to assess whether this species has the potential for rapid population recovery subsequent to a disaster, it will be important to find out if pairs are ever able to raise more than one young in Alaskan waters.

Food habits:

Our sample of foods used by seabirds of the Pribilof Islands improved in 1976. We now have material for comparing food habits on St. Paul Is. with those of birds on St. George Is. The use of the boat has been helpful in obtaining samples from a number of the smaller alcids.

We have been able to get reasonably large numbers of samples from Red-faced Cormorants, Black-legged Kittiwakes, Red-legged Kittiwakes, both murres, Parakeet Auklets and Least Auklets. The Crested Auklets and the two puffins are sufficiently low in abundance and hard to collect that I feel our rate of collection is about as good as we can hope for with these species.

In cooperation with Doug Forsel of the U.S.F. & W.S. we were able to shoot Least Auklets at the same places where we made vertical plankton tows. Although the numbers of tows and birds shot were small, it appears that the commonest items in the plankton nets are similar to the types of foods used by the auklets. This study will provide a valuable comparison with similar work done by Bedard in his study of auklet resource utilization at St. Lawrence Island. We look foreward to the availability of data on benthic and pelagic organisms from other OCSEP studies to compare with our results.

Radial Transects:

The cruise on the R/V Moana Wave from 7 July 1976 - 12 July 1976 was most successful. My only concern is that we obtained so much data that we will be hard pressed to analyze it completely by the time the final report is due, 31 January 1977. As mentioned in the Trip Report, several of our observations were of particular interest:

a) South of St. George Island large numbers of fulmars and Red-legged Kittiwakes were seen flying south in the evening. Apparently they forage at night, well to the south of the island. Huge numbers of fulmars were seen sitting on the water in a line several miles long behind a large factory vessel.

b) At both the east and west ends of St. George Is. immense flocks of murres were encountered on the water within 1-2 nautical miles of the island. Large flocks had not been encountered at these locations on previous trips.

c) At the shoal to the east of St. George Is. relatively few birds were found. This has been an area of high concentrations of birds on previous trips.

d) Large numbers of birds were found foraging in the tide-rips in the vicinity of Otter and Walrus Islands. This pattern is in agreement with what we had seen before.

e) Large numbers of several species were found foraging about 0.5-1.5 miles northwest of St. Paul Is.

f) Large numbers of murres were seen flying northwest along the north coast of St. Paul, returning to the high cliffs on the west end. Their foraging area was not known, although they may have been foraging near Walrus Is.

Overview of cruise results:

Our results suggest that most alcids forage fairly close to the islands where they nest, usually within 10 nautical miles. Tufted and Horned Puffins may travel further off shore. Cormorants forage close to their islands. Fulmars appear to move far off shore, and given the movements south of St. Ceroge Is. we believe most fulmars travel to deep water in order to forage. Black-legged Kittiwakes may forage in large flocks in tide-rips near the ends of their nesting islands, but others may forage farther at sea. My impression was that Red-legged Kittiwakes forage at greater distances.

The implication of these impressions for OCS oil and gas work, if they hold up when the data are analyzed, is that oil on the water within 10 nautical miles of a major alcid colony is likely to cause great loss of seabirds. In the tide-rips around the islands tens of thousands of vulnerable alcids are concentrated in dense foraging flocks which would be quickly wiped out in a spill. More distant from the islands seabird densities are lower, and a spill would have a less immediately devastating effect on the nesting colonies. However, it must be remembered, that with even moderately low densities of foraging breeding birds, there may be large numbers of migrants, so that the total numbers of seabirds at risk may still be great.

Estimates of St. Paul Island Seabrid Populations:

As part of a cooperative effort with Dr. J. Hickey's team on St. George Island, we hosted Lance Craighead and Ron Squibb while they made detailed counts of Low Bluffs (our Ridge Wall), Zapadni and Tolstoy Cliffs. Latter we made a second photographic survey of all cliff areas between Tsammana and South West Point, thereby assuring a virtually complete catelog of St. Paul Island seabirds. Negatives (approximately 300 frames) of our photographic survey are being duplicated prior to being sent to Dr. Hickey at Wisconsin.

At the same time that we did our July photographic survey, Molly Hunt walked the beach from Tsammana to Rush Hill High Bluffs, where rough weather forced us to evacuate her from the beach by boat. During an approximately 6 hour period she counted all Red-faced Cormorant and Red-legged Kittiwake nests along that stretch of beach. The remaining distance from High Bluffs to South West Point was surveyed by boat, a less satisfactory proposition due to the difficulty of accurately identifying Red-legged Kittiwakes on 200 ft. cliffs from a small, bouncing boat. Our counts, combined with those of Craighead and Squibb will provide a complete, accurate count ($\pm$10%) of all Red-faced Cormorants and Red-legged Kittiwakes nesting or attempting to nest on St. Paul Island. Dr. Hickey's team will be able to provide good data on a number of other species as well.

In addition, during June and July we made an intensive study of Least Auklets nesting on East Landing Beach, St. Paul Is. As of 29 July we had banded approximately 160 breeding auklets. Analysis of 15 recaptures gave a rough estimate of the breeding population for the segment of the beach sampled of about 1800-2000 birds. In comparison, we never counted more than about 100-200 birds on the beach at a time. While our estimate of population size may be inflated by net-shyness on the part of previously captured birds, our results and the sightings of color-marked and banded auklets suggest that there are far more birds using the beach than we could have estimated on the basis of visual counts alone.

As a biproduct of this work we were also able to establish the phenology of nesting, when during the seasonal and daily cycles non-breeding floaters visited the colony, that the two sexes may be operating on different daily schedules and that weights change on both a seasonal and a daily pattern. Some of our data will provide comparisons with that for Least Auklets gathered by Bedard on St. Lawrence Island. Other aspects of our work provide new insights into the biology of this species. These data will be of use to the OCSEP program because parameters such as timing of nesting and weights have been used as a measure of food availability and the health of seabird populations. Such measures would very likely be applied in "before and after comparison". If daily fluctuations and seasonal changes in weight are great, as our results suggest, then in order for year to year comparisons to be valid, it will be necessary to compare weights at the same time of the day and same stage of the reproductive cycle.

V. Problems encountered/Recommended Changes

Our most serious problem was that of providing adequate, reliable ground transportation. A modest amount of field time was lost searching for alternative transport or trying to fix the motorcycles. The acquisition of a Honda Three-wheeler for next year should alleviate this problem. Otherwise, the field work went as well as could be hoped for.

Data management and processing has gone reasonably well, although the lack of smooth plots has, and is holding up our analysis of our radial transect data.

This year I did miss the xerox of letters that Cal Lensink's office circulated in 1975. Those of us not on the U.S.F. & W.S. radio net were left out of a lot of important exchanges. Would it be too expensive to supply the few outlanders with sets so that we could know what others are finding, now that the circulation of letters is no longer in vogue?

VI. Estimate of Funds Expended

	Estimated accumulated expense to 30 Sept. 1976	Total funds Allocated $60,332
Salaries	$29,013	
Employee benefits	1,165	
Supplies and expenses	6,752	
Equipment	5,714	
Travel and per diem	12,072	
Other	921	
	$55,637	
	Estimated funds remaining	$4,695

VII. Acknowledgements

We thank Lance Craighead and Ron Squibb for help in obtaining data on growth rates and reproductive success of birds on St. George Is., Doug Forsel for help on the R/V Moana Wave cruise, Lt. J.G. William Thrall of the U.S. Coast Guard for aid with transportation, and the personnel of the National Marine Fisheries Pribilof Island Project for logistic support. Ken Dzimble also aided in mist-netting Least Auklets.

RU# 96

NO REPORT AVAILABLE AT THIS TIME

Quarterly Report

Contract No. 03-5-022-68

Research Unit No. 108

Reporting Period: 1 July 1976-

30 Sept. 1976

Number of Pages:

COMMUNITY STRUCTURE, DISTRIBUTION, AND INTERRELATIONSHIPS OF MARINE BIRDS IN THE GULF OF ALASKA

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Research Assistants: Wayne Hoffman
Dennis Heinemann

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30 September 1976

I. TASK OBJECTIVES

A. Patterns of seasonal abundance and distribution are being studied because of their direct relevance to oil development and transport activities, and also to use in our analysis of marine bird energetic impacts.

B. The dynamics of feeding flocks of seabirds are being investigated to determine the degrees and directions of dependency and/or interference between seabird species. This involves a description of the roles of different species in flock formation and development and an analysis of their contribution to the efficiency and performance of the system as a whole.

C. The energetics analysis is designed to estimate the impacts of marine birds on oceanic ecosystems in the Gulf of Alaska, and to predict the effects on those systems of major changes in bird populations, such as may occur from oil development and transport accidents.

II. FIELD ACTIVITIES

A & B. <u>Ship and Field Schedule and Scientific Party</u>.

Acona	20 July - 1 August	Wayne Hoffman (20-28 July
		Dennis Heinemann
		Range Bayer
		Jon Janosik
Chowiet I.	28 July - 19 Aug.	Wayne Hoffman
Surveyor	16 Aug. - 2 Sept.	Dennis Heinemann
		Wayne Hoffman (19-21 Aug.
		Gerald Sanger (USFWS; 1-2
Moana Wave	31 Aug. - 3 Sept.	Wayne Hoffman
Ungala I.	3-17 Sept.	Wayne Hoffman
Moana Wave	17-18 Sept.	Wayne Hoffman

C. Methods.

1. Distribution of Seabirds. Observations are made at all periods of the day, but proximate decisions on observations are largely dependent upon weather, visibility, and ship's activity. Observations are made as follows: the observer places himself on the flying bridge or elsewhere high on the foreward part of the ship. Observation is normally limited to one quadrant, from bow to beam. The side of the ship to be used is chosen on the basis of visibility and weather. Observations are made for periods of 15 or more minutes while the ship is travelling at a constant course and speed. We collect data on the behavior, position, distance, and identification of each bird seen. These data will allow us to calculate area-specific densities of seabirds to a greater level of accuracy than has previously been accomplished. In addition, several experimental transects were taken using the Bell Helicopter from the Surveyor, at altitudes of 100 - 400 feet. General colony surveys were also taken from the helicopter along the southwest shore of Nunivak Island in the Trinity Islands, and between Point Banks and Tonki Cape, Kodiak Island.

2. Multispecies feeding aggregations. The R/V Acona was used during the period 20 July to 1 August for intensive studies of seabird flocking in the Kodiak Basin and Western Gulf of Alaska. Observations were made both from the vessel and from its Boston Whalers. Specimens were collected by shotgun for analysis of food habits. Observational data were collected on flock formation, composition, and development, and on foraging rates and success of the birds involved.

One observer camped on Chowiet Island in the Semidi Islands from 28 July through 19 August to study nearshore feeding flocks from shore by spotting scope. The U.S. Fish and Wildlife service maintained a field camp on Chowiet Island through the summer, and the feeding flock observations collected by the OSU observer will be analyzed with the food habits, growth rate, and nesting success data collected simultaneously by the USFWS personnel

Feeding flocks in the Chiniak Bay and Spruce Island Passage areas of Kodiak were studied from the Surveyor's Motor Whaleboat Aug. 20 and 23 and from shore Aug. 25-29. Feeding flocks were also studied from Ungala Island Sept. 3-17. In these two areas, feeding rates and success, and flock formatio development and composition were emphasized.

3. Energetics. Data collected in the field on distribution and abundance of birds and on their food habits will be used, along with energetics, productivity, meteorological and breeding biology data from the literature, as inputs into the BIRD model (Wiens and Innis, 1974) to calculate the population energetics of the marine birds in Gulf of Alaska ecosystems. We will then be able to conduct computer simulations, modifying model inputs to predict the energetic consequences of various possible patterns of oil-related disturbance The BIRD model has been extensively modified during this quarter and is now in the final stages of being set up primarily for seabird applications.

Data Submission Schedule

Data submission has been delayed considerably beyond the schedule specified in our Milestone Chart, and slightly beyond that submitted in our revised Milestone Chart (filed 1 July 1976) and well beyond the due dates specified in the Data Flow Schedules for fiscal year 1976.

The first major source of delay was the common format development delay.

The seabird transect formats were finalized and delivered to us in March 1976. The dates specified on the fiscal year 1976 data flow schedules were thus already missed. We could not begin transmitting our 1975 data immediately at that point because 1) we were busy writing our annual report and revising our field data forms for easier transferral to prepunching forms under the new formats, and 2) at that time we still had not received the smooth plots of the 1975 tracklines which were necessary for position determination. Our field season began in April. We decided that, given the fixed term of our project, the eventual successful conclusion depended upon maximization of data collection in spring and summer 1976. Therefore data collection took priority over data processing during the period April-September 1976. Data processing and submission have top priority now (Sept. Nov. 1976). We have by now received most of the smoooth-plots of our 1975 tracklines. Because the 1975 data were collected before common formatting, they require fairly extensive manual translation of codes prior to keypunching. Therefore we are processing most of our 1976 transect data before the 1975 data. We can expect to meet the following schedule with our transect data.

Dates collected	Due dates (Data Flow Schedules)	Expected submission Dates	Platform
760512-760520	760915	761011	Discoverer
760824-760902	76 ?	761011	Surveyor
760815-760820	?	761020	Surveyor
750804-750913 (partial file)	760101	761020	Surveyor
760413-760430	760915	761020	Discoverer
760504-760510	?	760120	Discoverer
760607-760623	761030	761030	Miller Freeman
750804-750913 (completion of file)	760101	761120	Surveyor

(cont.)

750916-750923	760101	761120	Surveyor
751028-751108	760101	761120	Surveyor
(Surveyor 760512-760521 - only feeding flock data collected)			

The submission of feeding flock data will follow the submission of transect data. At the time our field work started in April, the feeding flock format was not finalized. Our field schedule precluded pursuit of this matter. We are now working again with NODC/EDS on this matter and we have been advised by them that verification may be completed in about three weeks. Assuming that is the case, we can expect to meet the following schedule:

Dates collected	Due Dates (Data Flow Schedule)	Expected submission date	Platform
750804-750913	760101	761130	Surveyor
75916-751108	760101	761130	Surveyor
751028-751108	760101	761130	Surveyor
760413-760430	760915	761230	Discoverer
760512-760521	760915	761230	Surveyor
760607-760623	760915	761230	Miller Freem
(760511-760520 - No flock data collected)			
760720-760801	?	770115	Acona
760728-760818	?	770115	Chowiet I.
760899-760823	?	770115	Surveyor
760824-760829	?	770115	Kodiak I.
760903-760917	?	770115	Unalga I.

III. RESULTS AND PRELIMINARY INTERPRETATIONS

A. Distribution

Laysan Albatross. Diomedea immutabilis. Our observations, as well as USFWS sightings, indicate that Laysan Albatrosses concentrate in the area of the Outer Continental Shelf and Slope, over water 100 - 1000 fathoms in depth. Further, the majority of the Gulf of Alaska sightings seem to be concentrated between Chirikof Island and Unimak Pass.

Parasitic Jaeger. Sterocorarius parasiticus. The area of Southwestern Kodiak Island and its outlying islands (Sitkalidak I., the Trinity Is. and numerous smaller islands) and the Semidi Islands contain a fairly large population of dark phase Parasitic Jaegers. These birds appear to feed by kleptoparasitism of tern and Black-legged Kittiwakes throughout the breeding season. Most jaegers breed inland and while breeding feed largely upon terrestrial prey. The continued dependence of this population on marine birds for their food while breeding suggests that it may be more vulnerable than other jaeger populations to oil development-related disturbance of the continental shelf areas.

Skua. Catharacta skua. During this quarter we were able to obtain the first verification of the occurrence of the Skua in Alaska. We saw and photographed one individual 2 miles east of Kodiak on 22 and 23 July. Juan Guzman (R.U. no. 239) observed it or another individual in the same area approximately one week later, and we obtained two sightings in the northern Gulf at approximately 58°24'N/148°05'W four days apart at the end of August. Observations from off Oregon, Washington, and British Columbia, where this southern hemisphere migrant is regular, indicate a greater than usual influx this summer.

Tufted Puffin. Lunda cirrhata. Observations in late July allow a more precise description of the distribution of Tufted Puffins in the Krentzin Island area. This area may contain the largest concentration of Tufted Puffins in the world. The largest colonies we observed were on Tanginak Island, in

Unimak Pass (54°12'N, 165°20'W), the Baby Islands (54°00'N 166°04'W) and Egg Island (53°25'N 166°03'W). Unalga Pass, Sedanka Pass, Akutan Pass, Baby Pass, and parts of Unimak Pass are extremely important feeding areas. Avatanak Strait is an exceptionally important feeding and passage area. Unimak Pass and probably other parts of the area are major spring staging areas. These factors make the region one of the most vulnerable areas to oil pollution in all Alaskan waters we have studied. The area is also considered fairly hazardous for navigation. Thus if the Eastern Bering Sea yields significant amounts of oil, this area probably warrants a permanent oil cleanup installation or facility.

Horned Puffin. Fratercula corniculata. A helicopter survey in mid-August discovered a major breeding concentration of Horned Puffins on the southwest shore of Nunivak Island, from Cape Mohican to Cape Mendenhall. This concentration was apparently not previously known, but it may prove to be the largest in the Eastern Bering Sea. It is certainly larger than any colonies in the Pribilofs or the Eastern Aleutians. A number of earlier surveys of colonies in Alaska have missed Horned Puffin concentrations because they were conducted too early. Horned Puffins are one of the last seabirds in Alaska to arrive on colony for the summer.

B. Energetics. The energetics calculations will begin during the final quarter of Calendar 1976. We have completed our collection of data and are preparing the data now for analysis. These data relate chiefly to distributional patterns and abundances, oceanographic conditions (primarily surface temperatures) and trophic functions. The model has been extensively modified and is now in the final stages of re-verification for this analysis.

C. <u>Feeding Flocks</u>. The common feeding aggregations involving species of gulls and of diving birds (primarily large Alcids and Cormorants) can be divided into two types. The Type I flocks are relatively small and short-lived. They involve at most a few hundred birds, and usually last from a few seconds to several minutes. Gulls (in the GOA usually Black-legged Kittiwakes) usually initiate the Type I flocks, and are almost always catalyst species in their formation. The Type II flocks are much larger and more permanent. They generally involve at least several thousand birds and may last for several days (they may break up at night and reform in the early morning; we do not have data enough to tell). We have not observed the initiation of Type II flocks. Type I flocks form over tight schools of fish such as smelt, sandlance, and herring. Type II flocks form over large, more dispersed concentrations of fish such as Capelin. Shearwaters are frequently abundant in Type II flocks.

Extensive data were collected this quarter on feeding flocks. The initiations of about 70 flocks were observed, and data were collected on the development and composition of a total of about 100 flocks. An additional 50 flocks were observed after formation and for them only composition information was collected. Foraging success data were collected on birds in 11 of the flocks. Feeding flock sizes ranged from 5 to 10,000 birds.

Multispecies feeding flocks tend to be a summer phenomenon. Kittiwakes and other Gulls will feed in flocks throughout the year, but the opportunities (schools of fish or other pelagic prey) are apparently less common. Cormorants also will participate occasionally out of the breeding season, but are most active as participants during the breeding season. The large alcids (Rhinoceros Auklets, the two Puffins, the two Murres) restrict their participation largely to the period when they are feeding young on the colony. This is probably due to a diet shift to pelagic crustaceans during the nonbreeding season.

Flock feeding appeared to be an especially important foraging tactic of the fish-eating birds around Kodiak. In July, August, and September, feeding flocks were observed on every day of observation. Feeding flocks were observed throughout the south and east shore areas of Kodiak, from Spruce Island to the Trinity Islands. Type II flocks were observed just east of the town of Kodiak, off Ugak Island, near Rolling Bay (the southwest end of Sitkalidak I.) and north of Tugidak Pass. The flock near Kodiak was apparently active for a period of two to three weeks and must have contributed a major share of the food consumed by the Kittiwake colonies of the area. Type one flocks were common around and in the Chiniak bay area on all visits during the quarter, and must supply a major part of the food supply of the Kittiwakes, Puffins, and Murres of the area. The exploitation of flocks by the Cormorants is apparently more casual since they can obtain food apparently at will in the form of nearshore benthic fishes. When flocks are present nearby they will participate but apparently are capable of foraging successfully without them.

In the Semidi Islands, Type I flocks were of irregular occurance and it appeared that on many days they were not present. Data collected by USFWS personnel demonstrated unusually poor nesting success of the flock feeding species in the Semidis this year. The lowered performance of the two Puffins, in particular, apparently resulted from the absence of the larger schooling baitfishes, which are normally exploited by feeding flock tactics. Presumably the Puffins would suffer similarly even in years of baitfish abundance if the locator/catalyst species (Blacklegged Kittiwakes and to some extent Glaucous-winged Gulls) were absent or reduced in numbers.

In the Semidi and Aleutian Islands, a third type of "flock" is important. Where extensive tide rips occur daily, the diving birds may feed extensively in the areas of sinking and converging water. These flocks differ from Type I and Type II flocks in that the flock location cues appear to be hydrographic rather than behavioral, the flocks are much more predictable in location, the level of interspecific interaction appears much lower, and the food items are usually much smaller. These rip aggregations are important foraging areas for the alcids, but appear to provide a less desirable food source to the large species, such as Puffins and Murres, because of the smaller average prey sizes.

D. Census Techniques. Our marine bird census technique has been refined to what we believe is a definitive state. We have made considerable progress in the preparation of a manuscript describing the technique for publication in an appropriate ecological journal. We are about ready to begin programming of our simulation test of census technique reliability.

Estimate of Funds Expended (through 30 Sept. 1976)

A.	Salaries and Wages		
	Principal Investigator	$ 1,118	
	Graduate Research Assistants and Hourly Wages	6,776	
B.	Payroll Assessments	1,281	
C.	Services and Supplies	6,541	
D.	Travel	10,248	
E.	Permanent Equipment		
	Camera equipment	3,718	
	Camping and Collecting equipment	443	
	Other equipment	1,018	
F.	Computer Services	2,000	
G.	Total Direct Costs		$33,133
H.	Indirect Costs	3,314	
	TOTAL		$36,447

TRANSECT DATA COLLECTED

Area	Transects	Minutes	Species	Total birds
Eastern Bering Sea	8	240	14	805
Western Gulf of Alaska	5	150	17	1137
Kodiak Basin	15	585	25	47215
Northern Gulf of Alaska	13	475	23	1162
Cook Inlet	12	345	15	1354
Totals	43	1795	33	51723

QUARTERLY REPORT

Contract No. 03-5-022-84
Research Unit #172
Reporting Period: 1 July - 30 Sept. 1976
Number of Pages: 4

Shorebird Dependence on Arctic Littoral Habitats

Research Coordinator: Peter G. Connors
Bodega Marine Laboratory
University of California
Bodega Bay, California 94923

Principal Investigator: R. W. Risebrough

Date of Report: October 1, 1976

I. Task Objectives

The ultimate objective of this study is the assessment of the degree and nature of dependence of each shorebird species on Arctic habitats which may be susceptible to perturbation from offshore oil development activities. The approach entails three major areas of investigation:

1. Seasonal occurrence of shorebirds by species, in a variety of arctic littoral and near-littoral habitats.

2. Foraging habitat preferences of shorebirds within the littoral zone, by species.

3. Diets of shorebirds in the arctic littoral zone, by species, as these change through the season.

II. Field and Laboratory Activities

A. (1) Field season continued at NARL, Barrow, July 1, 1976 - September 16, 1976.

(2) Brief survey visits in Beaufort - Chukchi:
Lonely, July 29, 30; August 12-14.
Peard Bay, July 30 - August 2; August 18, 19.
Wainwright, July 15; August 2,3; August 19, 20.
Icy Cape, July 28-30; August 16-19; August 26-29.
(Because of local governmental problems, we were unable to visit Pt. Lay.)

(3) Brief survey visits in Kotzebue Sound area:
Cape Krusenstem, July 23; August 30.
Cape Espenberg, July 22.
Wales, July 21, 22; August 31 - September 2.

B. Scientific Party

Research coordinator: Peter G. Connors, University of California, Bodega Marine Laboratory

Research assistants: Carolyn S. Connors, UC, BML
J. P. Myers, UC, Berkeley
Russell Greenberg, UC, Berkeley
Frank Gress, UC, BML
James T. Carlton, UC, Davis

C. Methods

Objective 1: Marked transects were established in littoral habitats (22 transects, 20 km total, 50 or 100 m wide) and, for comparison, on coastal tundra (10 transects, 10 km total, 100 m wide). All transects were censused at least once every 5 days throughout the season of shorebird use, recording all species by age and sex when possible.

Objective 2: For individual shorebirds foraging within the littoral zone, 6 variables were recorded describing the microhabitat selected by the birds. Two or four foraging points, chosen at preselected time intervals, were measured for each individual. Microhabitat variables recorded were:

1. distance to water's edge
2. water depth
3. substrate (grain size)
4. distance to algae
5. distance to other vegetation
6. depth of bill penetration

Objective 3: Shorebirds foraging in littoral areas were collected throughout the season for stomach content analysis. Stomach contents were preserved with formalin or ethanol by injection immediately after collection, and were removed later in the laboratory, thus preserving the skins for museum specimens. Benthic or plankton samples were taken at the foraging locations of most collected birds for comparison of potential prey to selected prey.

Other diet information was obtained by direct observation of foraging birds, often supplemented with benthic or plankton samples taken at the foraging site.

Related tasks: A regular schedule of quantitative plankton sampling was established along the Barrow Spit shores during August to study relationships between wind direction, plankton composition and density, and red phalarope distribution. A rectangular mouth, floating plankton net, to be towed by hand parallel to the shore in shallow water, was designed for this study, allowing us to sample the same fraction of the plankton that is most heavily utilized by the phalaropes.

Juvenile red phalaropes were trapped, measured, banded, and color-marked with paint during the August migration. Objectives were to assess the importance of this period for the accumulation of fat necessary for long distance migration and to determine whether individual birds are resident at Barrow for several weeks during this period or, alternatively, larger numbers of birds are passing through, stopping only briefly.

D. Sample Localities

Survey sites away from Barrow are listed above. At Barrow, transects range from Nunavak Bay, 10 km SW of NARL, to Plover Point and Point Barrow, 12 km NE of NARL, and from the Chukchi shore to 5 km inland and 3 km along the Elson Lagoon shore.

E. Data Collected

1. Approximately 500 transect censuses were completed during this period. 1212 microhabitat foraging points were

recorded on 313 birds of 12 species. 58 birds were collected, stomachs removed, and prey items sorted. 48 juvenile red phalaropes were trapped, banded, color-marked, and released.

2. Since the field data season continued until 16 September 1976, no analyses have been undertaken yet.

3. N/A. Transect areas are given in Methods, above.

III. Results

Because the field season continued almost to the date of this report, the bulk of the data gathered have not been analyzed or even tabulated. However, several general results of the season's work are discussed below.

IV. Preliminary Interpretation

In general, the timing of movements of shorebirds in littoral areas agreed with the pattern established during the 1975 season, but with several differences, especially in population magnitudes. The post-fledging heavy movement to the gravel shorelines (principally red phalaropes, ruddy turnstones, sanderlings and dunlins) occurred a few days earlier in 1976 (about 6-8 August) and appeared to be continuing at high densities later into September. Numbers of these species along Barrow Spit were higher this year, a change exhibited markedly by arctic terns, also. In contrast, densities of long-billed dowitchers, western sandpipers, and black-legged kittiwakes appeared to be lower in 1976.

The most striking difference discovered, however, was the change in plankton composition and density along the gravel shorelines. Densities of copepods and chaetognaths and larval crustaceans, principal foods of several species of shorebirds and gulls in 1975, were in 1976 roughly 1/10 to 1/100 the 1975 densities. Although juvenile red phalaropes were present in high numbers, the proportion of birds roosting averaged much higher in 1976. Euphausiids were fairly common (occasionally abundant) in 1976, providing a larger share of the phalarope diet than in 1975. In view of the prime importance of zooplankton in the late summer diet of several species of shorebirds, gulls, and terns which is emerging from our studies, and noting the remarkable variation in plankton conditions between 1975 and 1976, we strongly urge that studies of nearshore zooplankton in the arctic be expanded greatly. Our present knowledge does not begin to define the normal variation in this highly variable system, does not allow us to predict the effects of oil spills or other disturbances, and does not yet define the responses of avian predators to fluctuations, natural or anthropogenic, in this essential prey base.

The two shorebird species for which 10 or more specimens were obtained show very different fat-accumulation schedules in 1976. All juvenile sanderlings, collected from early to late August, had very high levels of fat. In contrast, fat levels in juvenile red phalaropes in early and mid-August were very low, indicating that these birds would not be capable of a sustained long-distance flight. By the end of August, phalaropes collected showed higher fat levels. Migration routes for these species from northern Alaska are not yet known.

Preliminary analysis of resightings of color-marked juvenile red phalaropes indicates a very rapid turnover in these birds on Barrow Spit. This suggests that during the 4 to 6 weeks in August and September when phalaropes were common on Barrow Spit, large numbers of individuals passed through, staying for only one or a few days. The importance of this to oil development is obvious: any local perturbation, such as an oil spill, will affect numbers of phalaropes far in excess of the population seen in the area at one time. If other sensitive species migrate in this same manner, the same argument will apply to them.

Aerial census flights, ground surveys, and discussions with researchers from ADF&G-RU3/4 (Divoky), allow a few generalizations at this time. Within the Beaufort and Chukchi areas 300 km to either side of Barrow, phalarope densities in August seem to be greatest (1) in the area of Barrow Spit - Plover Islands - Cooper Island, (2) at Peard Bay - Seahorse Islands - Wainwright, (3) possibly at Icy Cape. Probing mudflat sandpipers - dunlins, western and semipalmated sandpipers, long-billed dowitchers - are most dense in August in areas of extensive tidal stream slough mudflats, such as at Lonely, and lagoon tidal saltmarsh-mudflat areas such as Icy Cape. These habitats at Lonely and Icy Cape are also important as staging areas in the migration of Black Brant.

V. Problems

No insurmountable problems were encountered in the field, with the exception, already noted, of the necessary abandonment of our plans to survey at Point Lay. Local government restrictions prohibited this.

The tardiness in transferral of funds by NOAA to the University of California may produce some serious problems. As of August 31, 1976, the date of our last accounting, NOAA still had not transferred $9,000, allocated for research for the period ending September 30, 1976.

VI. Estimate of Funds Expended

Funds expended through August 31, 1976 totaled approximately $42,800.

FINAL REPORT

Contract #03-5-022-56
Research Unit #215
Reporting Period - 1 April 1975
to 30 Sept. 1976
Number of Pages - 36

AVIFAUNAL UTILIZATION OF THE OFFSHORE ISLAND AREA NEAR PRUDHOE BAY, ALASKA

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Marine Sorting Center
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This report was prepared by:

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29 September 1976

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FINAL REPORT

I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

The objective of this study is to document changes in numbers and activity patterns of avifauna over time and space. This study was restricted to a 10.2 km^2 area surrounding Egg Island, Alaska. Mean densities were greatest on 24 June (171 birds/km^2) and on 20 July (148 birds/km^2). These figures correspond to the peaks of spring and summer migration, respectively. Spring migration is concentrated almost entirely at sea. The bay is used increasingly by birds from early July through August. The most numerous birds in the area (Common Eiders, *Somateria mollissima*: King Eiders, *Somateria spectabilis*, and Oldsquaw, *Clangula hyemalis*) are all highly susceptible to oil spills. Common Eiders and, to a lesser extent, King Eiders breed on barrier islands. Oil development on these islands could interfere with nesting. Oil spills during the summer could kill a significant number of birds.

II. INTRODUCTION

A. General nature and scope of study:

This study was designed to provide supplemental data on bird numbers and use of barrier islands, in conjunction with a more intensive study of breeding birds on a single island (Schamel, 1974).

B. Specific objectives:

The main objectives of this study are to document:

1. Seasonal numerical changes
2. Daily and seasonal trends in spatial distribution
3. Diel activity patterns

III. CURRENT STATE OF KNOWLEDGE

Three studies have dealt with bird use of offshore islands along the Beaufort Sea coast (Schmidt, 1970; Divoky *et al.*, 1974; Schamel, 1974). Numbers of eiders using this coast have been estimated at Barrow, Alaska (Thompson and Person, 1963; Johnson, 1971) and in Canada (Barry, 1960, 1968). Flock (1973) used radar to describe the temporal and spatial aspects of spring migration at Barrow and Oliktok, Alaska. Bergman (1974) studied breeding waterbirds on the tundra immediately inland from the site of the present project. Bartels (1973) reported aerial and shipboard surveys along the Beaufort coast. Frame (1973) also reported cruise observations from offshore waters.

IV. STUDY AREA

Census work was conducted within a 1.8 km radius from an observation blind on Egg Island, Alaska (Fig. 1). This distance was the greatest at which birds could be readily identified by spotting scope. The 10.2 km^2 circle was subdivided into three regions: sea (5.3 km^2), island (0.2 km^2), and bay (4.7 km^2).

Egg Island is a barrier islet located at 70° 26' N and 148° 43' W, on the Beaufort Sea coast (Fig. 1). It lies 8 km northwest of Prudhoe Bay and 4 km northeast of the Kuparuk River delta, an area mentioned by Anderson (1913) as supporting large colonies of breeding eiders on sandspits. During a preliminary survey of islands in this area in July 1971, Egg Island was found to have the greatest concentration of nesting eiders.

The island is relatively small (7.5 ha) and flat (maximum elevation: 1.7 m) and is comprised of sand and gravel. Vegetation is extremely sparse,

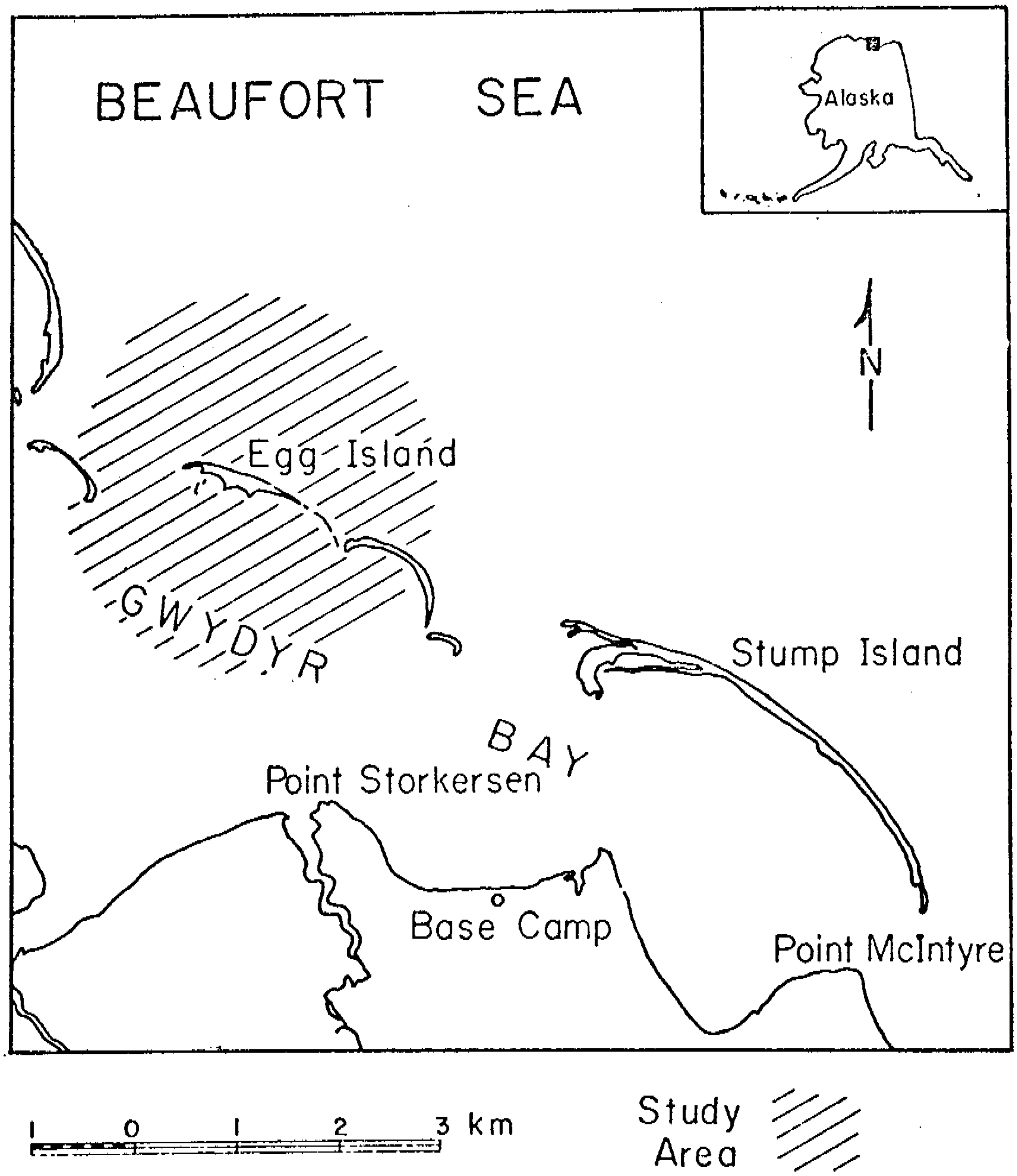

Figure 1. Map of the study area.

both in species and coverage. Only four species were found: *Honckenya peploides* (Sandbeach Sandwort), *Mertensia maritima* (Oysterleaf), *Elymus arenarius mollis* (Lyme Grass), and *Puccinellia phryganodes* (Alkali Grass). Overflow water from the break-up of the Kuparuk River inundates low areas of the island, creating temporary ponds. These are utilized for loafing, bathing, and drinking by eiders and other birds until July, when the ponds disappear.

During the winter and early spring, the island is icebound. After spring break-up the north shore becomes susceptible to the action of waves and ice. The extreme instability of Egg Island was first noted by Leffingwell (1919); erosion washed away his beacon in less than 3 years. Two half-buried oil drums indicated that major changes are still occurring. Although tide fluctuations for this area average 15 cm, changes in wind direction and velocity can cause even greater variations in water level. The influences of wind, ice, and currents constantly rework the island during summer and fall. These probably have the greatest long-range impact on the size and shape of the barrier islands. Fall storms are capable of effecting very rapid and short-term changes (Hume and Schalk, 1967). As storm waters recede, scattered sticks and logs are left behind. This material, important to nesting eiders, is deposited at a higher elevation than the high tide mark of late spring and summer, when storms are rare.

In 1972, overflow waters from the nearby Kuparuk River reached the Gwydyr Bay on 1 June. By 6 June, the overflow was beginning to drain through holes in the ice. The effects of this draining were quite noticeable on 10 June; some previously flooded areas were then dry. On 14 June, draining continued. Meanwhile, the Kuparuk River was cutting a large lead in the bay ice, west of Egg Island. By 16 June the lead had extended eastward, to include the southwest end of the island, and northward into the sea. The entire south shore of the island was ice-free on 20 June and 70% of the bay was ice-free by 28 June.

The Gwydyr Bay is considerably shallower than the corresponding section of the Beaufort Sea. Water depths in the bay section of the study area range from 1 to 2.5 m; at sea, depths range from 2 to 5 m. Water movement between the gravel islands temporarily concentrates invertebrates into this small area. Birds and fish (Arctic char, *Salvelinus alpinus*) are drawn here to feed upon mysids, amphipods and isopods.

In addition to Common Eiders, King Eiders, Arctic Terns (*Sterna paradisaea*), Glaucous Gulls (*Larus hyperboreus*), and Black Brant (*Branta nigricans*) nested on Egg Island.

The prevailing wind comes from the northeast.

V. SOURCES, METHODS, AND RATIONALE OF DATA COLLECTION

This study is based upon information gathered during the summer of 1972. Douglas Schamel and field assistant Dee Prescott were based on Egg Island, Alaska from 20 May through 12 August. Census data were collected from 12 June through 7 August using a 20X spotting scope from an elevated blind. All birds within a 1.8 km radius were identified (when possible) with respect to species, sex, location, and activity and then recorded. Instantaneous activity only was recorded, i.e., prolonged observations of individuals or small groups was avoided. All counts began in the eastern part of the sea and continued counter-clockwise to the west. Birds on the island were then counted, followed by those in the bay (from west to east). The count required two individuals: one observed and dictated while the other recorded the information on data sheets. Eighty-four hours of census data were stored on computer tape.

All references to time are given in Alaska Daylight Time.

VI. RESULTS

Seasonal Trends

The average number of species seen during an observation period increased from 12 June through 17 June (8 to 11 species). This figure then decreased on 18 June (8 species) and remained at this level until 10 July. From 11 July to 7 August, the average number of species dropped from 7 to 3.

Mean numbers peaked on 24 June (1750 individuals, 171 birds/km^2) (Fig. 2). Numbers then dropped to about 500 individuals (49 birds/km^2). From 1 July through 7 August, bird numbers generally fluctuated between 600 (59 birds/km^2) and 1100 (108 birds/km^2) individuals. They showed a general increase over this period (Fig. 2).

Mean bird numbers at sea show a bimodal distribution seasonally. The peaks of 1675 (316 birds/km^2) and 840 (158 birds/km^2) occurred on 24 June and 20 July, respectively (Fig. 3). By August, the number of birds seen at sea dropped to about 200 (38 birds/km^2). Bird numbers on the islands also showed two peaks, one on 9-10 July (113 individuals, 565 birds/km^2) and one on 7 August (119 individuals, 595 birds/km^2) (Fig. 3). Less than 100 birds (21 birds/km^2) were seen in the bay until 5 July (Fig. 3). After this time, numbers increased steadily through early August to about 500 individuals (105 birds/km^2).

Several species occurred in large numbers, at least seasonally, or were ubiquitous in the offshore island area. These include: the Yellow-billed Loon (*Gavia adamsii*), Arctic Loon (*Gavia arctica*), Red-throated Loon (*Gavia stellata*), Common Eider, King Eider, Oldsquaw, Red Phalarope (*Phalaropus fulicarius*), Glaucous Gull and Arctic Tern. With the exception of the loons, these species

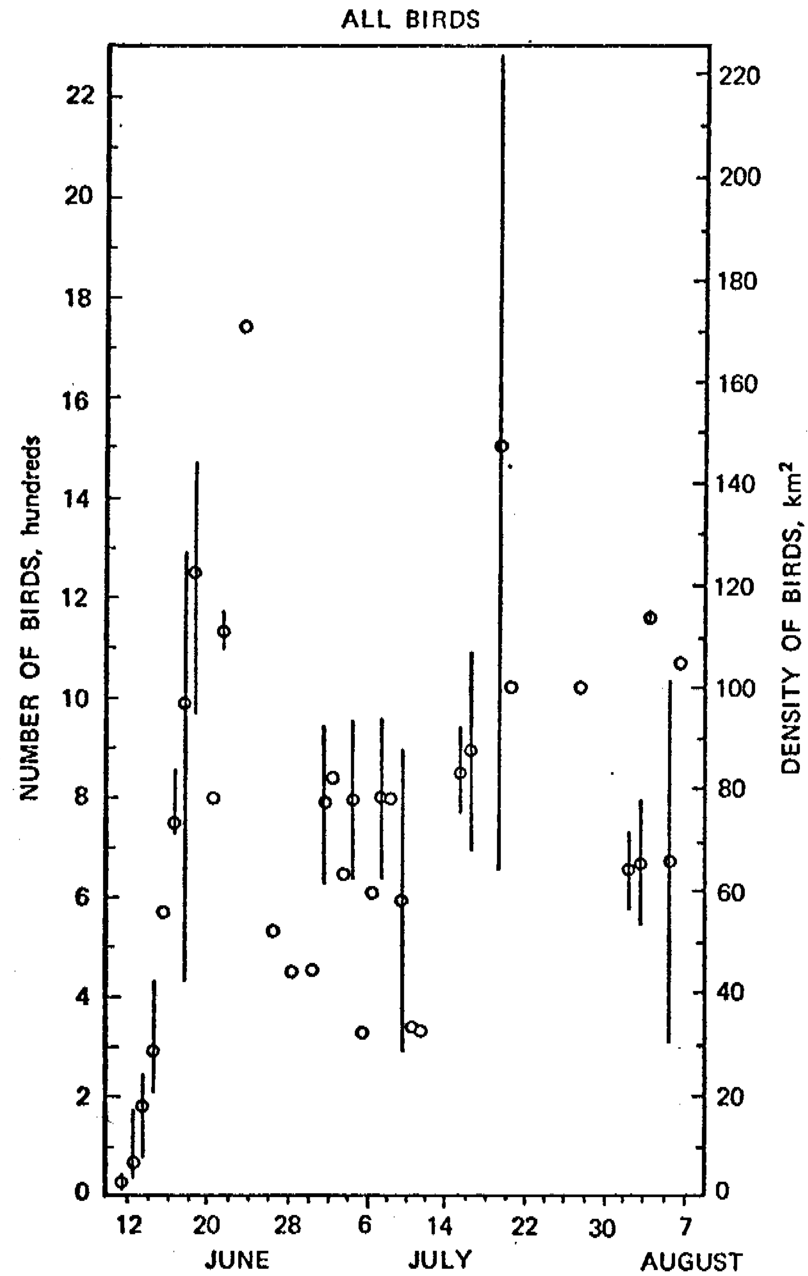

Figure 2. Daily mean values (circle) and ranges (line) of total bird numbers in the study area.

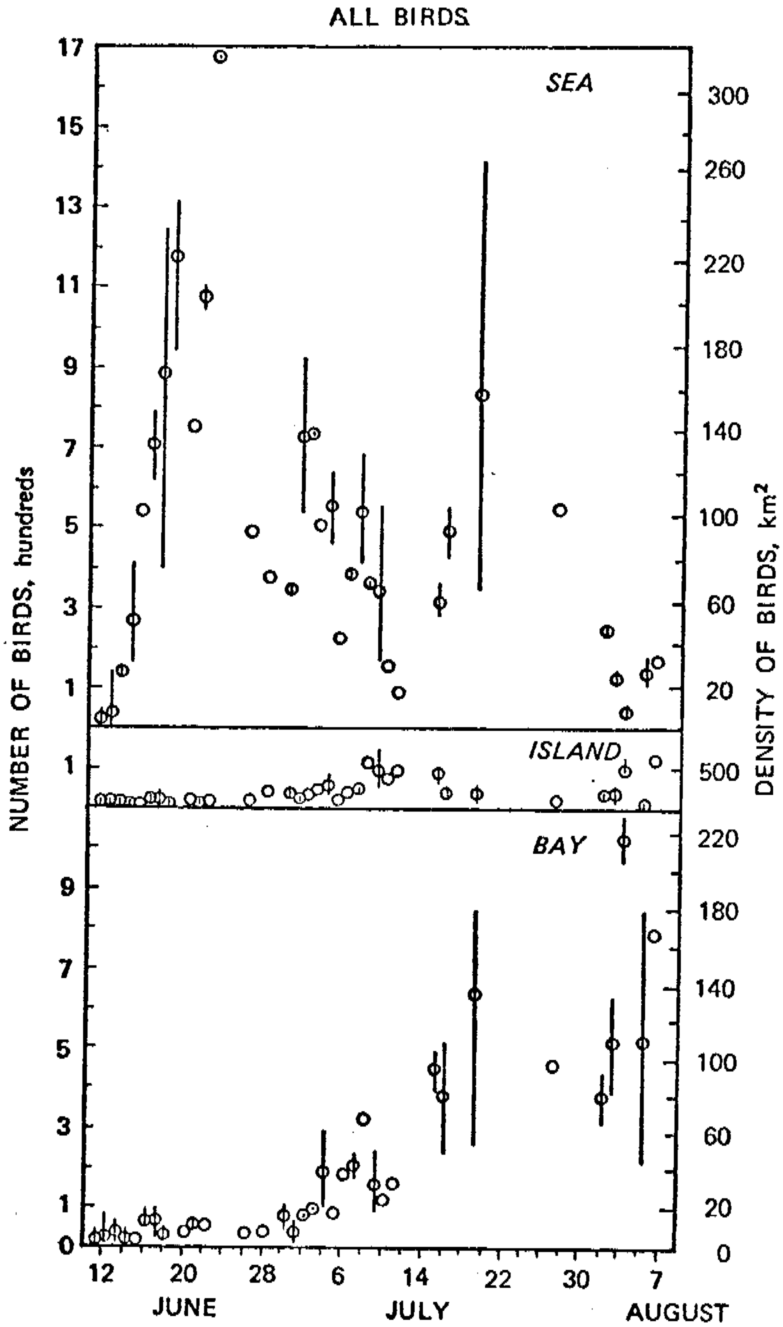

Figure 3. Daily mean values (circle) and ranges (line) of total bird numbers in the study area, by location.

have all been analyzed separately with respect to distribution over space and time. All loons have been combined into a single category, because of difficulties with identification under adverse conditions.

Loon numbers peaked on 16 June (40 individuals, 3.9 birds/km^2) and thereafter decreased steadily (Fig. 4). On 7 August, only one loon was observed in the study area (Fig. 4). Throughout the summer, more loons were found at sea ($\bar{X}$ = 8.3, 1.6 birds/km^2) than in the bay ($\bar{X}$ = 2.6, 0.6 birds/km^2). The heterogeneity chi-square test (Zar, 1974) isolated three blocks of the summer that could justifiably be pooled for normal chi-square analysis: 12 June - 10 July, 11 July - 27 July, and 28 July - 7 August. Significantly more loons used the sea from 12 June through 10 July than the bay (X^2 = 92.2, P < 0.001, N = 23). During the period 11 July through 27 July, both areas received equal use (X^2 = 0.07, 0.90 < P < 0.95, N = 4). More loons were observed in the bay than the sea from 28 July to 7 August, although this relationship was not statistically significant (X^2 = 2.0, 0.10 < P < 0.25, N = 6).

Common and King eiders showed similar trends over both time and space and are considered together. Their numbers rose dramatically, peaking on 18 to 19 June (Common Eider: $\bar{X}$ = 261, 25.7 birds/km^2; King Eider: $\bar{X}$ = 581, 56.7 birds/km^2), then decreased rapidly (Figs. 5 and 6). By 27 June, only 30 Common (2.9 birds/km^2) and 152 King (14.9 birds/km^2) eiders were seen (Figs. 5 and 6). Numbers continued to decrease, though more slowly, throughout the remainder of the season. On 7 August, no birds of either species were seen. The eiders, like the loons, were most numerous at sea. Only a small number (usually less than 20 of each species, 4.2 birds/km^2) were found in the bay (Figs. 5 and 6). Numbers of eiders on the island gradually increased

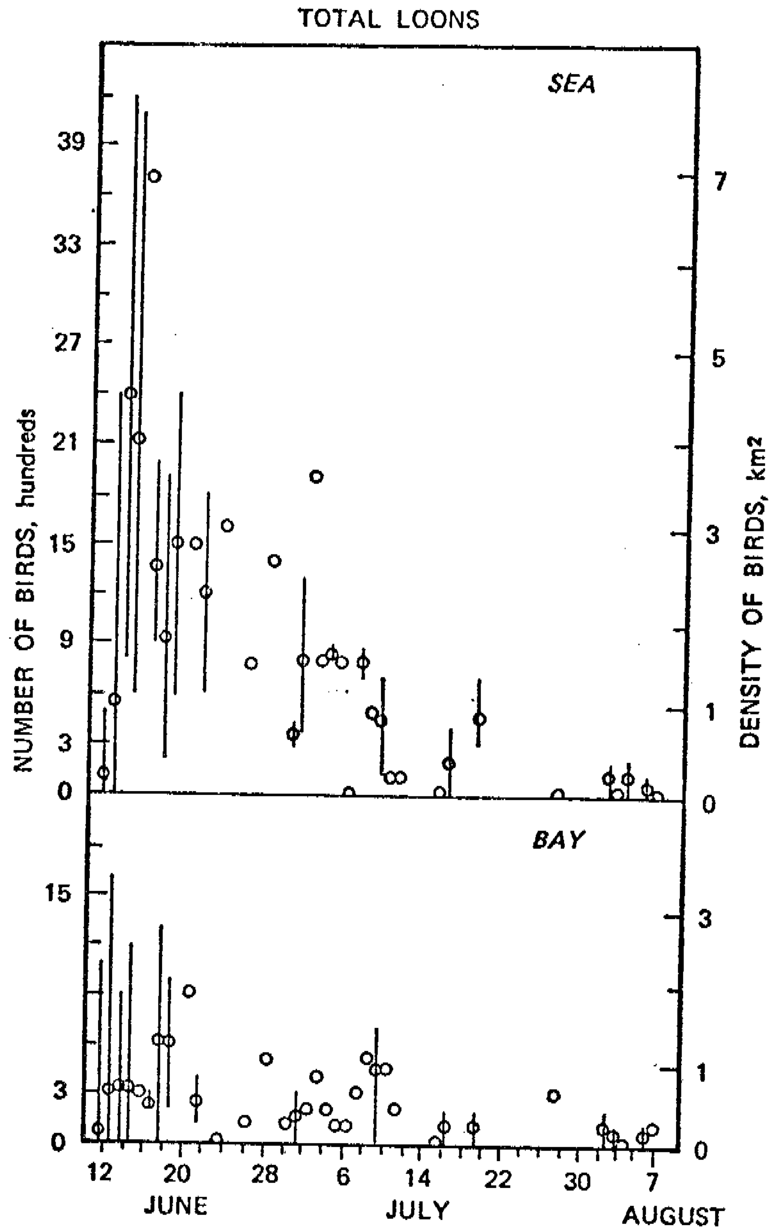

Figure 4. Daily mean values (circle) and ranges (line) of total loon numbers in the study area, by location.

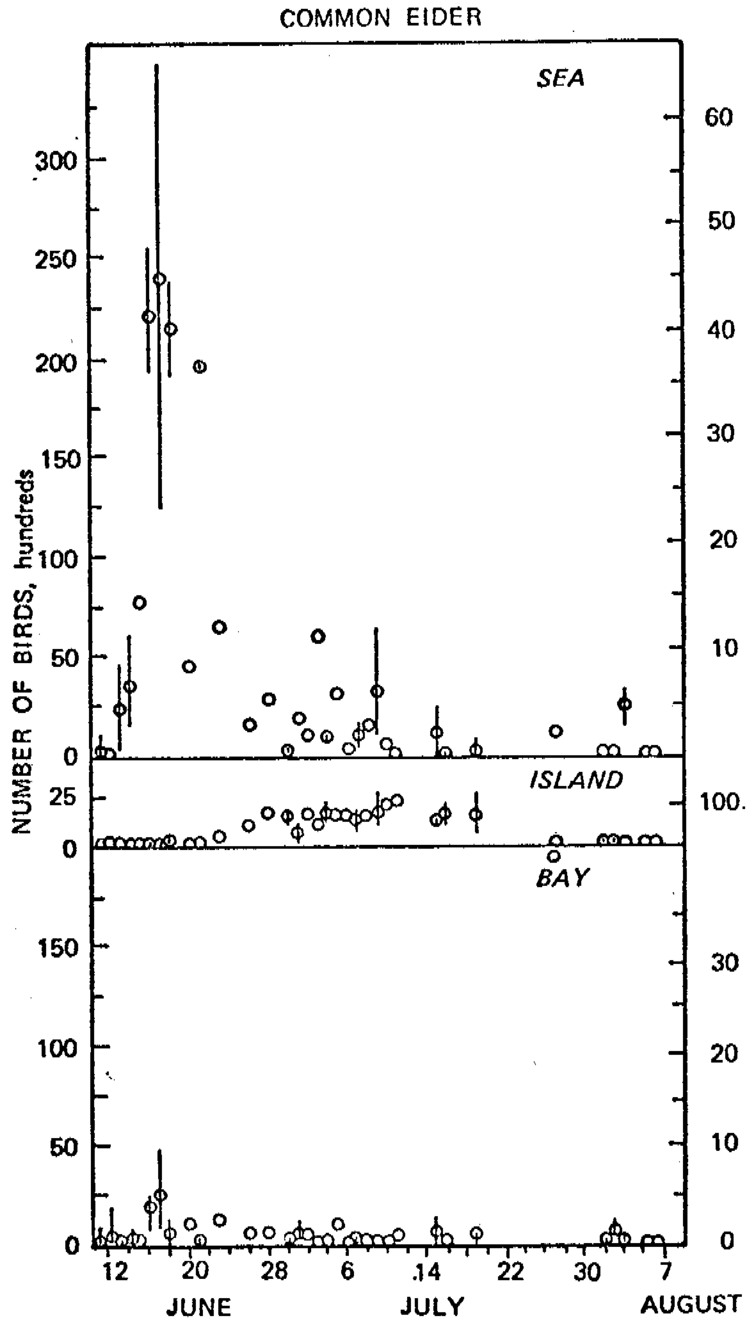

Figure 5. Daily mean values (circle) and ranges (line) of Common Eider numbers in the study area, by location.

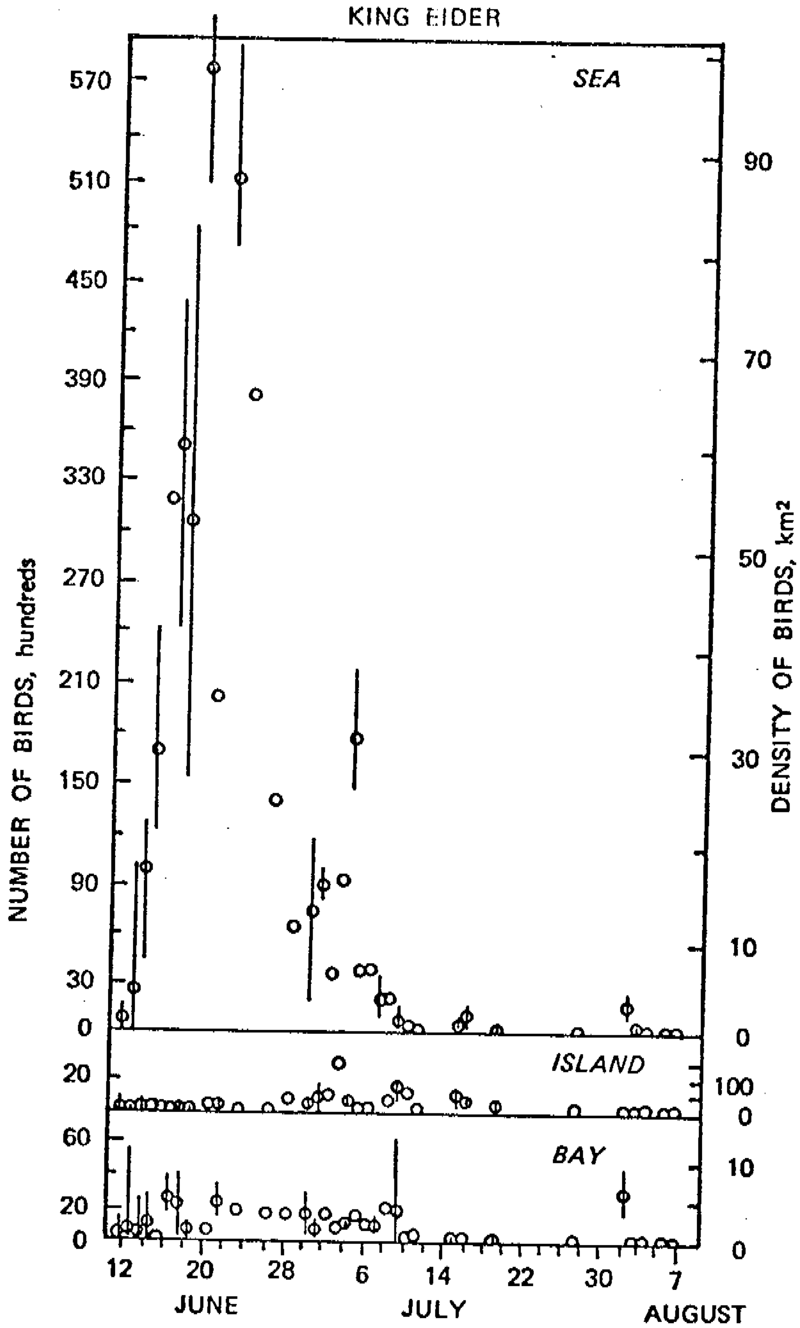

Figure 6. Daily mean values (circle) and ranges (line) of King Eiders numbers in the study area, by location.

through the first week of July, leveled off at about 15 Common (75.0 birds/km^2) and 5 King (25.0 birds/km^2) eiders through mid-July, then decreased to zero by August (Figs. 5 and 6).

Oldsquaw seem to show three separate influxes of birds. The first is a gradual increase from 12 June ($\bar{X}$ = 0.4, 0.04 birds/km^2) to 22 June ($\bar{X}$ = 126.5, 12 birds/km^2) (Fig. 7). The second is a rapid increase from 27 June ($\bar{X}$ = 35, 3 birds/km^2) to 3 July ($\bar{X}$ = 428, 42 birds/km^2), with numbers decreasing to 268 (26 birds/km^2) by 12 July (Fig. 7). The third influx started on 16 July ($\bar{X}$ = 629.7, 62 birds/km^2) and fluctuated at large numbers through 7 August ($\bar{X}$ = 1056.9, 104 birds/km^2) (Fig. 7). Until 1 July, few Oldsquaw were seen anywhere but the sea. After this date, their numbers in the bay grew steadily through 7 August, at which time 778 (166 birds/km^2) were counted here (Fig. 7). Meanwhile, their numbers in the sea fluctuated strongly during July and diminished by 7 August (160 individuals, 30 birds/km^2). The number of Oldsquaw on the island peaked on 10-12 July (ca. 60, 300 birds/km^2) and again in early August (ca. 100, 500 birds/km^2) (Fig. 7).

Spring numbers of Red Phalaropes peaked on 17 to 19 June ($\bar{X}$ = 12 birds, 1.2 birds/km^2) (Fig. 8). Only occasional phalaropes were seen from 20 June until 2 August (Fig. 8). On 4 August, a mean of 93.5 was recorded (9.1 birds/km^2) Numbers again decreased dramatically (Fig. 8). In the spring, most birds were sighted at sea, while in August, more use was made of the bay and island (Fig. 8).

Small shorebirds (*Calidris* sp., probably Semipalmated Sandpipers, *Calidris pusilla*) were observed in very small numbers in mid to late June. Daily averages ranged from 0-3 from 12 to 24 June, except for 17 June ($\bar{X}$ = 6.3, 0.6 birds/km^2). Thereafter, no peeps were seen until 20 July,

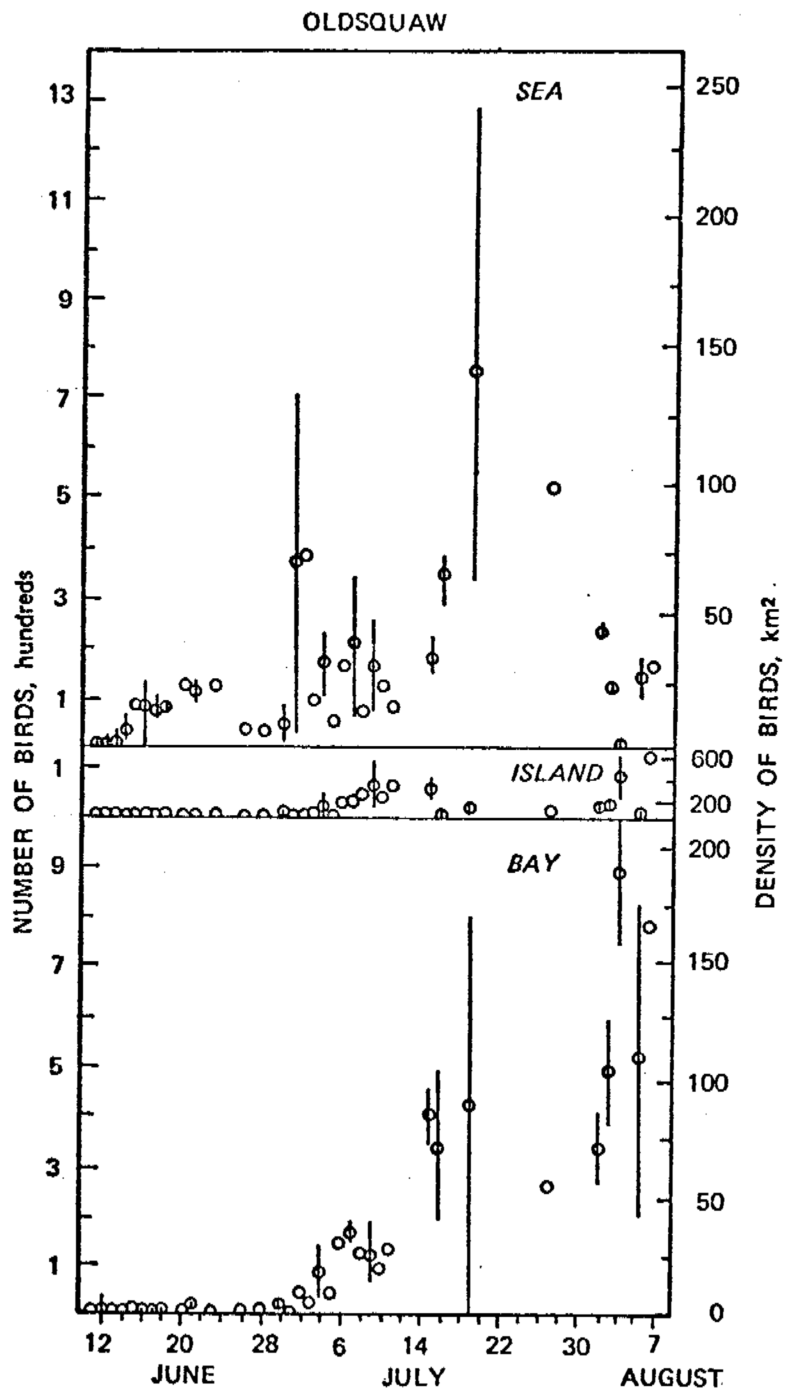

Figure 7. Daily mean values (circle) and ranges (line) of Oldsquaw numbers in the study area, by location.

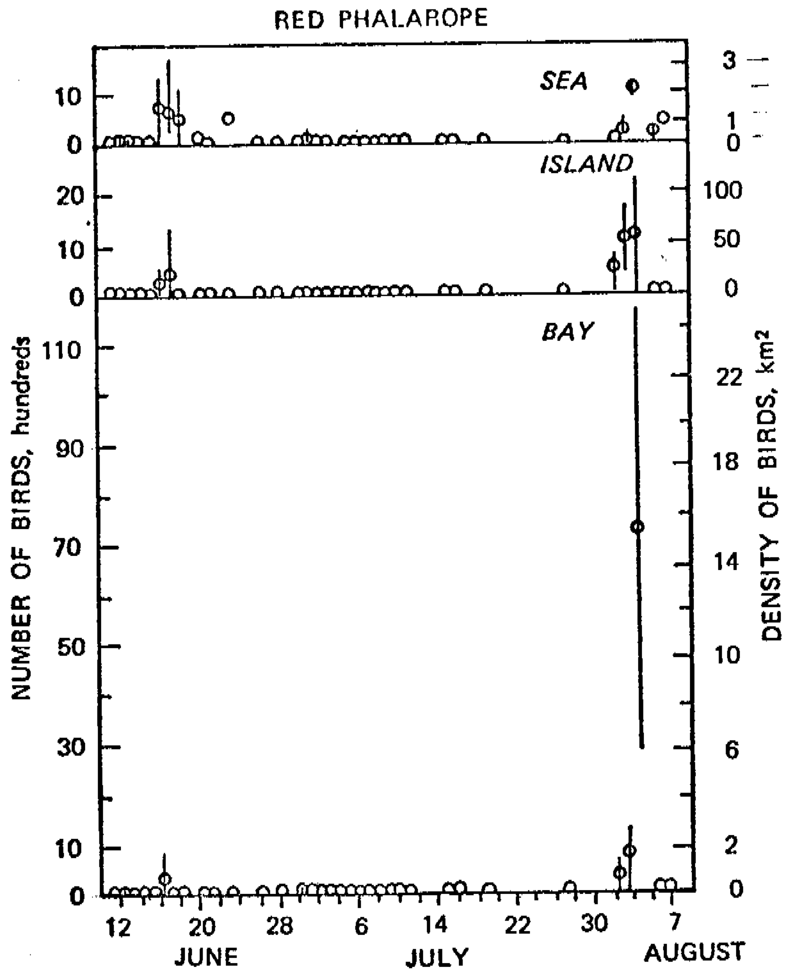

Figure 8. Daily mean values (circle) and ranges (line) of Red Phalarope numbers in the study area, by location.

when two landed briefly on the island and four were sighted flying west over the bay. Similar groups were occasionally seen through the end of the field season.

Mean numbers of Glaucous Gulls in the study area peaked on 19 June ($\bar{X}$ = 41.7, 4.1 birds/km^2) and 8 July ($\bar{X}$ = 57.5, 5.6 birds/km^2) (Fig. 9). Except for the early July peak, there was a general decline in numbers from 19 June through 7 August, when only 3 gulls were observed (0.3 birds/km^2). Until early July, most gulls were found at sea. Thereafter, more gulls were found in the bay than at sea (Fig. 9). Gull numbers on the island fluctuated from 2 to 8 birds until mid-July. After this date, their numbers declined (Fig. 9).

Numbers of Arctic Terns peaked on 17 June ($\bar{X}$ = 13.3, 1.3 birds/km^2) and 2 July ($\bar{X}$ = 13.5, 1.3 birds/km^2). Their numbers were greater on the island than in either the bay or the sea (Fig. 10). Except for the peak in early July, tern numbers declined steadily after 17 June. Very few of these birds were seen after mid-July.

Diel Activity Patterns

Only one species, Oldsquaw, was numerous throughout the summer. For this reason, it was the only species chosen for analysis of activity patterns. Oldsquaw seem to show two major trends. The first is a diel pattern of peak activity between 0800 and 1600 hours (Fig. 11). This pattern persists throughout the summer. The second is a seasonal pattern. Oldsquaw are most active during early summer. After the first of July, they become continually less active, at least through early August (Fig. 11).

"Active" behavior pertains to feeding, flying, displaying, aggression, nest searching, etc. "Inactive" behavior includes sleeping, preening, sitting, etc.

VII. DISCUSSION

Bird Numbers and Distribution

General account

The peak of both numbers of species and individuals in mid-June corresponds to the end of spring migration. During this time, many birds are moving laterally

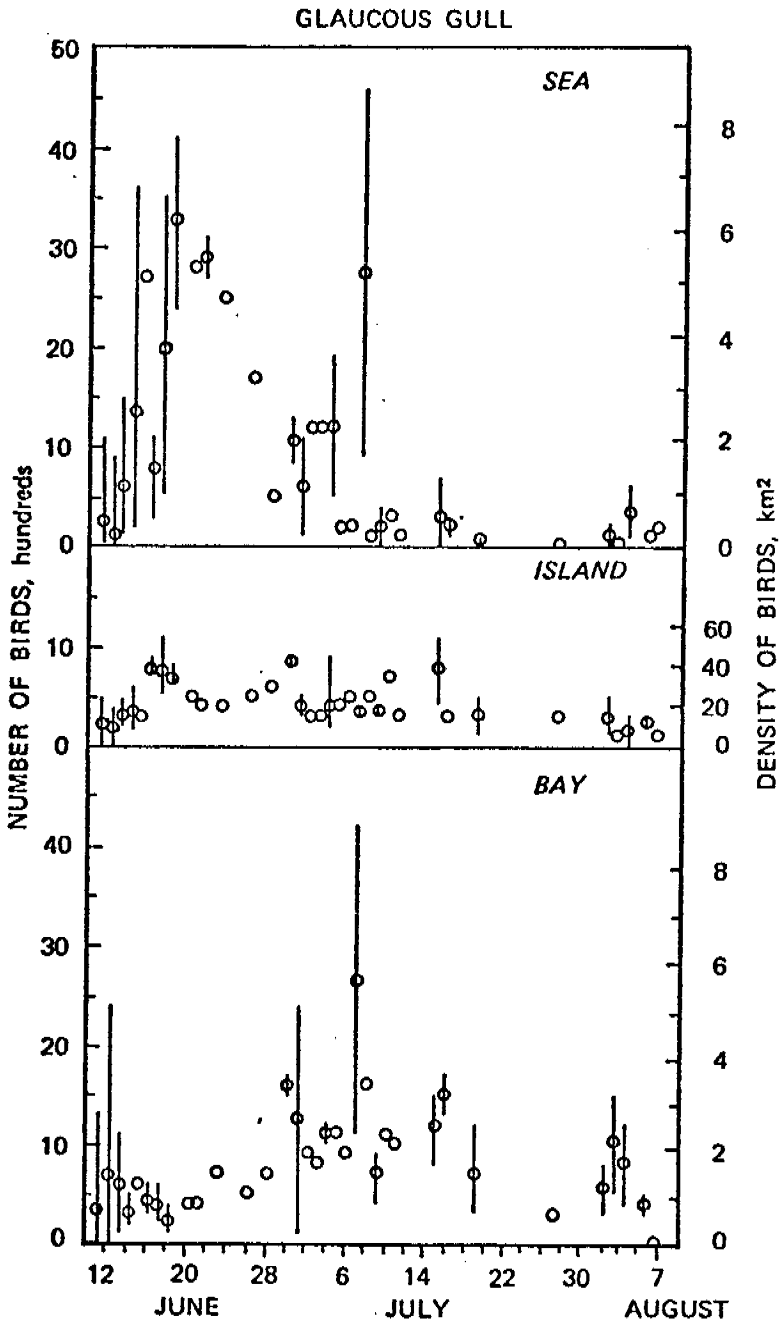

Figure 9. Daily mean values (circle) and ranges (line) of Glaucous Gull numbers in the study area, by location.

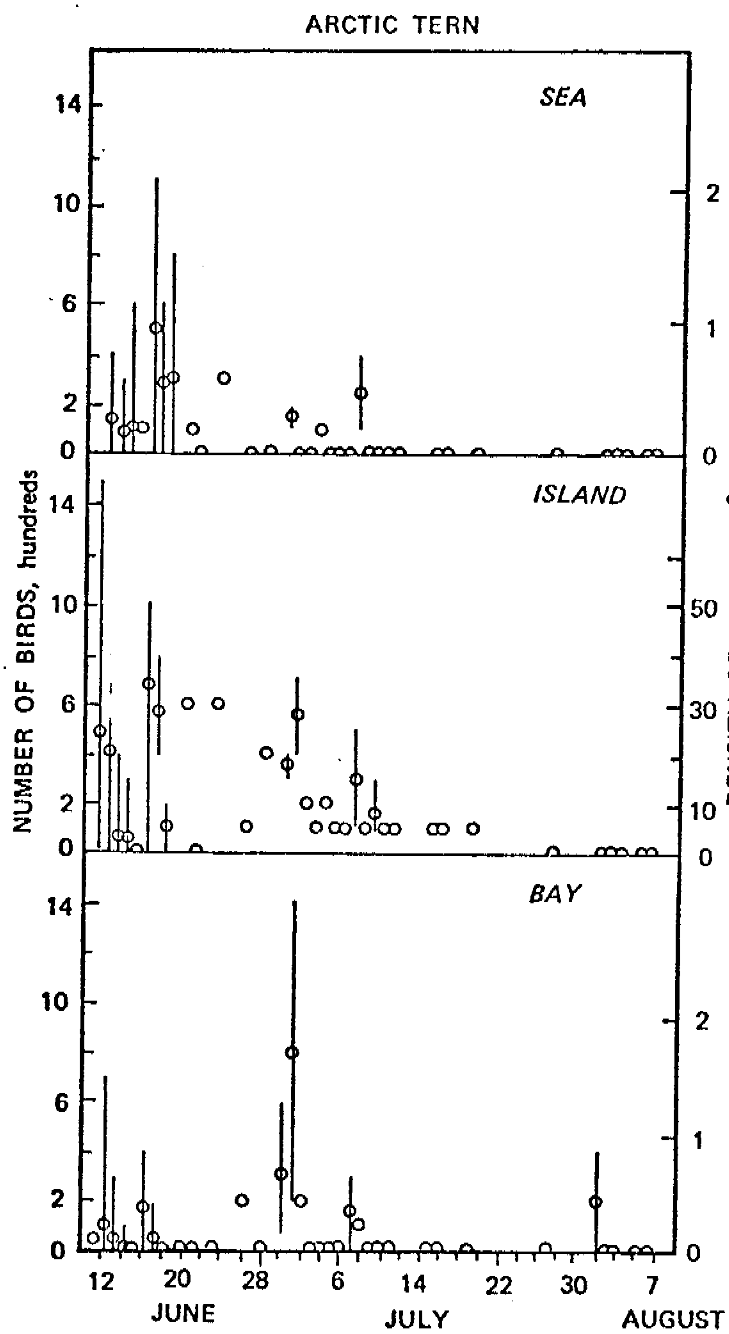

Figure 10. Daily mean values (circle) and ranges (line) of Arctic Tern numbers in the study area, by location.

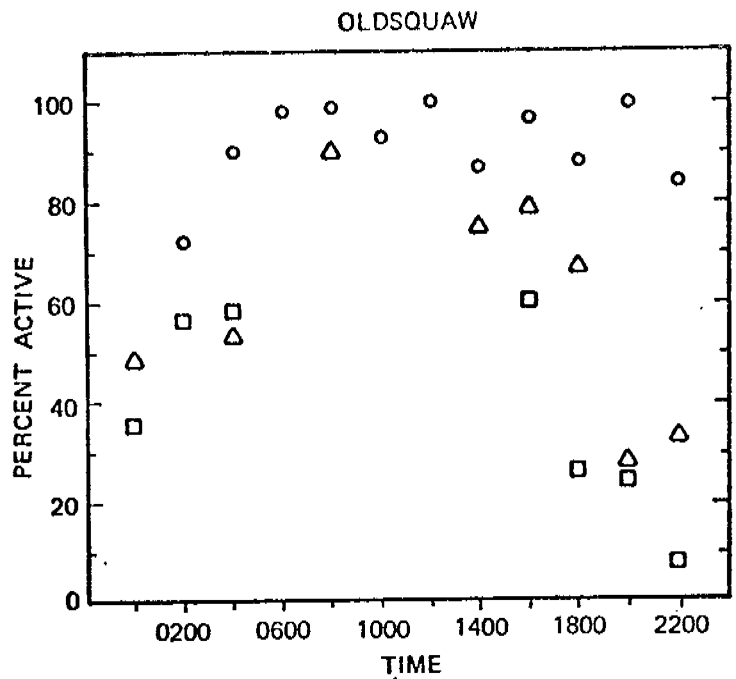

Figure 11. Percent active Oldsquaw in the study area, with respect to time and season. (0 = 12-30 June; Δ = 1-12 July; □ = 16 July through 7 August)

along the coast, primarily from west to east (Flock, 1973). The most numerous of the spring migrants in the study area were Common and King eiders (Figs. 5 and 6). The sharp decrease in total bird numbers in late June is largely due to their passage eastward. The most numerous species in the study area during July and August was the Oldsquaw, whose increasing numbers (Fig. 7) effectively balanced the general attrition of other species (Fig. 2).

Although more open water was available in the bay than in the sea in early June, the vast majority of birds was found at sea (Fig. 3). At least two possible explanations exist. First, it may be related to food availability. In arctic waters, species diversity, numbers and biomass all tend to increase with increased water depth (Ellis and Wilce, 1961; Sparks and Pereyra, 1966; Crane and Cooney, 1973; Feder and Schamel, 1975). The Gwydyr Bay is quite shallow (ca. 2 m), while the corresponding section of the Beaufort Sea is at least twice as deep. During the early June break-up of ice, eiders, loons, and gulls were most concentrated at the seaward edge of the lead. Large isopods, probably *Saduria entomon*, were frequent prey items captured by the ducks. Gulls pirated many of these isopods by diving at surfacing ducks. An alternative explanation to bird distribution at this time is that the migratory pathways of the birds may make feeding and resting at sea more convenient than the use of the bay. At Oliktok, approximately 30 km west of the study area, Flock (1973) recorded many birds migrating at sea during early June 1972. However, his radar also detected numerous birds moving over land. Unfortunately, radar blips cannot be identified by species.

The peaks of bird numbers on the islands in mid-July and early August (Fig. 3) correspond to: 1) the peak of the incubation period by eiders, and 2) molting Oldsquaw resting on the island, respectively. The number of birds using the island in mid-July is greater than the numbers of incubating birds. This is due to the presence of immature or failed breeding female eiders.

The steady rise of bird numbers inside the barrier islands (Fig. 3) is due to an influx of Oldsquaw (Fig. 7). According to Bergman (1974), most of the male Oldsquaw move to the coast from inland breeding areas by 14 to 21 July. By late July, most of these birds are molting. During this time, they are closely associated with barrier islands. They feed on both the seaward and bay sides of these islands, as well as in the tidally-affected shallows between islands. They rest and preen primarily on the leeward (bay) side, both in the sheltered shallows and on the islands.

Specific accounts

Loons - Loon numbers vary over time and space. Their occurrence in large numbers near Egg Island during mid-June (Fig. 4) may be due to two factors: 1) limited open water and, therefore, limited feeding areas, and 2) spring migrants. Inland from my study site, the ponds were not available to loons until about 20 June (Howard, 1974). Even then, inland food resources for loons were lacking. As more water became available inland and offshore, loons became more dispersed. Nesting at inland ponds began in late June. Although loons continued to feed offshore after ponds thawed and incubation began, their numbers offshore diminished continually. Howard (1974) noted that Arctic Loons fed extensively in inland lakes, while Red-throated Loons apparently fed only in salt water.

Feeding areas near the islands varied seasonally. Until mid-June, loons fed primarily at sea. From mid to late July, loons fed in equal numbers in both the sea and the bay. After that time, more loons fed in the bay than the sea. These differences may relate to changes 1) in diet, 2) in distribution of prey, or 3) in the breeding cycle (the birds may have been trying to minimize time spent away from the young). Late July is the time when the young are hatching (Bergman, 1974). Inland lakes are rich with invertebrates at this time and these organisms are readily eaten by Arctic Loons (Bergman, 1974). Thus, the dwindling number of loons in the island area may be due to parental duties and vast food resources inland and closer to the coast, making long trips to salt water prohibitive and unnecessary.

The daily variability of loon numbers is partly due to diel patterns. Loons were most numerous in the island area from 0800 to 1600 hours and least numerous from 2000 to 0200 hours. During late night and early morning hours, loons are found on inland lakes and ponds (personal observations).

Common and King eiders - The movement of Common and King eiders to breeding grounds further east ended by late June and early July. Almost all migrants were found at sea; few used the bay. The ratio of King to Common eiders during spring migration was approximately 2 to 1. At the eider pass at Point Barrow, Johnson (1971) estimated the ratio of King to Common eiders during fall migration as 19 to 1. Barry's (1968) estimates of the Beaufort Sea eider population are similar to Johnson's. The ten-fold difference between my ratio and that of other observers is certainly real. The two duck species are readily distinguishable by the color of their backs. Common Eiders have white backs; King Eiders have black. Even in bad weather, these differences are distinct. King Eiders may migrate earlier in the spring or may travel further out at sea. They may follow a more direct route to their Canadian breeding grounds, instead of flying along the undulating coastline. Probably 90% of the Beaufort Sea King Eiders breed in Canada, primarily on Victoria Island (Barry, 1960). Common Eiders are more numerous from Banks Island westward. Unfortunately, very little is known about the spring eider migration.

The rise in eider numbers on the island in late June through mid-July represents nest-searching pairs, nesting females and failed breeding or immature females. The breeding biology of these birds is reported by Schamel (1974).

Unlike spring migration, summer migration did not bring large numbers of eiders to the area for resting or feeding. This fact is shown in Figures 5 and 6. The first westward migrants were noted in early July. Two main factors may account for the dispersion of eiders during summer migration. First, the migration extends over a longer period of time. Summer migration lasts for two and a half or three months, whereas spring migration may only last for about one and a half or two months. Males are the first to head westward, in late June or early July through late July and early August. They are often joined by failed breeding females. Females and young migrate in September. The second factor affecting dispersal is open water availability. In spring, open water is limited and birds must congregate in whatever leads are available. In summer, however, water is almost unlimited near shore and the birds are able to disperse. Bartels (1973) flew aerial surveys and made shipboard observations from Barrow to the Sagavanirktok River delta (just east of the study area) from mid-August through mid-September, 1971. He found the largest concentration of eiders 13 to 16 km from shore. Within 8 km of shore, the mean eider density was 1.6 birds/km^2. The highest concentration of eiders he reported was 4.1 birds/km^2. At the peak of spring migration, a mean of approximately 120 birds/km^2 was found in the study area. These birds were 30 times as concentrated as Bartels' most dense area.

Oldsquaw - These birds appear to have three separate numerical influxes. The first, from 12 to 22 June probably corresponds to spring migration. The second increase, 27 June to 3 July, may be a composite influx of males from inland nesting areas, as well as arriving different age-class birds. The last influx, starting on 16 July, probably represents most of the males and failed breeders from inland, as suggested by Bergman (1974). These birds begin molting in mid to late July. During this time, large flocks of Oldsquaw could sometimes be seen in the sea and bay. Movements of these flocks in and out of the study area contributed to the tremendous variation of Oldsquaw numbers on 20 July. It is possible that these birds stage a molt migration to the nearshore Prudhoe waters from other areas along the coast. Unfortunately, quantitative information from other areas is lacking. Schmidt (1970) estimated 6,000 Oldsquaw used a bay near Nuvagapak Point, Alaska, near the Canadian border. Lateral movement along the islands is the probable explanation for numerical variation in the study area in August.

Bartels (1973) found Oldsquaw to be concentrated in an area from 3 to 8 km from shore. The mean density of these birds was $173/km^2$, which correlates almost exactly with the early August densities in this study.

Red Phalarope - Red Phalaropes are shorebirds that spend the non-breeding season at sea. It is not too surprising, then, that these birds were first sighted at Egg Island, rather than at the coastal base camp. June migrants were flying towards the coast from the sea. The peak of phalarope numbers in June came just as nest initiation began inland (Bergman, 1974). These birds probably mark the end of spring migration. The small number of phalaropes seen in late June corresponds to the departure of females from the breeding grounds. In early August, young phalaropes fly to the coast, where they congregate in nearshore waters. They are also found at least 80 km out to sea at this time (Frame, 1973). Although it is not known how long phalaropes remain in the Prudhoe area, I suspect they are present until at least the first part of September.

Small shorebirds - Semipalmated Sandpipers are coastal migrants during both spring and fall. Since barrier islands are not choice feeding areas for these birds, their presence in very small numbers can best be attributed to local wandering during migration. I suspect that they are more common along the mainland coast, particularly at river deltas and mudflats.

Glaucous Gull - These birds were present on the island from our arrival to our departure. The peak of gull numbers in the study area in late June was probably not correlated with incoming birds. Rather, this peak corresponds to the fact that the only open water was within or near the study area boundaries. Gulls had begun establishing territories and constructing nest sites in early June. It is doubtful that many gulls would still be migrating to the breeding areas in mid to late June. The peak of gull numbers in early July may correspond to birds that had failed in nesting attempts and were leaving the breeding grounds. The steady decline in gull numbers through 7 August suggests that these birds were rapidly vacating these nearshore waters, probably for the winter. These data complement those of Frame (1973), who saw few Glaucous Gulls in the offshore waters during early August.

Arctic Tern - We first noted Arctic Terns on 2 June. By 8 June, some were displaying and forming nest depressions on the island. The peak of tern numbers in mid-June probably corresponds primarily to the limited open water and, to a lesser extent, the end of spring migration. At this time, numerous terns were establishing territories on the island and feeding in nearby waters, mostly at sea. After the first of July, most terns abandoned attempts to nest and quickly departed from the study area.

Part of the wide range in tern numbers daily can be attributed to diel patterns. These birds were most numerous in the area from 2200 to 0600 hours. During mid-day (1000 to 1200) a mean number of less than one bird was seen. Terns are visual hunters and require good lighting for successful hunts. They apparently spend the brightest part of the day hunting away from the island colonies, returning at night.

Frame (1973) did not encounter terns in the offshore waters in early August. It is likely that their departure from the island area in mid-July marked the begining of migration from the Beaufort Sea.

Diel Activity Patterns

The trend of intense mid-day activity and late night/early morning roosting displayed by Oldsquaw (Fig. 11) seems to be the basic pattern for most of the birds using the nearshore waters. Birds that feed in these waters but breed inland (loons) are present during full daylight but head inland to breeding lakes during the low light night hours. Those birds that feed in nearshore waters and breed on barrier islands (eiders and terns) often disperse during the day and return to the islands at night to search for nest sites, set up territories or rest.

The decreasing activity of Oldsquaw seasonally probably corresponds to physiological and phenological changes. During mid to late June, Oldsquaw are still arriving on the breeding grounds. Males are displaying for or defending mates. Females are storing energy for egg production. By early July, much of the breeding activity has subsided, particularly at barrier islands. By late July, the birds are molting. The decreasing daylight throughout this period complements the physiological change. The loss of light should reduce feeding attempts during the night hours. Figure 11 shows that less than 50% of the Oldsquaw were active in July and early August from 1800 to 2400 hours. In June, activity levels never fell below 70% (Fig. 11).

Comparison of Inland and Nearshore Bird Densities

Inland and nearshore bird densities are compared in Table 1. Inland data come from Bergman's (1974) transects. This comparison provides an insight into migration pathways and habitat use. Sea ducks (eiders, oldsquaw, and scoters, *Melanitta* sp.) are more concentrated in nearshore waters in June than inland. This corresponds to spring migration at sea and limited feeding

Table 1. A comparison of inland and nearshore bird densities near Prudhoe Bay, Alaska.

Species	No. per km^2			
	June		August	
	Inland[a]	Nearshore[b]	Inland[a]	Nearshore[b]
All loons	3.2	3.9	3.6	0.2
Whistling Swan	0.1	-	0.4	-
Canada Goose	-	-[c]	-	-
Black Brant	5.1	52.4	-	-
White-fronted Goose	1.6	-	8.6	-
Pintail	7.8	-[d]	21.1	-
Greater Scaup	-	0.1	-	-
Common Eider	-	25.6	-	2.5
King Eider	4.3	57.3	1.2	4.4
Spectacled Eider	0.8	-[d]	0.4	-
Oldsquaw	5.1	12.4	9.0	103.5
White-winged Scoter	-	0.2	-	-
Surf Scoter	-	<0.1	-	0.2
Red-breasted Merganser	-	0.1	-	-
Golden Plover	1.6	0.2	5.9	-
Black-bellied Plover	0.4	-	2.3	-
Ruddy Turnstone	0.4	<0.1	0.4	0.3
Buff-breasted Sandpiper	10.0	-	1.0	-
Pectoral Sandpiper	22.0	-	37.0	-
Dunlin	16.0	-	15.0	-[d]
Baird's Sandpiper	4.0	-	5.0	-
Semipalmated Sandpiper	20.0	<0.1	10.0	0.4
Red Phalarope	37.0	1.0	37.0	9.2
Northern Phalarope	2.0	-	3.0	-
Parasitic Jaeger	0.4	0.2	0.8	-
Pomarine Jaeger	-	0.2	-	-
Long-tailed Jaeger	0.4	<0.1	0.4	-
Glaucous Gull	0.2	4.1	0.3	1.3
Sabine's Gull	-	0.3	-	-

Table 1. Continued

Species	No. per km^2 June Inland[a]	June Nearshore[b]	August Inland[a]	August Nearshore[b]
Arctic Tern	-	1.3	-	0.2
Thick-billed Murre	-	-[c]	-	-
Black Guillemot	-	-[c]	-	-
Snowy Owl	-	<0.1	-	-
Unknown Redpoll	-	<0.1	-	-
Lapland Longspur	25.0	-	5.0	-
Snow Bunting	3.0	-[e]	5.0	-

[a]High densities from Bergman's (1974) transects.

[b]Highest mean daily densities from this study.

[c]Species seen in small numbers only during July.

[d]Species seen in area but not during census.

[e]Species seen in small numbers only during May.

areas. Black Brant, which migrate at sea, were 10 times more concentrated near the barrier islands than inland during June. Pintails (*Anas acuta*), Whistling Swans (*Olor columbianus*) and White-fronted Geese (*Anser albifrons*) all breed inland and do not use the sea as a major migration route. Buff-breasted (*Tryngites subruficollis*), Baird's (*Calidris bairdii*) and Pectoral Sandpipers (*Calidris melanotos*), as well as Northern Phalaropes (*Phalaropus lobatus*) are inland migrants in spring. Plovers (*Pluvialis* sp.), Ruddy Turnstones (*Arenaria interpres*), Dunlins (*Calidris alpina*), Semipalmated Sandpipers (*Calidris pusilla*) and Red Phalaropes reach the northern breeding grounds by a coastal route. The high density of shorebirds in Bergman's transects reflects primarily breeding birds. The nearshore densities represent migrants only. Pomarine Jaegers (*Stercorarius pomarinus*) were rarely seen because their main prey item, lemmings, were at a low. Parasitic and Long-tailed Jaegers (*Stercorarius parasiticus* and *S. longicaudus*), bird and insect predators, nested on the tundra. Jaegers were seldom seen in the nearshore area, except during spring migration. Glaucous Gulls did not nest inland and were common there only at caribou (*Rangifer tarandus*) carcasses. Sabine's Gulls (*Xema sabini*) and Arctic Terns were not seen inland. In the nearshore waters, Sabine's Gulls were seen only during spring migration. Terns fed near the barrier islands and attempted to nest there. Thick-billed Murres (*Uria lomvia*) and Black Guillemots (*Cepphus grylle*) were seen only near the islands and only in July. The murres probably were early migrants from the Cape Perry colony in Canada (Barry, 1960). Guillemots breed on some of the barrier islands west of the Colville River (Divoky *et al.*, 1974). Lapland Longspurs (*Calcarius lapponicus*) and Snow Buntings (*Plectrophenax nivalis*) breed and, for the most part, migrate inland.

VIII. CONCLUSIONS

Birds were present in the study area from our arrival on 20 May through our departure on 12 August. Thompson and Person (1963) and Johnson (1971) recorded eider migration past Point Barrow through early September. Birds probably commonly occur in the study area from early May through late September.

Numerically, Common and King eiders and Oldsquaws were the predominant species in the study area. Eiders were most numerous during June and early July. They used primarily the sea for feeding and resting. Oldsquaw numbers increased steadily after 1 July. Until late July, these birds were about equally abundant in both the sea and bay. In August, they were more numerous in the bay.

During spring migration, limited open water concentrates large numbers of birds into small areas. Along this section of coast, rivers provide the first open water, usually about 1 June. By 1 July, much of the sea and bay has open water.

Human presence on breeding islands during the nest initiation and early incubation periods of eiders (mid-June through late July) can cause excessive predation by gulls or desertion. Low aircraft overflights can also flush eiders from nests during this critical period and cause predation of eggs. During late incubation, eiders are less likely to desert.

IX. MANAGEMENT RECOMMENDATIONS

It would be best if all oil-related activities on or near barrier islands ceased from 1 May through 30 September. Human activity during June and July could damage eider production. Intensive activity or oil spills during August and September could damage the molting Oldsquaw population. The river deltas should be strictly protected from oil development. During spring migration large numbers of birds congregate near the deltas, where water is available. Barry's (1960) surveys suggest that 900,000 King Eiders migrate past coastal Prudhoe Bay annually. An oil spill in May or June could kill a large percentage of these birds.

X. NEEDS FOR FURTHER STUDY

This study establishes the numerical distribution of birds over space and time. No effort was made to determine why this distribution exists. This should be examined. Such a study would require extensive and intensive sampling of prey items (invertebrate and fishes) to correlate with bird observations.

The present study is limited to a single, very small, area. Comparative quantitative information from other areas along the coast is completely lacking. Additional census sites may prove valuable, even if data were limited in scope to seasonal counts (instead of daily or weekly).

Examination of the data has located many important questions. In terms of total bird numbers, King Eiders are very important migrants. However, we do not know much about their temporal or spatial relations during migration. Bartels (1973) estimated that nearly 400,000 post-breeding Oldsquaw are found in the nearshore waters from Barrow to the Canadian border. What we do not know is how these birds are distributed along the coast. Choice molting areas may exist which need special protection. Loons disappeared from the study area by early August. They were still caring for young inland at this time. Do they feed heavily at inland sites or are they feeding in other salt water areas? We do not know. River delta areas are a likely feeding locale for Red-throated Loons at this time. However, we do not know where they are going. Finally, one wonders just how much disturbance birds can withstand before breeding, resting, feeding or molting areas are deserted.

XI. ACKNOWLEDGEMENTS

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APPENDIX A

Schedule of observation periods on Egg Island, Alaska, 1972.

Date	Time Coverage	No. Observation Periods	
June 12	1630 - 2400	10	
13	1300 - 2400	17	
14	0800 - 1600	8	
15	0800 - 1600	8	
16	1400 - 1600	1	
17	0000 - 0600	3	
18	0300 - 0500	1	
	0600 - 0800	1	
	1600 - 2100	2	5
	2200 - 2400	1	
19	1600 - 2400	3	
20	-	-	
21	1600 - 1800	1	
22	1100 - 1500	2	
23	-	-	
24	1630 - 1745	1	
25, 26	-	-	
27	1630 - 1745	1	
28	-	-	
29	1600 - 1700	1	
30	-	-	
July 1	0300 - 0400	1	2
	0800 - 0900	1	
2	0000 - 0100	1	2
	1630 - 1730	1	
3	1545 - 1645	1	
4	1600 - 1700	1	
5	0800 - 0900	1	2
	1600 - 1700	1	
6	1600 - 1700	1	
7	2330 - 0030	1	
8	0400 - 0500	1	2
	0700 - 0800	1	
9	0000 - 0100	1	
10	1600 - 2300	4	
11	1400 - 1500	1	
12	1400 - 1500	1	
13-15	-	-	
16	0000 - 0500	3	
17	0000 - 0100	1	2
	1600 - 1700	1	
18-19	-	-	
20	1600 - 2100	3	
21-27	-	-	
28	1600 - 1700	1	
29-31	-	-	

APPENDIX A (Continued)

Date	Time Coverage	No. Observation Periods
August 1	-	-
2	1800 - 2100	2
3	2000 - 2300	2
4	2000 - 2300	2
5	-	-
6	1600 - 1900	2
7	2000 - 2100	1

TO: NOAA Environmental Research Laboratories, Boulder, Colorado; OCSEA Project Offices, Juneau and Fairbanks, Alaska.

FROM: Principal investigator, William H. Drury
Organization: College of the Atlantic
Eden Street
Bar Harbor, Maine 04609

SUBJECT: Six months report on fieldwork for 1976
Contract 03-5-022-77 Tasks #237 & #238
Period: 15 May 1976 - 1 October 1976

TITLE: Birds of Coastal Habitat on the South Shore of Seward Peninsula, Alaska.

I. Task Objectives

A. Studies of populations, community structure and ecology of Marine birds at Bluff Cliffs and Sledge Island.

1. To determine the number and distribution of each species relative to other species, to periods of the breeding season, and to characteristics of available habitat within the colony or study area.
2. To provide estimates of nesting success of principal species.
3. To establish and describe sampling areas which may be utilized in subsequent years or by other persons for monitoring the status of populations.
4. To determine the amount and kinds of foods utilized by the principal species, and to describe daily foraging patterns, when possible to determine the relationship of food selected to that available.
5. To describe the chronology and phenology of events in the biology of breeding birds, including changes in population from the beginning of site occupation in the spring through departure in the fall.
6. To provide comparison of current data with recent historical data.

B. Survey of the use of Coastal habitats by waterfowl and shorebirds.

1. To determine the number and distribution of principal species at spring arrival, during breeding season and in fall gatherings, as there are related to characteristics of available habitat within the area.
2. To provide estimates of production or nesting success of principal species for which estimates can be made from the air.
3. To establish and describe sampling areas which may be used in later years or by others for monitoring the status of populations.
4. To describe the chronology and phenology of events in the use of coastal habitats by waterfowl: changes in populations from arrival in spring through departure in fall.

5. To provide a comparison of current data with recent historical data.

II. Field Activities - Bluff-Sledge & Coastal Waterfowl

A. Field Schedule

May 27- party arrived Nome

May 29 to June 4 - air survey of shoreline, lagoons, and sea ice;preliminary visits to Bluff Cliffs.

June 4 - party established at Bluff Cliffs continues on the site until late September; visits to study sites every other day until late September.

Coastal survey to intermediate stops between Nome and Rocky Point: June (2), July (4), August (2);

On foot surveys of coastal lagoons June (2), July (3);

Censuses of Bird Cliffs Bluff June (5), July (5)
Topkok,June (1)
Rocky Point,July (1), August (1)
Square Rock,June (2), July (1), August (1)
Cape Darby,August (1)
Cape Denbigh,August (1)
Egg Island,August (1)

Collections of food samples,June (1),July (4)

Air surveys of coastal areas,June (3), August (3) September (2)

Air surveys of sea,June (1), August (1), Sept (1)

July 14 - 19 - surface surveys of coastal tundra and safety lagoon

July 21 - August 3 - party to Sledge
Surveys of Bird Cliffs (3)
Transect south (1)

August 5 - party on board OSS Surveyor
Ship transects of Norton Sound, small boat surveys and censuses of Bird Cliffs
Air surveys of coastal areas and near shore

August 14 - party disembarked from OSS Surveyor

August 20 - 24 - test of effects of overflights on cliffs, air survey and photography of bird cliffs in Norton Sound. Surface surveys of Safety Sound.

September - party at Bluff,details not yet available.

B. Scientific Party

William Drury, Principal Investigator, present 27 May - 26 August

John French, party leader at Bluff, undergraduate, the University of Wisconsin, present 4 June - 20 August.

Benjamin Steele, party leader, graduated Harvard College, present 27 May - mid October.

Robert Crawford, field assistant, undergraduate the Evergreen State College, present 3 June - 27 August.

John Drury, field assistant, undergraduate the Lincoln-Sudbury Regional High School, present 8 June - 25 August.

Mary Drury, field assistant, graduated Vassar College, present 30 June - 10 September.

Peter Drury, field assistant, undergraduate the Evergreen State College, present 3 June - mid October.

Catherine Ramsdell, field assistant, undergraduate College of the Atlantic, present 8 June - 27 August.

C. Methods

1. a) Surveys

Air reconnaissances was made of the perimeter in Norton Sound and transects over the sea in Norton Sound. We made reconnaissance surveys of coastal habitats using the OSS Surveyor's helicopter and using fixed wing aircraft. Surface surveys and censuses were made of most seabird nesting areas in the area.

b) Transects while travelling

Most travel during the field season of 1976 was by air. During this travel we made observations of the waterfowl in wetlands we passed over.

We made a few transects by small boat (14 trips - 375 miles).

We also followed transect routes across Norton Sound on OSS Surveyor.

c) During air surveys of the beaches of Norton Sound we recorded the numbers of adult , subadult and first year young of Glaucous gulls.

2. Studies at Bird Cliffs

a) Censuses of the entire cliff nesting area were made by small boat at several times of day and several times during the season at Bluff Cliffs. Censuses were also made, using OSS Surveyor's whale boat, of the Bluff, Sledge Island Cliffs, and other cliffs in Norton Sound.

b) Photographic record was made at Egg Island, Cape Denbigh as well as at study sights at Bluff and Sledge Island.

c) Study sites were established: two at Sledge Island and twenty three at Bluff cliffs. At these study sites counts and observations of species present were made at regular intervals as long as the party was in the area. Photographs of the area were taken; a sketch map was drawn; nests of Kittiwakes were located and numbered; location of eggs or young of Murres were mapped.

d) The number of eggs that hatched and young that fledged can be derived at Bluff study sites and in many cases a precise date assigned to relevant events.

e) We made observations of food brought to the cliffs during the regular visits. Searches were made for food dropped on accesible ledges. At Bluff, transects were made about 1 mile from the cliffs to count the numbers and directions of birds communting from and to the cliffs.

3. Studies of Waterfowl

a) Air reconnaissance was made of previously known wetlands areas as well as new areas. These surveys provided data for making comparisons of the numbers of waterfowl and shorebirds using wetland areas.

Surveys were made in May when sea ice was still

present and most inland lakes frozen over. Additional surveys were made in mid August as waterfowl and shore birds gathered in lower reaches of rivers. Surveys will be continued in September and early October so as to identify the peak of numbers and how the numbers decrease as migration passes.
Subjective comparisons were made between data gathered by fixed wing aircraft and helicopters surveying the same areas.

b) Surface visits were made to Safety Lagoon and the lower reaches of the Bonanza River in August in order to identify shorebird migrants and to confirm identity of waterfowl seen from the air.

c) On air and surface surveys, counts of numbers of adults with young were made, when possible, primarily Pintail and Whistling Swans.

D. Sample Localities

1. Surveys and censuses were made by air at Egg Island, Black Point, Tolstoi Point, Egavik, Sledge Island, and Cape Denbigh.
Surveys and censuses were made from the surface at Black Point, Little Black Point, Square Rock, Bluff Cliffs, Tonok, Topkok,Sledge Island, Stuart Island, Whale Island, Egg Island, Cape Denbigh and Cape Darby.
2. Two study sites previously established at Sledge Island were revisited, and sixteen study sites previously established at Bluff Cliffs were repeatedly visited and seven new study sites were established.
3. Transects were taken by air on seven routes over Norton Sound. Transects were taken from surface craft on 15 routes over Norton Sound using both OSS Surveyor's and our own small boats.
4. Air surveys were made for waterfowl at Stuart Island, along the southeast coast of Norton Sound from Healy to Klikitarik and from Black Point to Shaktoolik, at the wetlands north of Moses Point, at Golovin Bay and Fish River flats, at Taylor Lagoons, at Bonanza River and Safety Lagoon, at Flambeau and Eldorado River, the area between Nome River and Cripple River lowlands, at SinukRiver lowlands, and the west coast of Seward Peninsula between Woolley Lagoons and Point Spencer lowlands.

III. Results

A. Data Collected: these figures are approximate because a party is still in the field.

Survey censuses of cliffs - 30
Photographs of cliff areas - 5
Visits to study sites about-750
Nautical miles of transects for distribution at sea - 170 on 15 lines
Ten minute watches for distribution at sea - 110
Five minute watches for direction and volume of flight at cliffs - 105
Lowland surveys for waterfowl - 12:(850 miles)

On foot surveys - 15 (total 50 miles)
Air surveys in transit - 12
Coastal surveys in small boats - 15 (total 350 miles)
Trips collecting food - 8

B. Species number and distribution

1. The table lists estimates of numbers of seabirds seen at seabird cliffs in Norton Sound during June, July, and August. Some of our data are not available because they are in field notebooks still in Alaska. All the data on numbers and changes in numbers will be re-examined for our final report.
   The numbers of Murres, Puffins and Auklets varied greatly from hour to hour and day to day. It has been suggested by students in England that at least 5 censuses be made of each cliff before a reliable number is found. However, for our purposes, I don't believe a high level of precision is necessary.
   We can see that Egg Island and Sledge Island have about equal numbers of Murres (fewer than 5000). We can use these figures to compare population sizes with other islands and other species, acknowledging that our scale is approximately logarithmic.
2. We also ran transects of Norton Sound by air in June and on OSS Surveyor in August. Both these exercises, whose data will be "reduced" and presented in a final report, showed that seabirds were gathered in large numbers near the nesting cliffs, that seabirds were unexpectedly sparce between 3 and 20 miles and were unexpectedly numerous between 30 and 60 miles from the cliffs.
   Ocean transects should be repeated within each sampling period too, because the behavior of birds varies relative to the ship and because the visibility of birds on the water varies with fog, rain and the state of the sea.
3. Waterfowl distribution and numbers are shown in Table 2. Counts were made along the shore and along zig-zag searches over wetlands areas. We have not made surveys of the wetlands of the Unalakleet River, the Shaktoolik lowlands, nor those south of the Koyuk River. The party at Bluff during September was going to try to survey these areas.

	Stuart Island	Whale Island	Egg Island	Black Point	Tolstoi Point	Egavik	Cape Denbigh, No.	Cape Darby, E.	Cape Darby, W.	Rocky Point	Little Rocky Point	Square Rock	Bluff	Tonok	Topkok	Sledge Island	Cape Denbigh, S
Pelagic Cormorant	1		1	25/35	15		75/23	300/90	19/2	110	80			2	150	165	75/24
Golden Eagle													2				
Peregrine Falcon							2		2				2		2	2	
Glaucous Gull	15	6		3	15		30	225/37	65/10					2	40	6	20
Black-legged Kittiwake	60	8	525				1200					500	3700			1300	650
Murres	110		2000				5900					1400/1700	38600/16500			2900	4,300
Proportion common to thick billed			100/2														
Black Guillemot																	
Pigeon Guillemot										DATA NOT AVAILABLE	DATA NOT AVAILABLE				20	12	
Kittlitz's Minelet																3	
Parakeet Auklet			5										65/4			85	
Crested Auklet																	
Least Auklet																	
Horned Puffin	185	10	210	200/300	20		40	475	100			32/61	380/365	5	50	110	35
Tufted Puffin	15		25				3	50	1			1	5		30	13	

Table 1. Seabird Nesting Cliffs
Norton Sound
1976

Species	Stuart Island	Moses Point	Fish River	Safety Lagoon	Sinuk River	Woolley-Douglas	Point-Spencer	
Arctic Loon				6		2	6	
Red-Throated Loon				11		23	13	
Whistling Swan				11/5		1/	25/0	
Large Canada Goose		500		96		25	200	
Cackling Goose		8						
Black Brant								
Emperor Goose						8 ad / 35 [illegible]		
White-fronted Goose		15						
Snow Goose				3				
Pintail		245	312	275		36		
Green-winged Teal				8				
Wigeon		185				5		
Greater Scaup				39				
Lesser Scaup of Canvas back				12				
Red-breasted Merganser						30		
Glaucous Gulls		55	105	230 ad / 96 subad		216 / 20	ad. * [illegible]	
Arctic Terns				32		29	9	
"Calidris" Sandpipers				70		15	35	
Whimbrels				5		15		
Golden Plover				9				
Sandhill Cranes							5	
Glaucous gull breeding Island						32 ad / 15 chicks	71 ad / 5 chicks	

Table 2. Waterfowl Wetlands
Norton Sound
1976

C. Schedule

1. Seabirds. We flew over Sledge and Bluff in late May and early June when ice had just left Bluff. Fast ice still surrounded Sledge Island at this season; the sea birds were in the water below the cliffs but were not seen on the cliffs.
   Our first visit to Bluff on May 29 indicated that at that season there are periods when the cliffs are unoccupied and that both Murres and Kittiwakes come in in groups. One section of the cliff would be occupied and several other areas used for nesting in previous years were empty. Cormorants were already at the cliffs. Puffins came in later, about the second week of June.
   Cormorants were seen carrying nesting material on 27 May. The first fledgling was seen at Cape Darby on August 11.
   Kittiwakes apparently began their breeding schedule normally, but some kind of disturbance was evident at Bluff about 20 June, and the birds did not get back on schedule. The chicks in eastern Norton Sound were more numerous and a couple of weeks older than those at Bluff and Sledge Island.
   Murres occupied the cliffs sporadically in early June. We saw a high proportion of Thick-billed Murres on the first visits. The Thick-billed Murres laid eggs before the Common Murres. At Bluff all Thick-billed Murre chicks had "jumped" before the peak of hatching of Common Murre eggs.
   Glaucous gulls had completed clutches by mid-June. Eggs began to hatch 2-5 July and chicks began to fledge in mid-August.
2. Waterfowl.
   a) Pintail and Red-breasted Mergansers (among fresh water ducks) and Harlequins, Old Squaw amd Erders (among sea ducks) as well as Red-throated Loons and Arctic Loons had arrived by late May. They gathered in leads and settled on tiny patches of melt water. The Brant had apparently not arrived and Canada Geese were few. We saw 3 Snow Geese in May.
      We next surveyed for waterfowl schedule in mid July, when Pintail and Teal broods were out. Pintail and Teal seemed to breed succesfully in ponds in the Mine talings around Nome. We observed again that ponds near eskimo camps were empty of waterfowl.
      By the second week of August, Pintail had begun to gather on the lower reaches of tundra Rivers and Canada Geese were moving into the area. We saw Snow Geese and White-fronted geese in mid August.
   b) We had little opportunity to observe shore birds except to notice that Snipe, Golden Plover, Bar-tailed Godwits, and western Sandpipers seemed as numerous as in 1975. Whimbrels seemed more numerous. Whimbrel chicks, golden Plover chicks, and Godwit chicks were out by 10 July.

Shore birds gathered on the flats in Safety Lagoon in mid August. This gathering seemed to be larger than any we were aware of in 1975, but in 1975 we had not yet learned the channels through the mud flats and therefore, could not survey the whole area.

Table 3. Measurements of Reproductive Performance

Pelagic Cormorants

Date	Place	Number of Nests and Chicks		Productivity Ratio (chicks per nest)
Aug.	Cape Darby,E.	25 nests	39 chicks	1.6
		8 nests	5 chicks	.6
		46 nests	62 chicks	1.3
	Cape Darby, W.	74 nests	114 chicks	1.5
Aug.	Bluff	12 nests	14 chicks	1.2
July	Sledge	10 nests	32 chicks	2.3
		36 nests	76 chicks	2.1

Table 4. Measurements of Reproductive Performance

Glaucous Gulls

Place	Pairs	Chicks	Ratio, pairs/chicks
Cape Denbigh,S.	18	11	.6
Cape Denbigh,N.	16	18	1.1
Cape Darby,E.	60	24	
Cape Darby,S.	40	7	
Cape Darby,W.	45	10	
Total	145	41	.3
Cape Woolley	32	15	
Point Spencer	71	5	
Total	103	20	.2
Safety Lagoon	8	2	
Sunset-Sunrise	30	18	
Total	38	20	.5

Age Structure

Place	Adults	Subadults	Chicks
Eastern Norton Sound Beaches (August 20)	1021	327	149
Seen on Colonies	---	---	151
Safety Lagoon Bonanza	227	93	---
Cape Woolley-Point Spencer	137	20	---
Total	1385	440	310
Age Structure	.65	.21	.145

Total Gulls: 2135

Table 5. Measurements of Reproductive Performance

Kittiwakes

Sledge Island

	Nests	Incubators	Reproductive success nests chicks
July 26, Stake 1	16	7	
	19	4	
	35	6	
	36	3	
	106	20	=.2
Stake 2	28	4	=.14
July 23,			
west of Stack	38	4	single eggers=.1
from water	21	4	=.19
Total 7 Samples			
	193	32	=.17

Bluff Cliffs

	area1	area2	area3	area4	area5	area6	area7	area8	area9	totals
ts	270	152	306	338	109	431	167	199	151	2123
ubators	70	27	49	48	15	85	14	24	7	339
cks	2	--	2	--	--	--	2	5	4	15
samples	4	2	3	3	2	4	2	2	2	24
dn/nest	.26	.18	.16	.14	.14	.20	.08	.12	.05	.16

Cape Denbigh, N. / **Cape Denbigh, S.**

	area 1	area 2	area 3	area 4	Totals	area 1	area 2	area 3	Totals
ts	421	125	175	44	765	209	227	152	588
ubators	135	16	48	6	205	45	72	40	157
cks	---	---	---	--	---	---	---	---	---
samples	3	3	3	2	11	4	4	2	10
dn/nest	.32	.13	.27	.14	.27	.21	.31	.26	.27

Egg Island / **Sledge Island Boat**

	area1	area2	chicks only area3	Totals	area1	area2	area3	area4	area5	Totals
ts	58	34	311	403	211	124	226	144	147	852
ubators	23	12	---	35	7	6	6	9	8	36
cks			40	40	---	---	---	---	---	---
samples	2	1	2	5	3	3	4	5	2	17
dn/nest	.04	.35	.13		.03	.05	.03	.06	.05	.04

D. Trophic Relations including measurements of reproductive success.

1. Seabirds

a) As in 1975, Pelagic Cormorants appeared to produce more young per nest than the other species (table 3).

b) Glaucous Gulls nested with approximately the same success as in 1975 in the areas where we could measure reproduction (table 4). This figure, about .5 per nest, is that which we suggested to be the "wild type" reproductive performance for Herring Gulls in New England.
We also censused Glaucous Gulls by age groups for the second year and present a life table now, 65% adults, 21% subadult and 14% chicks of the year in August. Glaucous Gulls again nested both on rocky cliff tops and on marshy islands in lakes. We cannot detect any difference in reproductive success between the two habitat types, but there may be an increase in reproductive success towards the east.

c) Black-legged Kittiwakes had a poor year. The best performance, small samples at Egg Island, was below average for 1975 (table 5). The next best, at Cape Denbigh, could be compared only to the worst performances in 1975. Reproduction at Bluff and Sledge Island was disastrously poor.
We took photographs cf the bird cliffs again this year; Egg Island, Cape Denbigh, and Bluff. The technique is not satisfactory, but measurements of success taken from the photographs do show the same trends as counts from the water.
It may be important that the schedule of reproduction was earlier in eastern Norton Sound as well as more successful. We will pursue these details and the history of individual nests studied at Bluff in the later report.

d) <u>Murres</u>. As far as the data now available indicate, about the same number of eggs were laid by Murres at Bluff and Sledge as in 1975.
In June at Bluff, there were perhaps 20%-25% of the birds present as compared to what we estimated in July 1975. Numbers increased substantially in July, but only to numbers below the average numbers found in 1975.
If we do confirm the impression that the numbers of eggs laid was comparable between the two years it will suggest that as many as 2/3 to 3/4 of the birds on the cliffs are excluded from breeding. In other words, about half of the pairs that come to the cliffs are able to lay and incubate an egg.

e) <u>Food</u>. The food seen brought to the cliffs by Murres and Puffins was indistinguishable from that seen in 1975.
Murres: Pricklebacks, Salmon and Cod; Puffins: Sand La
The "flags" of droppings under Thick-billed Murres an

Kittiwakes in June and early July suggested that they were feeding on a pink crustaceau. We saw feeding mélés of Kittiwakes at Sledge Island in late July and early August. Minke whales were associated with these mélés again. The mélés at Bluff included Puffins and a few Murres.

f) Distribution while feeding. Kittiwakes appear to feed near the shore in Norton Sound. Glaucous Gulls in Norton Sound feed along the shallow beaches, at mouths of rivers, on berries on wet tundra and gather especially on walrus carcasses.
Murres fed at great distances from the colony. They were numerous at the greatest distances. We ran transects from the colony to the south (60 - 70 miles), but we seemed to have passed out of their feeding area when we reached the shallower water northwest of the mouth of the Yukon River.
Horned Puffins were most numerous between 3 and 10 miles and up to 30 miles from the colony. Tufted Puffins fed at greater distances, 10-35 miles, according to our few data.
Kittiwakes fed in the brash ice where ice was breaking up, in the stillwater and eddies right at the foot of cliffs. They followed closely after Walrus and Grey Whales and fed around the large mammals as they surfaced.

2. Waterfowl and Shorebirds
   a) Our observations indicate that Pintail, Teal and the shore birds had reproductive success comparable to that of 1975. Pintail probably did better in 1976 than in 1975.
   Our few data on Whistling Swans indicate that fewer pairs were successful in 1976 than in 1975, but the successful 1976 parents had larger broods than those in 1975. The result was a comparable level of performance.

IV. Preliminary Synthesis of data and interpretation.

A. Distribution

Marine birds -- 1. Three species, Pelagic Cormorants, Glaucous Gulls and Horned Puffins nest in moderately large (150 nests) and small groups. These three species nest in small colonies scattered along the shore. These species also feed relatively close to their colonies and thus, conform to the general pattern described by Lack in 1966 for the ecological-sociological adaptations of such short distance feeders.
Tufted Puffins are found in small numbers with Horned Puffins in the smaller "outpost" colonies, but their numbers in mid and eastern Norton Sound are too small to allow us to put them in a clear category.
Horned Puffins are more numerous at Bluff and King Island than elsewhere. Glaucous Gulls are comparatively evenly distributed. There are larger colonies at Topkok and Cape Darby than at the other seabird cliffs.

2. Black-legged Kittiwakes, Common Murres and Thick-billed

Murres nest only at the large seabird cliffs, and these species regularly fly long distances (evidently up to 75 nautical miles) to feed. Breeding success in Kittiwakes in 1975 and 1976 appeared to be lowest in the west and highest in the east.

3. Parakeet Auklet and Pigeon Guillemot are largely concentrated at King Island, although a few Pigeon Guillemots nest at Sledge Island and Topkok and a few Parakeet Auklets occur at Sledge Island, Bluff Cliffs and Egg Island.
4. Common Murres are more numerous relative to Thick-billed Murres than I expected. Common Murres are more than 95% of the Murres in Norton Sound and make up 30-60% of the Murres at King Island.
5. When the sea ice was breaking up, sea birds of all species occured more among the ice pans than in the patches of open water in between. This is obvious from the air, from travel in small boats, and from observations from vantage points on land. It is also consistent with traditional eskimo hunting practices.

Waterfowl

6. The distribution of water fowl at sea was also associated with masses of drifting ice. Old Squaws and Eiders fed among and along the edge of the ice. Black Scoters ,Mergansers and geese in flocks flew along the edge of patches of drifting ice.
Waterfowl also gathered in numbers in the leads at the mouths of larger rivers before the sea ice moved out. Waterfowl gathered in open areas in eastern Norton Sound and made excursions north-westward, visiting even small patches of melt water in low places, such as marshes and edges of frozen ponds. In the mornings, flocks flew west;in the evening many flew eastward again.
7. Red-throated and Arctic Loons were present in early June in the leads at river mouths. Arctic Loons nested in large lakes 1/2 mile long or more. Red-throated Loons nested not only in coves of large lakes, but in small lakes about 100 meters long.
Whistling Swans occur in small numbers in the wetlands north of Moses Point, in the Golovin Bay flats, in the flats north of Safety Lagoon and between Cape Woolley and Point Spencer. Their greatest numbers are in the Sinuk River lowlands westward to Cape Woolley. Swans appear to nest primarily in lakes formed by thawing of frozen lowlands - "thaw sinks".
Pintail were numerous in all the lowlands, perhaps less numerous north of Cape Woolley than east of there.
Red-breasted Mergansers were numerous in leads at river mouths and first melting pools in early June. They then moved to rivers.
Harlequin ducks were numerous in all shore leads in June. Flocks of Post-breeding males occured at all seabird cliffs.
Old Squaws were most numerous in patches of sea ice in June and as flocks of post-breeding males along shore in July.

8. Fall gatherings of waterfowl occured in lower meandering areas of coastal rivers and in the lagoons formed by long shore bars partly blocking river outlets. Targer shore birds, Whimbrels, Godwits, and Plovers gathered in similar places in mid and late August. The best places to see fall gatherings are a) the flats along the canal in the middle of Stuart Island, b) the flats north of Moses Point, c) the flats at the mouth of the Fish River, and d) the meanders and salt marshes of the mouth of Bonanza River.

B. Schedule. The periodic censuses of breeding cliffs and the regular visits to study sites have combined to give us a picture of how numbers change with season, from day to day with weather, and from hour to hour. Most of this information becomes tedious detail but some generalities seem valid at the point.

1. Species gather in flocks on the water before the cliffs, especially when coming to the cliffs early in the season and in the evening.
2. Kittiwakes and Murres appear to come back first in late April and early May. They occupy some sections of cliffs at first, leaving others empty. By mid June these species have fully occupied the cliffs. It appeared that after the first occupation of the cliffs the Murres left for about 10 days to two weeks before coming back to lay eggs.
   In July, additional Murres come to the cliffs and we don't know just what age group these birds represent. Murre chicks jumped beginning with Thick-billed chicks in early August and chicks were still leaving in mid-September of 1975. Murres left patches of the cliff in late August 1975 and the cliffs were nearly all clear of Murres by late September.
   The numbers of Kittiwakes seemed to increase in late August and fighting for nesting sites increased as if future breeders were trying to establish territories. In 1976 Kittiwakes that did not have eggs persisted at nests and continued "long calls" and "choking" into July. It is doubtful that any eggs laid after mid July can produce young.
   Counts at our study sites provide data for predicting the number of eggs of Murres or nests of Kittiwakes from counts of the total numbers of birds.
3. Horned Puffins and Pigeon Guillemots arrive on the cliff later than Kittiwakes and Murres. Their first big arrival seems to be in mid June. Tufted Puffins appear to arrive in late June.
4. Waterfowl appear to arrive in Norton Sound before their habitat is ready and their occupation of breeding grounds seems to be timed by the spring thaw. By mid-July shore bird young and broods of ducks, geese and swans are present, but most waterfowl broods hide. They are probably best censused in late July and early August, although the young are larger somewhat later. The broods of ducks seem to move away from nesting lakes before those of swans do.

Migrating geese arrive on the flats by mid-August and Cranes move through in early September.
Black Brant move along the coast in Spring and fall later than do the other geese.

C. Trophic Relations

1. The disastrous reproductive performance of Kittiwakes in 1976 should allow us to learn about factors that influence their success. It appeared that weather rather than food was the factor. Weather may have denied them access to food.
   Our observations of Murres during 1976 suggest that we may be able to identify the "hard core" of breeding birds and separate then from the surprisingly large number of "non breeders". If we can identify the real breeders, we can relate those numbers to the numbers of eggs found at study sites and on ledges we searched for food.
2. These observations indicate that the numbers of birds on the cliffs drop sharply in strong winds and that the numbers fall gradually during periods of rough weather. The reasons for leaving are different, but the combination of a period of storm about 20 June and wind about 25 June may have affected egg laying in Kittiwakes (which was the link in the reproductive chain that seems to have broken). If so, it will be important to learn whether (and if not, why not) egg laying was less in Murres in our region. Apparently reproductive success was normal in 1976 for Pelagic Cormorants and Glaucous Gulls.
3. Our transects on the Surveyor have clarified the feeding grounds of Murres, and to a lesser extent, Horned and Tufted Puffins and Kittiwakes. However, we know little of the feeding grounds of the Auklets or Pigeon Guillemots.
4. So far we think we can be confident a) that food is concentrated in broken drift ice in spring; b) that nesting conditions for Kittiwakes are more favorable in eastern Norton Sound than western; c) that nesting conditions for Cormorants is evenly distributed over all of Norton Basin; and d) that nesting conditions for Thick-billed Murres, Pigeon Guillemots and the three species of Auklet are more favorable in the Chirikov Basin than in Norton Sound.
5. We have no information on trophic relations of waterfowl and shorebirds.

V. Relation to Development

1. The opportunity to make detailed studies at a seabird cliff during a disaster year is a lucky one. Several of the changes in numbers and in breeding success which we have observed resembles changes one might predict to be associated with economic development of the region. This suggests that we can a)measure the impact and b) warn against premature conclusions being drawn when development is in progress.
2. The transects at sea indicate that feeding seabirds are

widely dispersed, hence, oil spills anywhere can be expected to do some damage. On the other hand, their wide dispersal indicates that feeding grounds would proabaly not all be contaminated by local spills. Local spills at seabirds cliffs remain the most serious danger.

It is clear that waterfowl gather at leads in the ice in spring and in the zone of river meanders, salt-marshes and lagoons in the fall. Apparently these waterfowl gathering areas are more productive in the east and south of Norton Sound than in the northwest. Yet, for some species, (perhaps Whistling Swans, Black Brant and Emperor Geese) the reverse seems to be the case.

3. My impression is that there is at least as much potential damage threatening the vulnerable human communities and their villages as that threatening habitats and wildlife. I am not qualified to report or assess these impacts, but I think they deserve serious attention.
    a) At present the rich influential opportunists both natives and "carpet baggers", are profiting by the speeded up economy in Nome while the "hot" economy is making life more difficult for many "poor".
    b) A problem which will increase is that resulting from increasing ease of travel for year round hunting at waterfowl and marine bird concentrations.

VI. Problems

A. Biological Questions and problems to be solved by our crew.

1. Measuring breeding success.
    a) I believe we have dependable ways of measuring breeding success for Pelagic Cormorants, Glaucous Gulls and Black-legged Kittiwakes. These techniques need dependable sea going transportation to be applied over a large area.
    b) For Murres, when each cliff we visited was new and strange, it was not at all clear how we could put a number on a measurement of success. Now that the same youths have visited the same ledges, on the same day, on two successive years, we can reword the question. The question is not entirely how many young were produced per breeding pair. It includes the question what are the differences between years? If we can count the number of Murres with strong attachment to sample ledges and count the number of eggs on those ledges in mid and late July, we can compare performance between years. Some of the best counts come from ledges we can climb to - hence, these are peripheral or vulnerable ledges. But if we define our question as "what are similarities and differences between years?" we can ask "why should differences between years be expressed in different ways on peripheralledges, as compared to central ones?". However, we might expect greater differences

on peripheral ledges than would be observed in central ledges.

c) We made some progress in finding nesting crevices of Horned Puffins and seeing their contents. Our samples are still small.

2. Getting Food Samples. We can see food brought in to nestlings of Puffins, Murres and Kittiwakes and collect that dropped by adults. We have no good method of learning the food used by the parents for themselves when courting, incubating or bringing food to the young.
   We will need to collect birds on the feeding grounds or get the cooperation of others(see below).
3. Travel to the feeding grounds. We learned this year that feeding grounds are well offshore, as much as 30 - 40 miles for species regarded as feeding close to their nests elsewhere, and as far as 80 miles (the limit of our survey) for long distance types such as Murres. No small boats will be adequate to survey for the location of feeding grounds or to sample food adequately.
   For proper completion of our survey of breeding biology we need to visit feeding grounds during each phase of the breeding cycle. I expect that we can sketch out distribution and its changes by transects made in twin engine fixed winged aircraft. We may be able to get adequate information from the work of bird observers on OCSEAP ships working in Norton Basin.
4. Travel to study cliffs. We have satisfactory arrangements for getting to the seabird cliffs at Bluff and for visiting study sites there, depending mainly on charter flights.
   We were able to get to and from Sledge Island in 1976 using brute ingenuity and help from our friends and supervisors. But I am convinced we will need another boat if the Sledge work is to continue, unless transport can be provided by NOAA ships in the area.
5. Travel needs for 1977.
   a) We will want to expand our air coverage of the sea of Norton Basin to make transects in late May, in June, in July, in August, and in September.
   b) We will want to repeat our flights to certain cliffs so as to photograph Kittiwake nests in mid August and estimate numbers at the same time.
   c) We will want to repeat our air surveys of waterfowl breeding and gathering areas and extend these to the areas northwest (Teller to Wales) inland (Imuruk Basin and Council) and east (Koyuk River, Shaktoolik and Unalakleet Rivers).
   d) We will want to increase the number of visits to Sledge Island making visits in June, July and August. On the same trips, we want to make surveys of the Sinuk River lowlands on the grounds.

B. Problems related to other OCSEAP activities.
   1. Travel. Someone should visit Little Dromede Island and Fairway Rock to repeat Kenyon's 1950 estimates and estimate reproductive success. If no one else is

doing this, our party might undertake to do this.

2. Trophic studies. In order to relate our studies at Seabird cliffs to "trophic-dynamics" of the Norton Basin, we need data taken from sampling on the feeding grounds including a) numbers and kinds of birds per unit area, b) samples of food being taken by the birds, c) distribution and abundance of prey species. One of the major needs of the OCSEAP Program is to study the physical, chemical and biological structure of the sea in the Norton Basin between 3 meters depth and 50 meters depth. Another is to learn of the life histories, movements and productivity of major prey species, such as Amphipods, Copepods, Euphausiids, Pandalids, and the Teleost fishes: Ammodytes, Gadus (S.L.), Lumpenus, Mallotus and Osmerus. We need to discuss whether this work can be undertaken and, if it can be, how we can help and have access to the data.
3. Helicopters and sea birds. It is clear that helicopters cause unusually severe panic among seabirds. Thus, we found helicopters not very useful in making transects because birds dived well ahead of us. We also noted the major panics were created when helicopters passed over sea bird cliffs to drop off shore parties. The effects of helicopters on nesting seabirds must be considered seriously in plans for other OCSEAP operations and any operations related to development. I expect, for instance, that frivilous visits to bird nesting islands will increase markedly unless effective steps are taken to control them.
4. Money Matters. It has proven difficult for our small organization, College of the Atlantic, to assume a deficit of nearly $30,000 in financing the field work. This deficit comes on top of an annual operating budget deficit of about the same size, at the time of most severe cash-flow problems at the College. We need to find some way of mitigating the effects of this deficit and the added costs of borrowing the money ahead.
5. As I have suggested before, living space and storage space are in short supply in Nome. If and when NOAA's OCSEAP has many ships and parties working in Norton Basin, it will be important to make special arrangements for housing and space. Otherwise, NOAA's presence will exaggerate the outrageous profiteering that local entrepreneurs are able to get away with.

ESTIMATED EXPENDITURES

This is a preliminary accounting. The party is still in the field.

C.P.F. 1	Salaries	$9,850.
	Fringe Benefits	1,625.
	Overhead	1,500.
C.P.F. 2	Travel & per diem	
	Travel to Alaska	5,120.
	Local Air Surveys	3,015.
	Per diem Nome est.	1,200.
	Per diem Camps	3,810.
	Local Travel	1,150.
	Auto	
	Maine	
	Outboard	
C.P.F. 3	Equipment	2,685.
C.P.F. 4	Other direct costs	410.
	Photo.	
Total		$30,365.

FIFTH QUARTELY REPORT.

RESEARCH UNIT # 239

"Ecology and Behavior of Southern Hemisphere Shearwaters (Genus Puffinus) and other Seabirds, when over the Outer Continental Shelf of the Bering Sea and Gulf of Alaska during the Northern Summer".

Subject: Submit Data Report. Field work carried out in Gulf of Alaska and Bering Sea during May and June, 1976.

Juan Guzmán
University of Calgary
Calgary, Alberta, Canada.

September, 1976.

I. Task Objectives.

The most important objectives of this project were to obtain information on:

A.- The degree of overlap in the geographical distribution of the Short-tailed Shearwater (Puffinus tenuirostris) and the Sooty Shearwater (Puffinus griseus) during the northern summer in the study area, and the relationship between the distribution of these Shearwaters and a) particular water conditions, b) the distance from shore, c) the foods available to them, and d) the passage of weather systems.

B.- The plumage, molt and reproductive condition of living and / or collected specimens.

C.- The behavioral dynamics of shearwaters at both the individual and flock (social) levels.

D.-Baseline residues of certain pollutants in tissues (to be analysed only if this can be carried out, at no cost to this project, by another agency).

II. Field Activities.

A. Ship Schedule: In accordance with the schedule of the NOAA Research Vessels, we decided to make use of NOAA Ship DISCOVERER during the month of May and NOAA Ship SURVEYOR during June. I boarded DISCOVERER in Juneau on May 1st. and I got off in Kodiak on May 31. From June 5 to June 25, I was onboard SURVEYOR, which I boarded in Kodiak and got off in Seattle.

B. Scientific Party: The field work for this Research Unit was carried out by Juan Guzman of the University of Calgary.

C. Methods:

1. DISCOVERER Cruise. During this cruise we covered 3 legs, the first one in Cook Inlet, the second in Icy Bay and Yakutat Bay, and the third in lower Cook Inlet and Prince William Sound (see map 1). During this cruise I carried out transects from the flying bridge (atop the wheelhouse, aproximately 40 feet high), from where a virtualy unobstructed view was obtained. The station records were made walking around the flying bridge and main deck. All the data was collected in the same type of forms than those used last year (OBS- 3-75 for Pelagic Bird Observations: Station Record and OBS- 2-75 for Pelagic Bird Observations: Transect Records). All the transects carried out between May 3 and May 20 have been considered Experimental Transects (E-Transects) because both sides of the ship were considered during each Transect Record, and the time considered varied from 10 minutes to 30 minutes.

This method of considering both sides of the ship during each single transect showed to be no practical, because it is very difficult to observe the all area at the same time with a significant degree of accuracy. Also the values for bird density are no comparable with those for normal transects (which con-consider only one side), chiefly because most of the birds normaly cross off the bow from one side to the other, then usually almost the same number of birds that could be counted off one side are being considered with this method into an area twice larger. Since May 24 I started taking transects of 10 minutes period and considering only one side (starboard or port), in the same way that U.S. Fish & Wildlife Service's Office of Anchorage does. The 10 minutes period proved to be much more practical than last year's 15 minutes, because allows to take a higher number of observations during a single day. Also is easier to work 2 or 3 continuous transects in "block periods". The data on behavior has been included under remarks.

2. SURVEYOR Cruise. During this cruise we covered 1 transect line from Kodiak to Seattle and 1 leg in Bristol Bay (Pribilof Islands, Amak Island, Dutch Harbor and all the way from and to Kodiak (see map two). During this cruise I carried out Normal Transects of 10 minutes period, considering one side of the ship at the time (starboard or port). When shearwaters were seen (out of normal transects) E-Transects were taken, in

which the time period was variable, as well as the distance from the ship, and also could include one or both sides. Cosequentely the area covered was highly varaible. The behavior of shearwaters and other sea birds was recorded in remarks. Station Observations were carried out in the same way than during the first cruise.

Whith the assistance of some crew members and other biologists onboard I collected 13 Short-tailed Shearwater (<u>Puffinus tenuirostris</u>) from a small boat. This sample was taken close to Amak Island on June 15, 1976.

Gaps between observation records represent periods when no observations were made because of darkness, fog or other activities.

III. Results.

A total number of 336 Observations sheets were recorded during May and June, 1976. From these number, 180 are Normal Transects, 116 E-Transects and 40 are Stations Records. A total list of the species observed is included in table 1. The analyses of distribution, density, feeding activities, of shearwaters during this period of time will be included in the Final Report, as well as, hopefully, correlation with environmental data.

Even when the analyses of the data is not ready yet, the predominance of shearwaters is evident; from 538158 birds counted in all the observations, about 80% are shearwaters belonging to both species cosidered under this project (Puffinus tenuirostris and P. griseus). Molt in shearwaters was noticed during both months of field work, but my personal feeling is that was increasing towards the end of June; more accurate information will be obtained once analysed the field data. Molt was also recorded in all the shearwaters collected. Dealing with feeding activities, shearwaters were seen diving from the surface, diving by plunging and feeding on the the surface by sinking the head into the water. These feeding activities were observed in Gulf of Alaska, but not in Bering Sea. I assume that feeding behavior vary in differents zones of the ocean (or possible inside the same zone in different times) depending of the food resources available. From the sample collected close to Amak Island on June 15, I dissected two stomachs, which were full of Euphausids (Crustacea).

TABLE No. 1. List of Species observed during May and June.

Loon - Gavia sp.

Laysan Albatross - Diomedea immutabilis

Black-footed Albatross - Diomedea nigripes

Fulmar - Fulmarus glacialis

New Zealand Shearwater - Puffinus bulleri

Sooty Shearwater - Puffinus griseus

Short-tailed Shearwater - Puffinus tenuirostris

Scaled Petrel - Pterodroma inexpectata

Fork-tailed Storm Petrel - Oceanodroma furcata

Leach's Storm Petrel - Oceanodroma leucorhoa

Double-crested Cormorant - Phalacrocorax auritus

Pelagic Cormorant - Phalacrocorax pelagicus

Red-faced Cormorant - Phalacrocorax urile

Oldsquaw - Clangula hyemalis

Red Phalarope - Phalaropus fulicarius

Northern Phalarope - Lobipes lobatus

Parasitic Jaeger - Stercorarius parasiticus

Pomarine Jaeger - Stercorarius pomarinus

Long-tailed Jaeger - Stercorarius longicaudus

Glaucous-winged Gull - Larus glaucescens

Western Gull - Larus occidentalis

Herring Gull - Larus argentatus

Glaucous Gull - Larus hyperboreus

Mew Gull - Larus canus

Black-legged Kittiwake - Rissa tridactyla

Cont. Table No 1.

Red-legged Kittiwake - Rissa brevirostris

Arctic Tern - Sterna paradisasea

Aleutian Tern - Sterna aleutica

Common Murre - Uria aalge

Thick-billed Murre - Uria lomvia

Pigeon Guillemot - Cepphus columba

Horned Puffin - Fratercula corniculata

Tufted Puffin - Lunda cirrhata

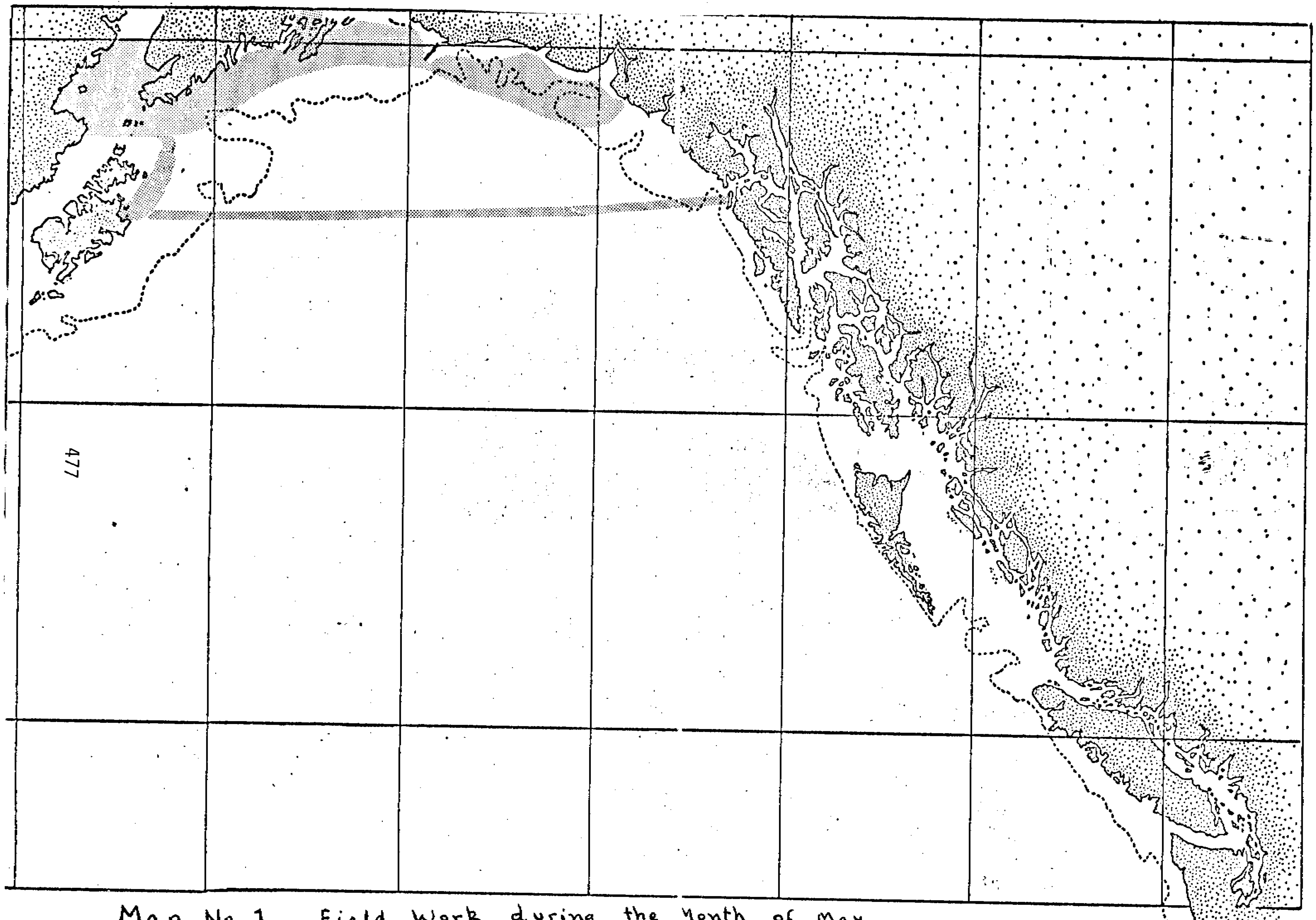
Crested Auklet - Aethia cristatella

Least Auklet - Aethia pusilla

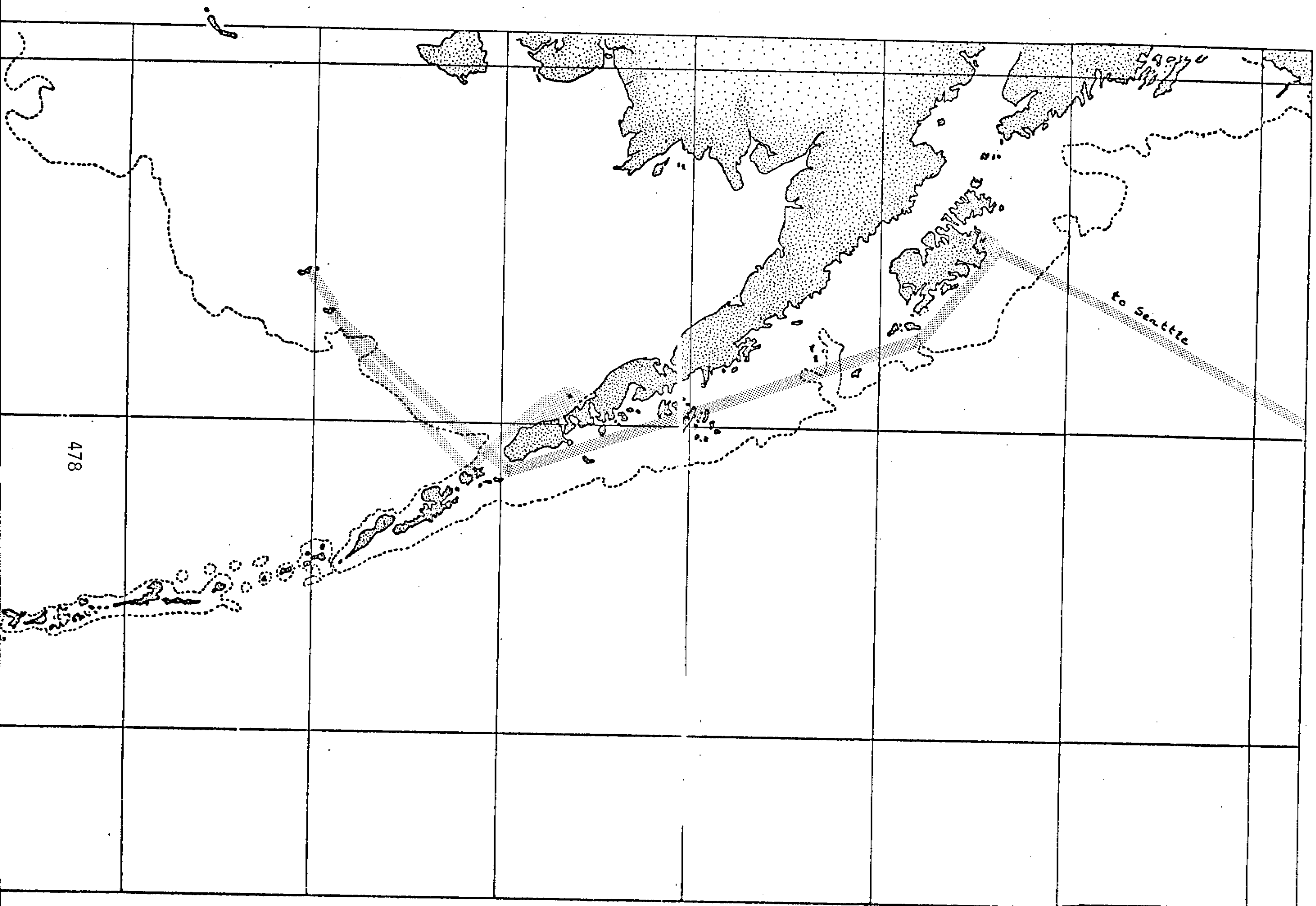
Marbled Murrelet - Brachyramphus marmoratum

Ancient Murrelet - Synthliboramphus antiquum

Parakeet Auklet - Cyclorrhynchus psittacula



Map No. 1. Field Work during the Month of May.



Map No. 2. Field Work during the Month of June.

QUARTERLY REPORT

Contract: 01-5-022-2538
Research Unit: RU-337
Reporting Period: July 1, 1976 to
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SEASONAL DISTRIBUTION AND ABUNDANCE OF MARINE BIRDS

Calvin J. Lensink
James C. Bartonek
Co-principal Investigators

and

Patrick J. Gould
Craig S. Harrison
Gerald A. Sanger
Susan C. Bates
Co-investigators

U.S. Fish and Wildlife Service
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800 A Street - Suite 110
Anchorage, Alaska 99501

October 1, 1976

INTRODUCTION

This report describes activities by U.S. Fish and Wildlife Service personnel related to shipboard and aerial surveys of marine birds in Alaska waters during the quarter from 1 July to 30 September 1976.

The objective of this research unit is to describe the seasonal density distribution of marine birds in those portions of the Gulf of Alaska, the Bering Sea, and the Arctic Ocean that have been identified by the U.S. Department of the Interior for leasing and development of their oil and gas potentials. This research unit considers only the offshore environment and does not include species generally confined to the nearshore and littoral habitats. It does not directly consider the distribution of pelagic species when they occupy shoreline habitats such as during the breeding season.

STUDY AREA

Shipboard surveys of birds during the third quarter of 1976 were conducted in the Gulf of Alaska and to a lesser degree in the Bering and Chukchi Seas. Observations were made during transits from Seattle to Nome and from Seattle to Kodiak. Aerial surveys were conducted over the Beaufort and Chukchi Seas and the northeastern and east-central Bering Sea.

METHODS

Methods used in the shipboard surveys of marine birds are described in our Annual Report RU #337, Part I and II, of 1 April 1976.

RESULTS AND DISCUSSION

U.S. Fish and Wildlife Service personnel conducted shipboard surveys during this quarter from the NOAA-operated R/V Moana Wave, Discoverer, Miller Freeman, and Surveyor, the private M/V Lindblad Explorer, and the chartered F/V Nordic Prince. Table 1 lists dates, areas of coverage, and personnel conducting these surveys.

We continued to avoid duplicating the somewhat similar efforts by personnel working for George J. Divoky (RU#330/196); and, therefore, we did not collect data near the ice edge or in the ice during summer. We also unilaterally deferred our somewhat similar activities to those of Juan Guzman (RU#239), Dennis Heineman and Wayne Hoffman (RU#108), and George Hunt (RU#83).

Aerial surveys were conducted by Craig Harrison, Colleen Handel, and Art Sowls over the Beaufort and Chukchi Seas and the northeastern and east-central Bering Sea. The surveys included nearly 60 hours of flying time in the U.S. Department of Interior's modified Grumman Goose N780. Skyrocketing costs for operating the Lockheed "Neptune" (P2V) precluded its further use for survey purposes.

Effort continued during this quarter to get shipboard survey data into a form useable for automatic data processing. As of 24 September, data had been sent for keypunching for USFWS Field Operations FW5004, FW5009, FW5011, FW5013, FW5018, FW5023, FW5024, FW5028, FW5030, FW5032, FW6018, FW6019, FW6021, FW6050, FW6052, FW6057, FW6068, FW6070, FW6071, and FW6083 (see Annual Report, 1 April 1976; Quarterly Report, 1 July 1976; and Table 1 of this report for description of coverage of these field operations). As reported last quarter, magnetic tape of data from Field Operation FW5028 was submitted to the Juneau Project Office, but we anticipate several additional tapes will be submitted during the last few days of this quarter. Of the data acquired during 1975, 1,162 transects (46%) will have been either keypunched or keypunched and taped by the end of this quarter. Because of NOAA's new "ship event" numbering system, we will not be able to give an accounting of the number of transects taken or processed until we obtain summary reports of the processed data.

We anticipate that all shipboard and aerial census date, except for that at December 1976, collected under the OCSEAP funding will be key-punched and submitted on magnetic tape to Juneau by the end of December 1976. Other data collected by nonOCSEAP programs will be incorporated into the system as time and money permits.

Table 1. Log of U.S. Fish and Wildlife Service, Office of Biological Services - Coastal Ecosystems' field operations for the study of marine birds, 1 July to 30 September 1976. (● = field operations associated with RU#337).

Date	Field Operation Number	Platform or Type of Study	Location	Personnel
22 Apr - 5 Aug	76022	Field Camp	Hinchinbrook I.	David Nysewander, Pete Knudtson
26 Apr - 9 Sep	76023	Field Camp	Cape Peirce	Margaret Peterson, Marilyn Sigman
29 Apr - 3 Sep	76024	Field Camp	Semidi Is.	Scott Hatch, Martha Hatch
●29 Apr - 7 Sep	76025 to 49	NORDIC PRINCE	Prince William Sound to Shumagin Is.	Art Sowls, Pat Gould, John Hall, Pat Baird, Kevin Powers, Ed Bailey
9 May - 1 Sep	76053	Field Camp	Forrester I.	Earl Possardt, Tony DeGange
11 May - 5 Sep	76054	Field Camp	Barren Is.	David Manuwal, Dee Boersma, Naomi Manuwal, Mike Amarel, Mary Nerini
16 May to date	76056	Field Camp	Nelson Lagoon	Bob Gill, Paul Jorgensen, Tony DeGange
20 May - 3 Sep	76059	Field Camp	Semidi Is.	Galen Burrell, Lora Leschner
20 May - 1 Sep	76060	Field Camp	Ugaiushak I.	Duff Wehle
20 May - 11 Jul	76061	Field Camp	Ugaiushak I.	Eric Hoberg, Kevin Powers
20 May - 3 Sep	76062	Field Camp	Big Koniuji I.	Bob Day
20 May - 3 Sep	76063	Field Camp	Big Koniuji I.	Ted Schad, Allen Moe

Table 1 (Cont'd). Log of U.S. Fish and Wildlife Service, Office of Biological Services - Coastal Ecosystems' field operations for the study of marine birds, 1 July to 30 September 1976.

Date	Field Operation Number	Platform or Type of Study	Location	Personnel
1 Jun - 27 Sep	76069	Field Camp	Kodiak I.	Matt Dick, Jay Nelson
6 Jun - 2 Aug	76073	Field Camp	Middleton I.	Marshall Howe, Dave Frazer
15 Jun - 23 Jul	76074	Field Camp	Yukon Delta	Bob Jones, Matt Kirchhoff
● 22 Jun - 17 Jul	76075	MOANA WAVE	Leg VIII	Doug Forsell
30 Jun - 16 Jul	76076	Field Camp	Unimak Pass	Mark Rauzon
● 15 - 16 Jul	76077	DISCOVERER	Seattle-Kodiak	Keith Metzner
● 17 - 31 Jul	76078	DISCOVERER	NWGOA	Keith Metzner
27 Apr - 7 Sep	76080	Field Camp	Copper R. Delta	Stan Senner
7 May - Sep	76081	Field Camp	Wooded Islands	Peter Mickelson, Bud Lenhausen
● 5 - 30 Jul	76082	LINDBLAD EXPLORER	GOA; APS, BS, HB	Colleen Handel, Sue Bates
● 23 - 31 Jul	76083	MOANA WAVE	NWGOA	Craig Harrison
● 4 - 18 Aug	76085	DISCOVERER	Leg II	Keith Metzner
● 17 - 27 Aug	76086	Aerial Survey	Arctic Ocean, NE Bering Sea	Craig Harrison, Colleen Handel, Art Sowls, Radike (NMFS)

Table 1 (Cont'd). Log of U.S. Fish and Wildlife Service, Office of Biological Services - Coastal Ecosystems' field operations for the study of marine birds, 1 July to 30 September 1976.

Date	Field Operation Number	Platform or Type of Study	Location	Personnel
●23 Aug - 2 Sep	76087	MILLER FREEMAN	Transit Seattle-Nome	Pat Baird
●31 Aug - 19 Sep	76088	MOANA WAVE	Norton Sound, Hope Basin	Pat Gould
●20 Sep to date	76089	MOANA WAVE	Bering Sea	Pat Gould
● 1 - 3 Sep	76090	SURVEYOR	GOA	Gerald Sanger
15 Sep to date	76091	Field Camp	Unimak Pass	Jay Nelson

QUARTERLY REPORT

Contract: 01-5-022-2538/
01-06-022-11437
Research Unit: RU-338/343
Reporting Period: July 1, 1976 to
September 30, 1976
Number of Pages: i + 39

PRELIMINARY CATALOG OF SEABIRD COLONIES

AND

PHOTOGRAPHIC MAPPING OF SEABIRD COLONIES

Calvin J. Lensink
James C. Bartonek
Co-principal Investigators

and

Arthur L. Sowls
Susan C. Bates
Co-investigators

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October 1, 1976

INTRODUCTION

This report contains the preliminary catalog of seabird colonies in the Bristol Bay Basin and a summary of other activities during the quarter from 1 July through 30 September 1976.

The objectives of the two Research Units (RU #338 and 343) covered in this quarterly report are to catalog seabird colonies, providing information about their location, composition, size, and the amount of land occupied, and to obtain a photographic record of the colonies.

STUDY AREA

Information on the location, composition, size, and status of seabird colonies is being actively acquired by us from the Gulf of Alaska to Cape Peirce where field studies associated with Research Units (RU #341 and 342) have allowed us the opportunity to examine both unsurveyed and cursorily surveyed areas. Our activity in the northern Bering Sea, Chukchi Sea and Beaufort Sea is passive because of contracting limitations; and it is dependent upon both historic information, OCSEAP cooperators, and other cooperators.

METHODS

Methods are described in our annual report of 1 April 1976.

RESULTS AND DISCUSSION

The location and relative size of marine bird colonies bounding the Bristol Bay basin are summarized in Figure 1. Location of U.S. Geological Survey topographic maps (1:250,000 scale) used in this portion of the catalog are shown in Figure 2. Colony catalog numbers and the relative size of the colonies are shown in Figures 3 to 21. Table 1 lists name of colony and the source and date of information. Table 2 lists species abundance at these colonies.

A majority of the largest colonies within this region are managed to give primary consideration to wildlife protection, e.g., colonies on Unimak Island and Amak Island are within the Aleutian Islands National Wildlife Refuge, colonies within the Walrus Islands group are within the Walrus Islands State Game Sanctuary, and coloneis from Shiak Island westward around Cape Newenham within the Cape Newenham National Wildlife Refuge.

Cataloging in the Gulf of Alaska, especially from Prince William Sound to False Pass at the southwestern end of the Alaska Peninsula has been materially benefited by surveys from the chartered F/V Nordic Prince which operates there in association with our Research Units #341 and 342. Information on colony status is also being acquired in the immediate vicinity of our site specific study areas (see our Quarterly

Reports RU #341/342, 1 July and 1 September 1976). These new data will be used to revise that portion of the catalog presented in the Annual Report RU 338/343 (1 April 1976).

During this quarter, that portion of the catalog pertaining to the Kodiak Archipelago was revised from that appearing in the Annual Report (1 April 1976) and the first revision appearing in the Quarterly Report (1 July 1976) for RU 338/343. U.S. Geological Survey topographic maps "Trinity Island 032", "Kaguyak 033", "Kodiak 034", "Karluk 035", and "Afognak 043" were revised by informational changes on 1, 1, 17, 8, and 1 colonies, respectively, and by the addition of 3, 1, 49, 2, and 112 colonies, respectively, previously unreported. This revised information was made available to both U.S. Fish and Wildlife Service and Bureau of Land Management offices responsible for resource evaluation of outer continental shelf oil and gas lease sale in the Kodiak Basin.

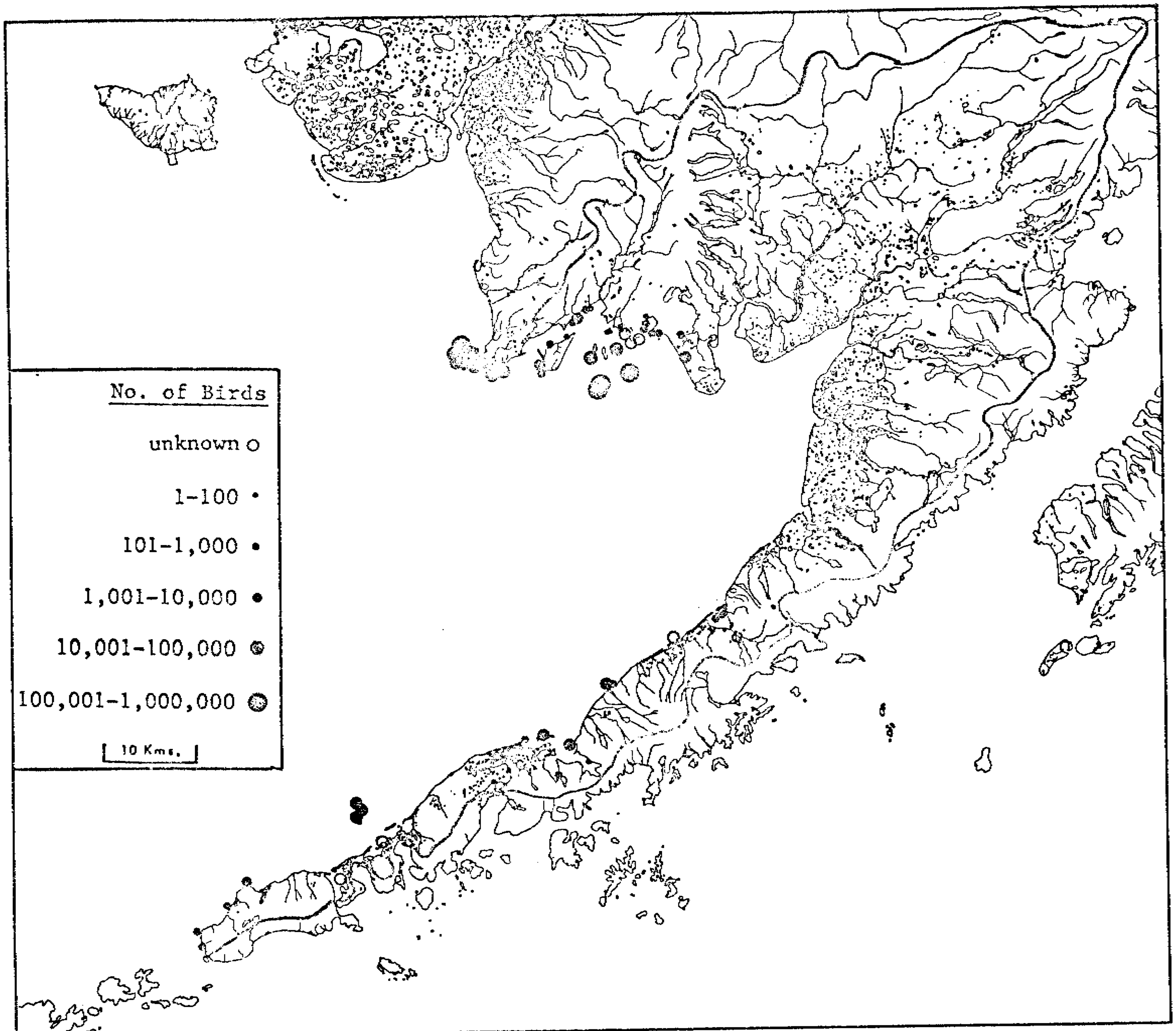

Figure 1. Distribution of marine bird colonies in Bristol Bay, Alaska.

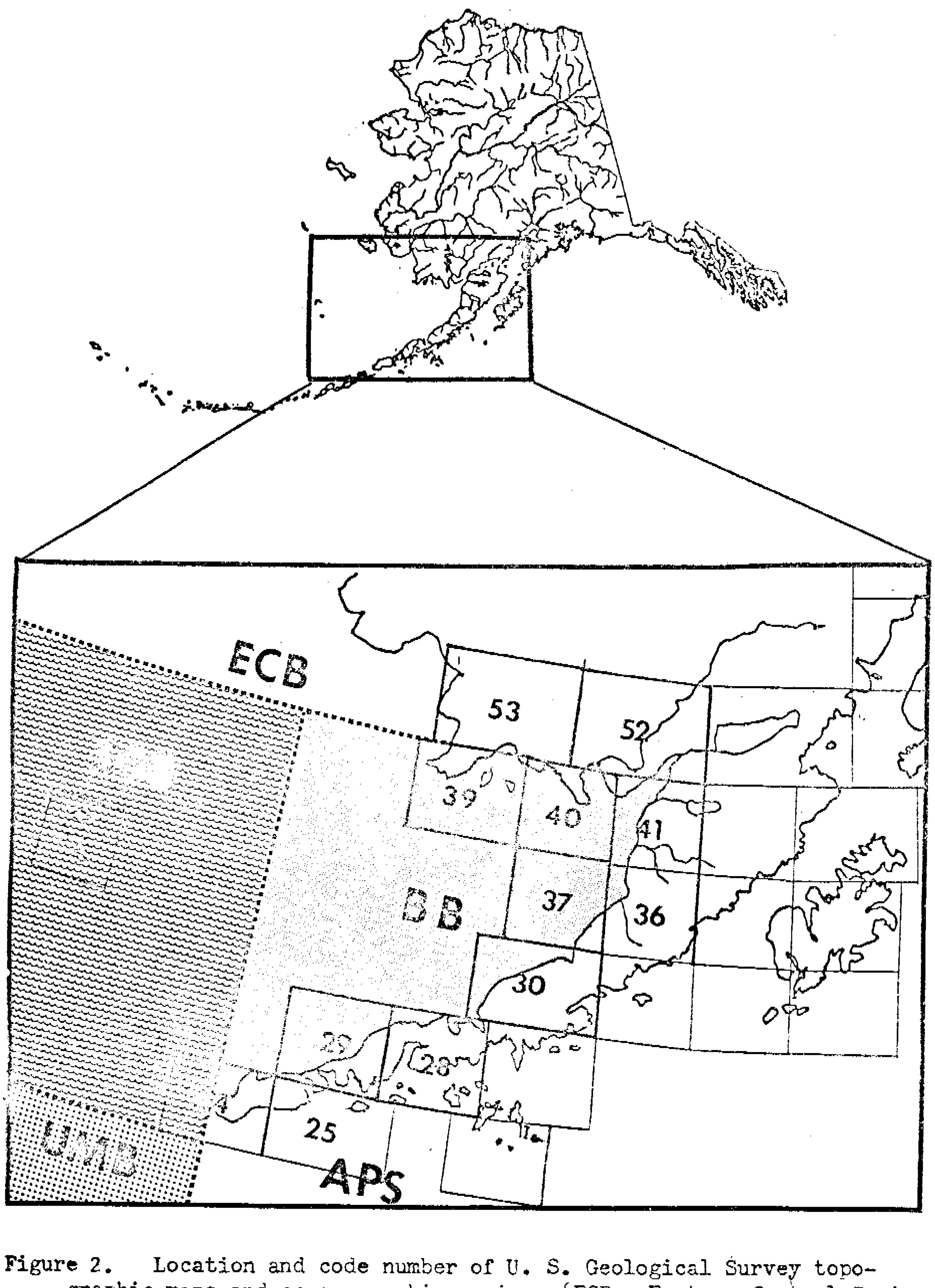

Figure 2. Location and code number of U. S. Geological Survey topographic maps and oceanographic regions (ECB = Eastern Central Bering Sea, SGB = St. George Basin, BB = Bristol Bay Basin, APS = Alaska Peninsula South) reported in this catalog of seabird colonies (source U. S. Fish and Wildlife Service, Office of Biological Services, Coastal Ecosystems, Anchorage, Alaska).

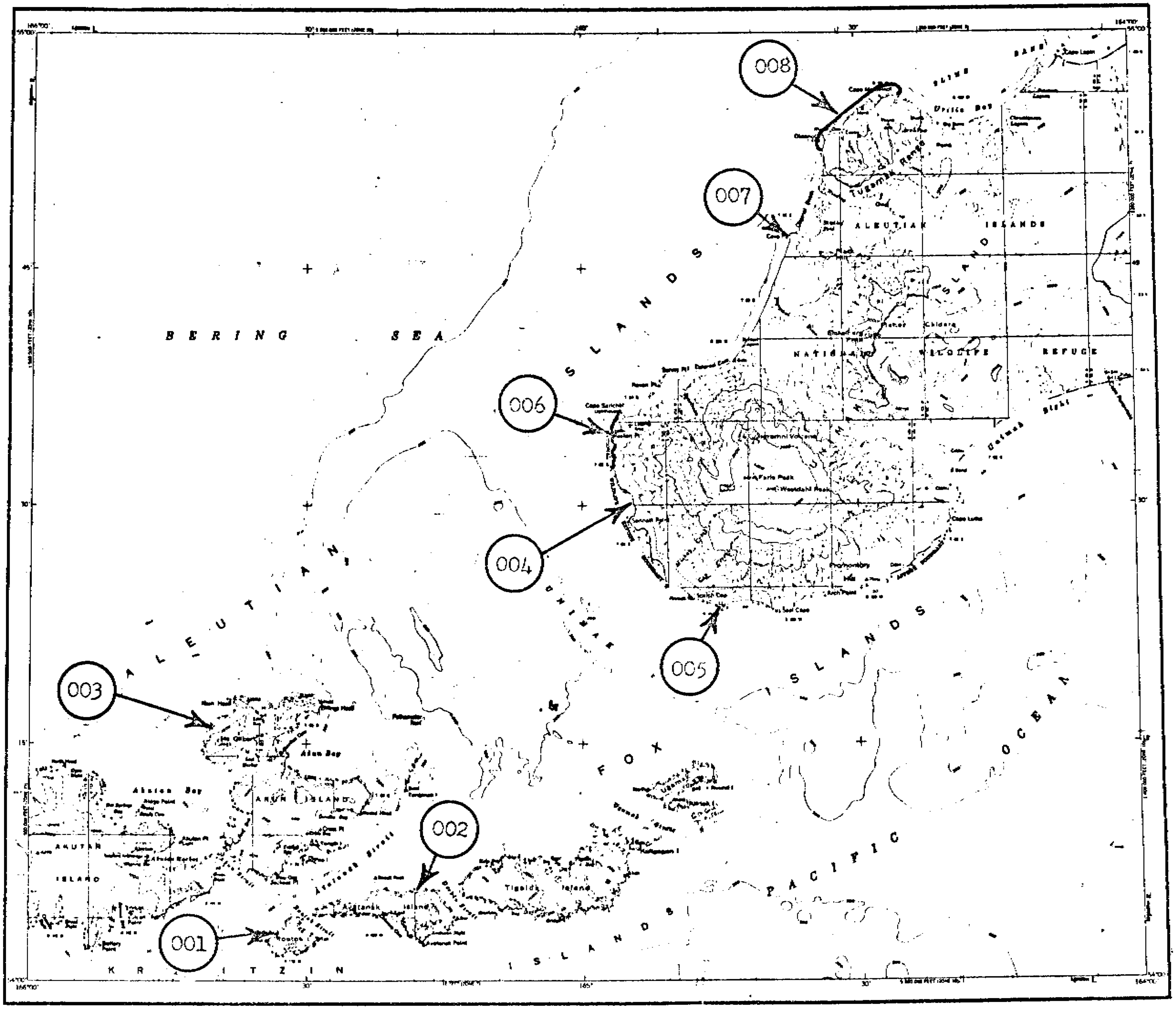

Figure 3.--Locations of known seabird colonies in topographic area 024, Unimak

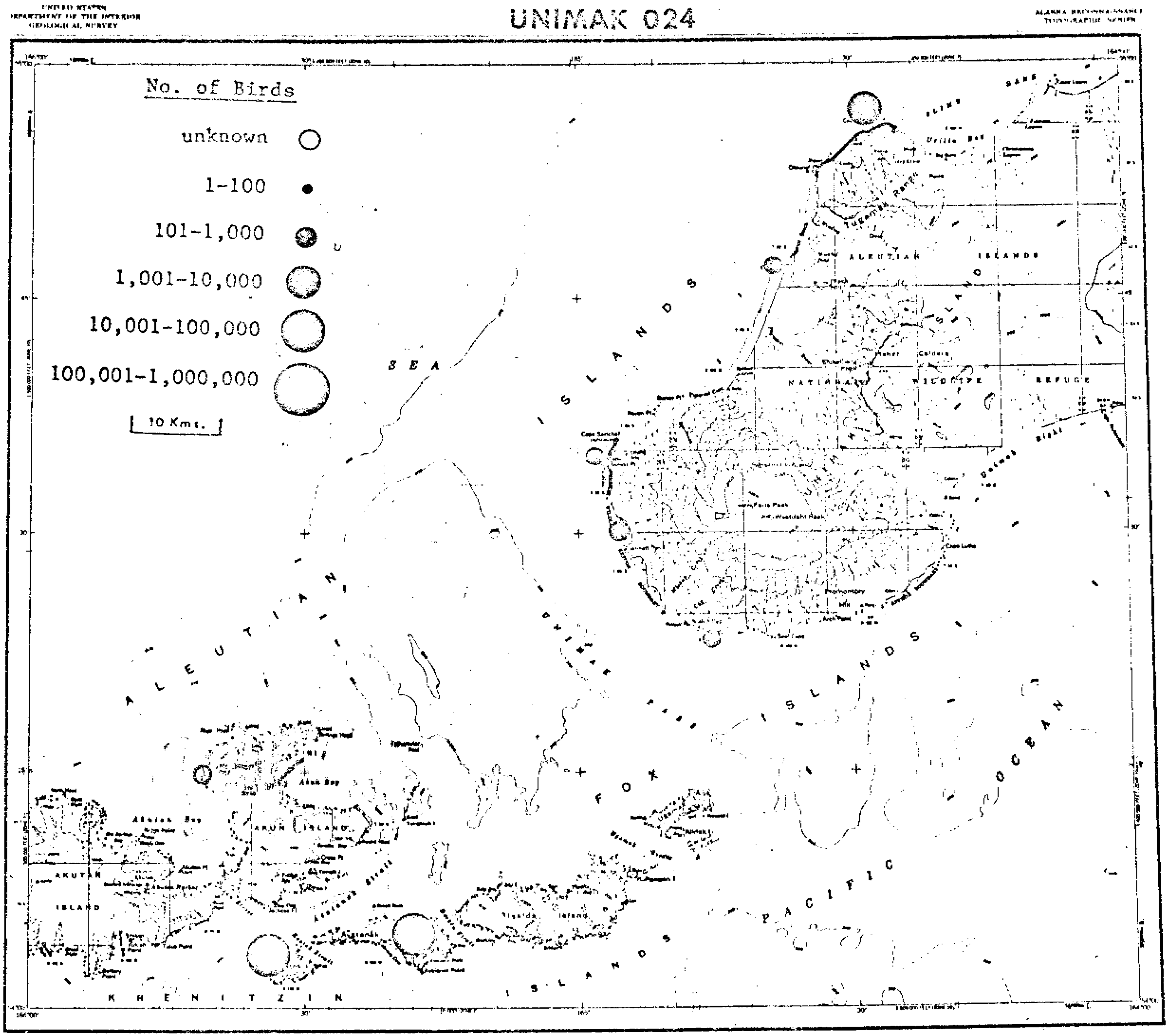

Figure 4. Comparative numbers of seabirds in colonies in topographic area 024, Unimak.

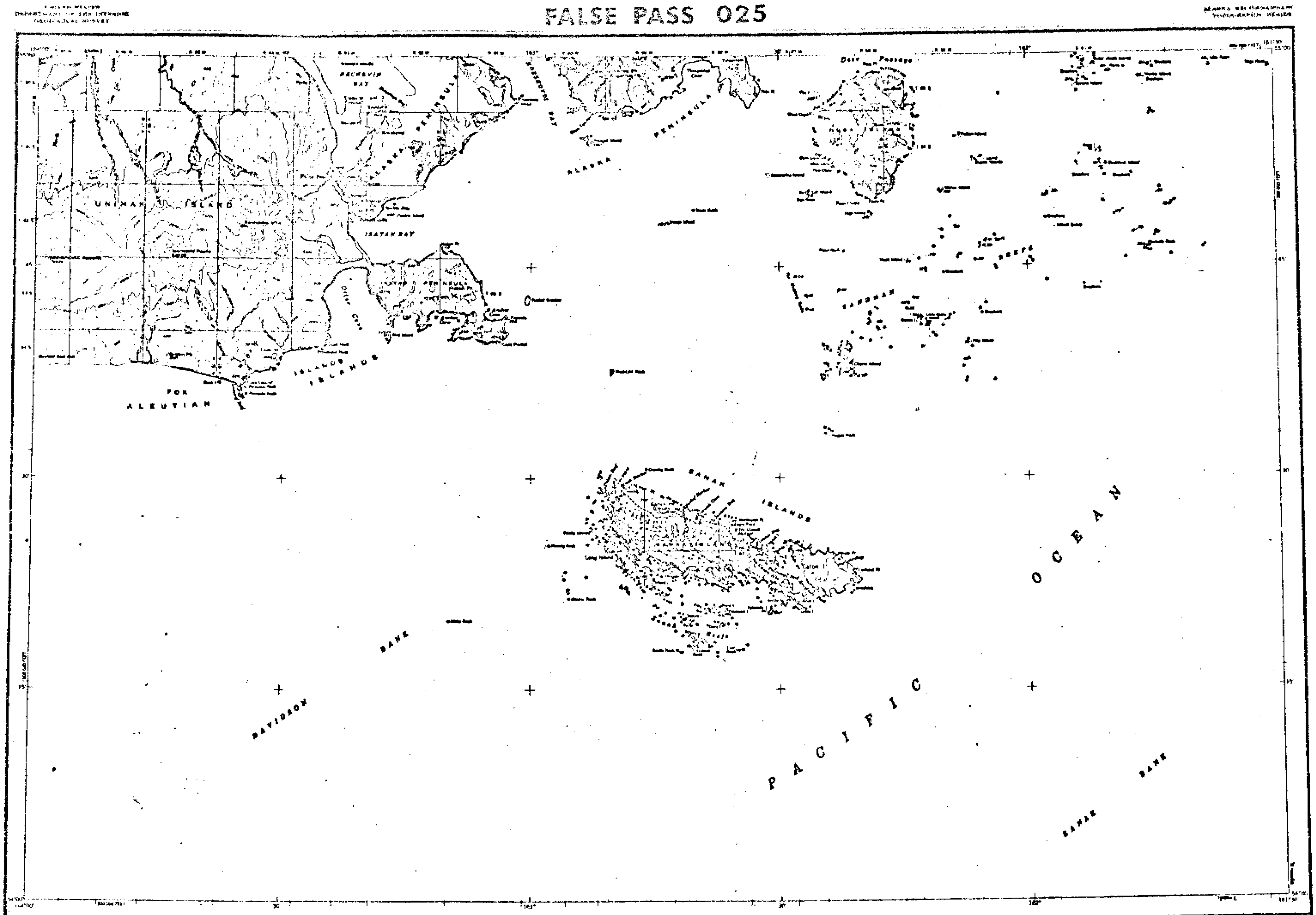

Figure 5. No reported seabird colonies in the Bristol Bay portion (arrow) of topographic area 025, False Pass.

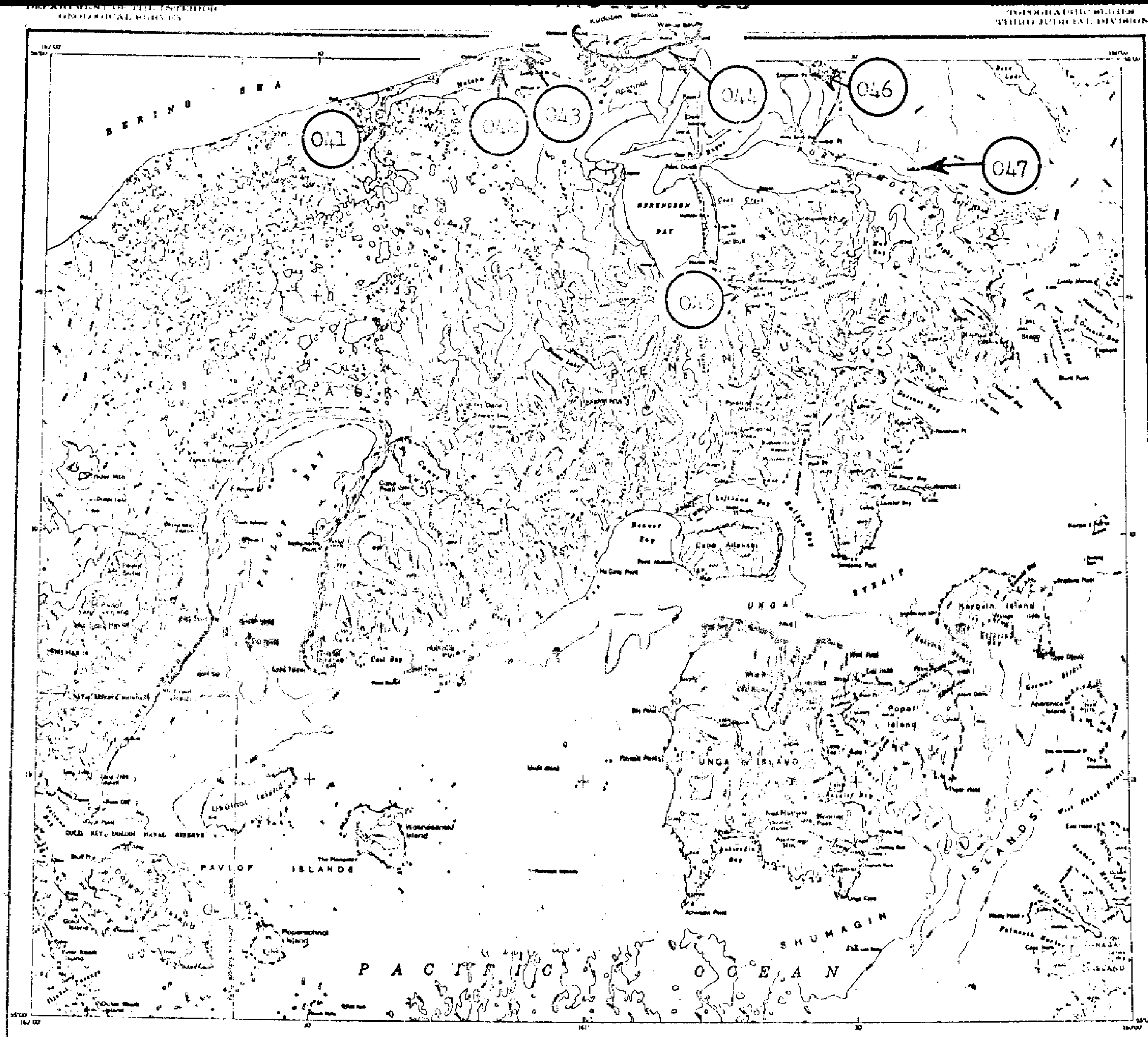

Figure 6. Locations of known seabird colonies in topographic area 028, Port Moller.

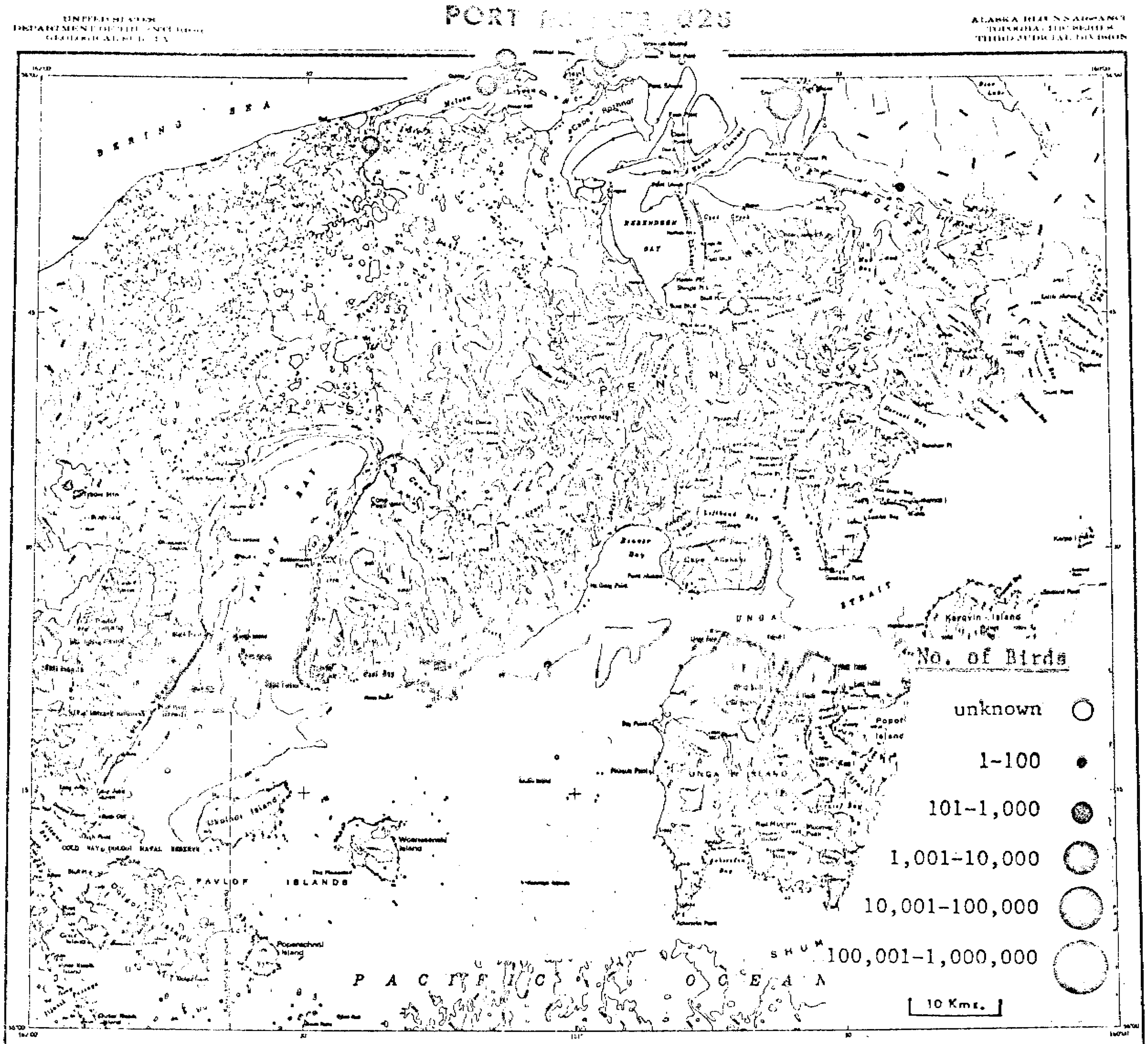

Figure 7. Comparative numbers of seabirds in colonies in topographic area 028, Port Moller.

Figure 8. Locations of known seabird colonies in the Bristol Bay portion of topographic area 029, Cold Bay.

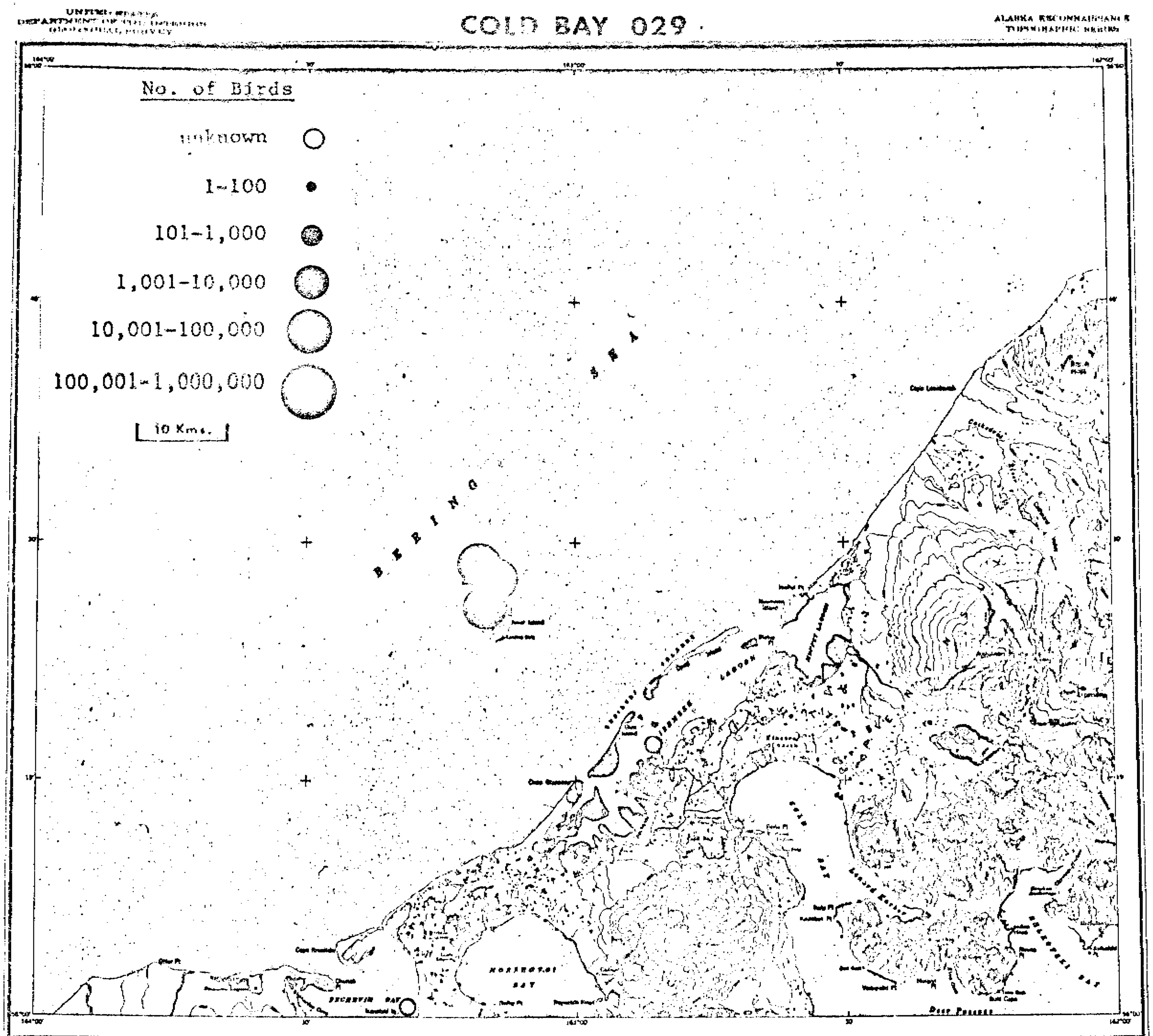

Figure 9. Comparative numbers of seabirds in colonies in the Bristol Bay portion of topographic area 029, Cold Bay

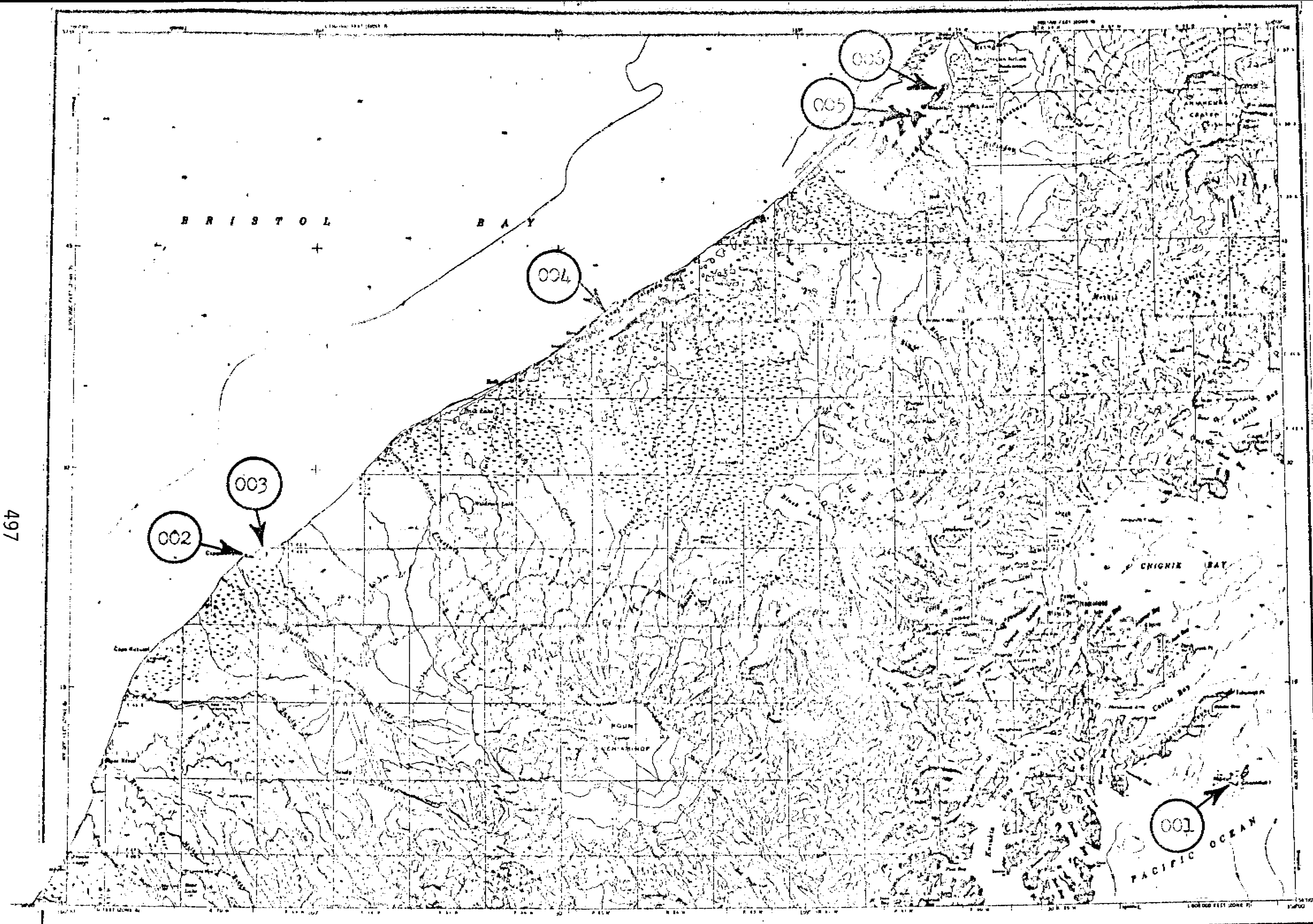

Figure 10. Locations of known seabird colonies in topographic area 030, Chignik.

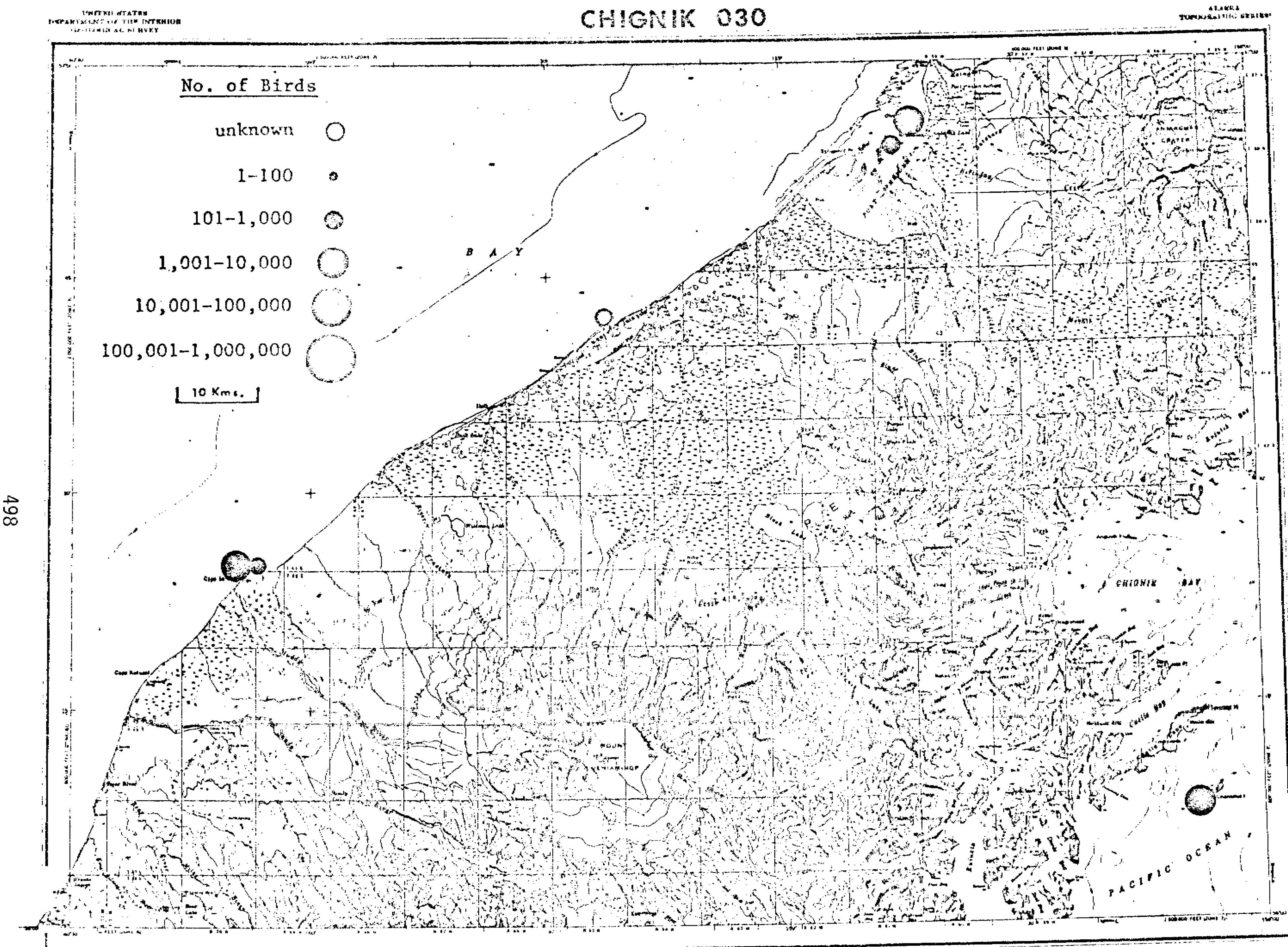

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Figure 11. Comparative numbers of seabirds in colonies in topographic area 030, Chignik.

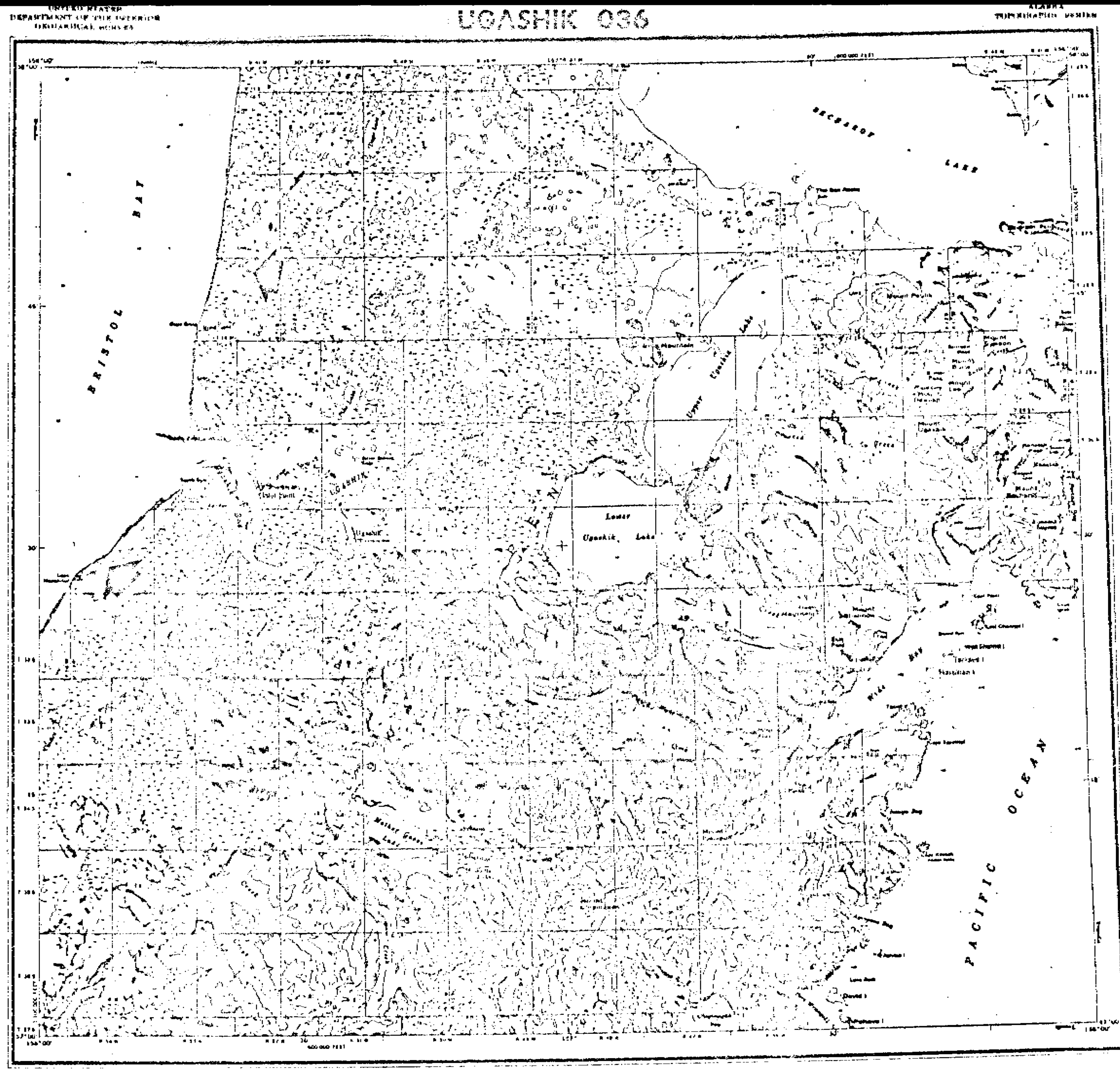

Figure 12. No reported seabird colonies in the Bristol Bay portion (arrows) of topographic area 036, Ugashik.

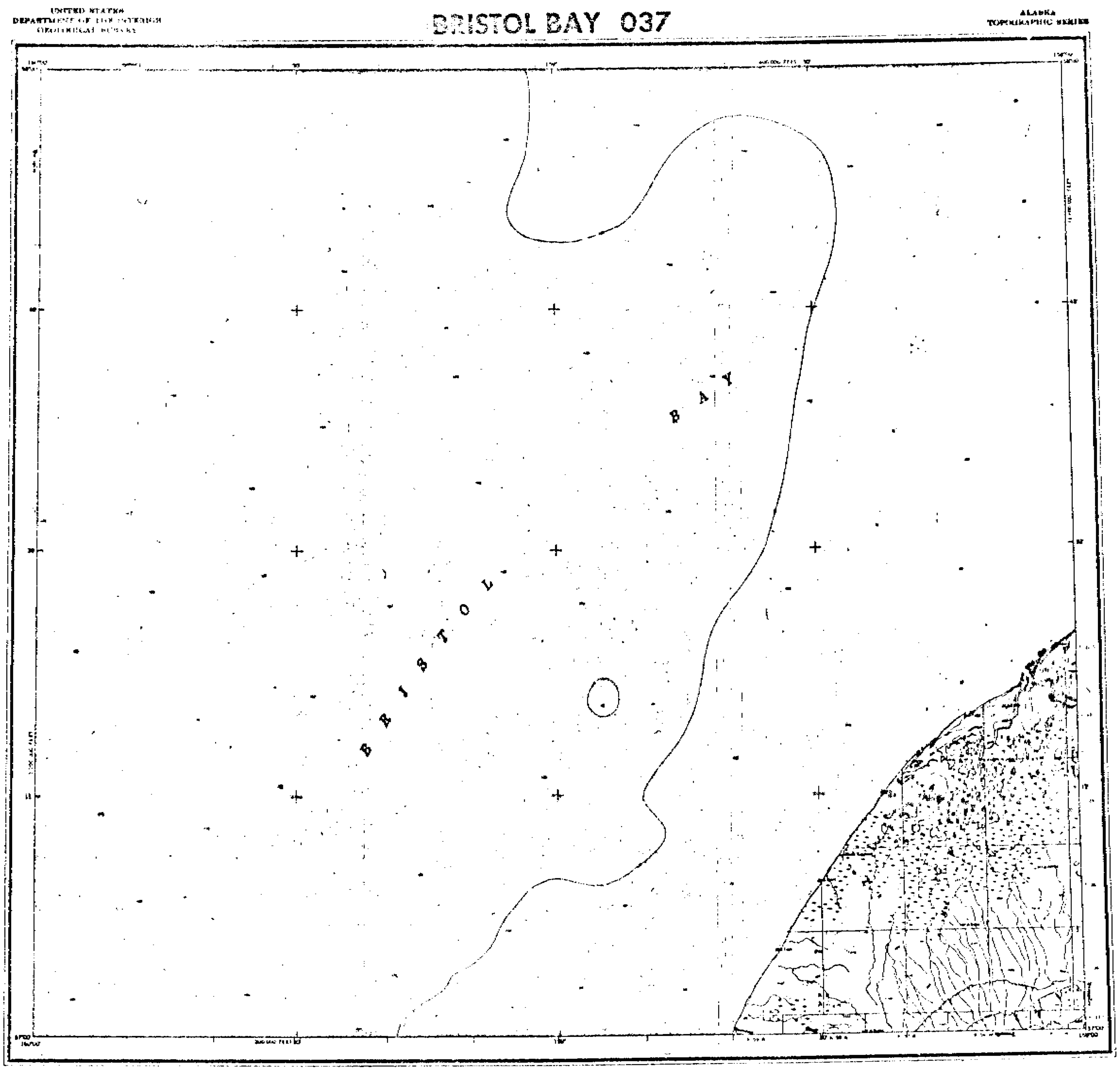

Figure 13. No reported seabird colonies in topographic area 037, Bristol Bay.

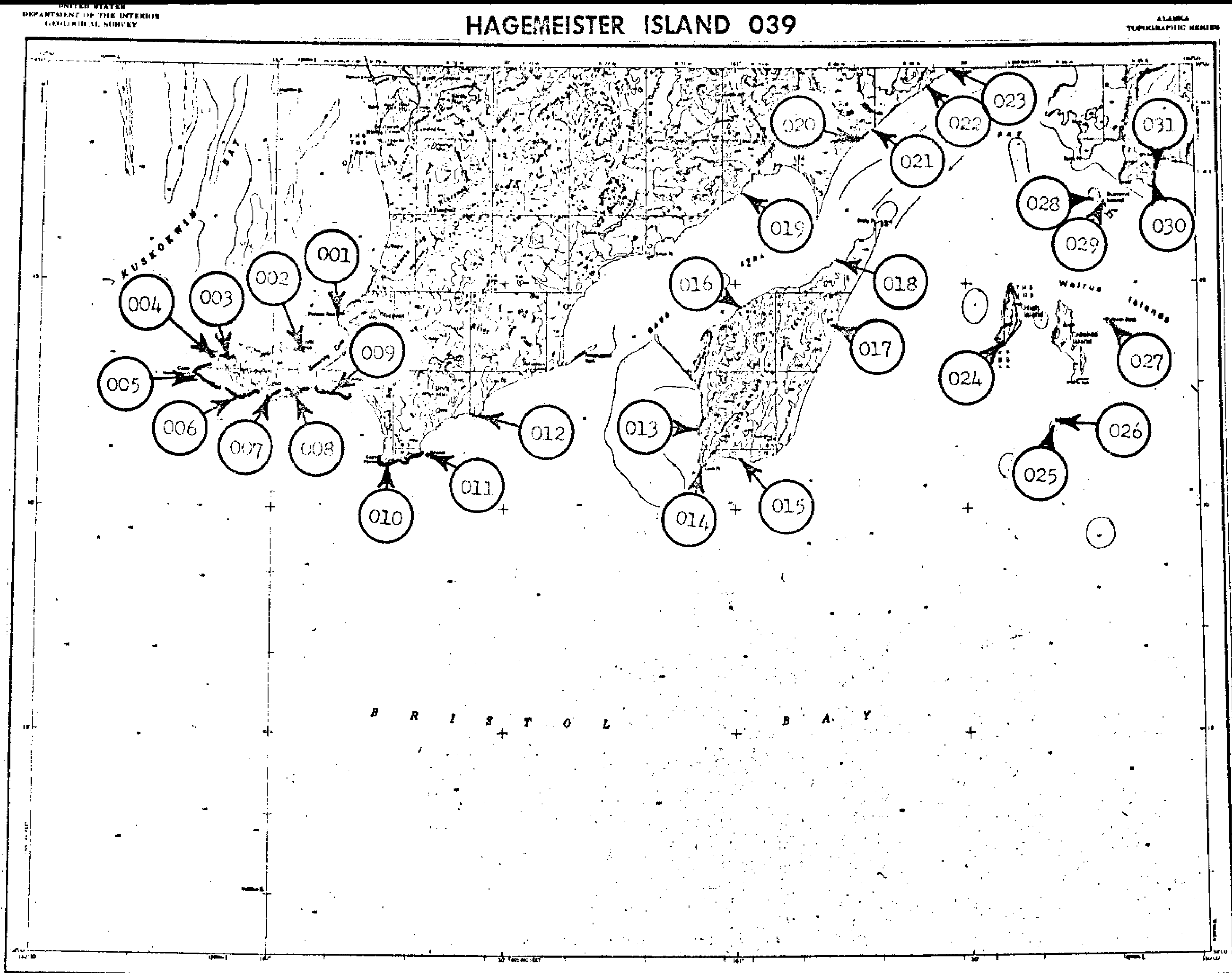

Figure 14. Comparative numbers of seabirds in colonies in topographic area 039, Hagemeister Island.

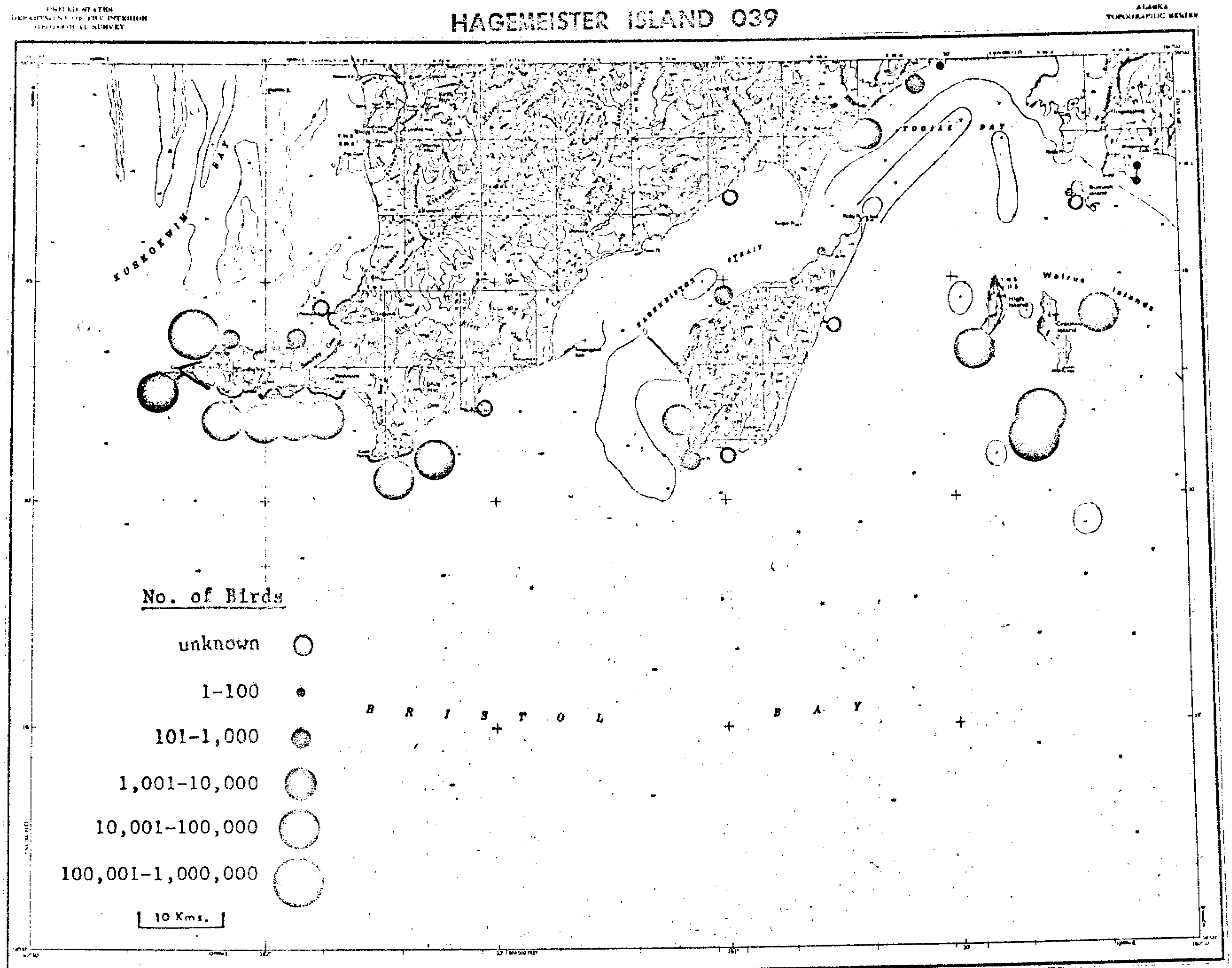

Figure 15. Locations of known seabird colonies in topographic area 039, Hagemeister Island.

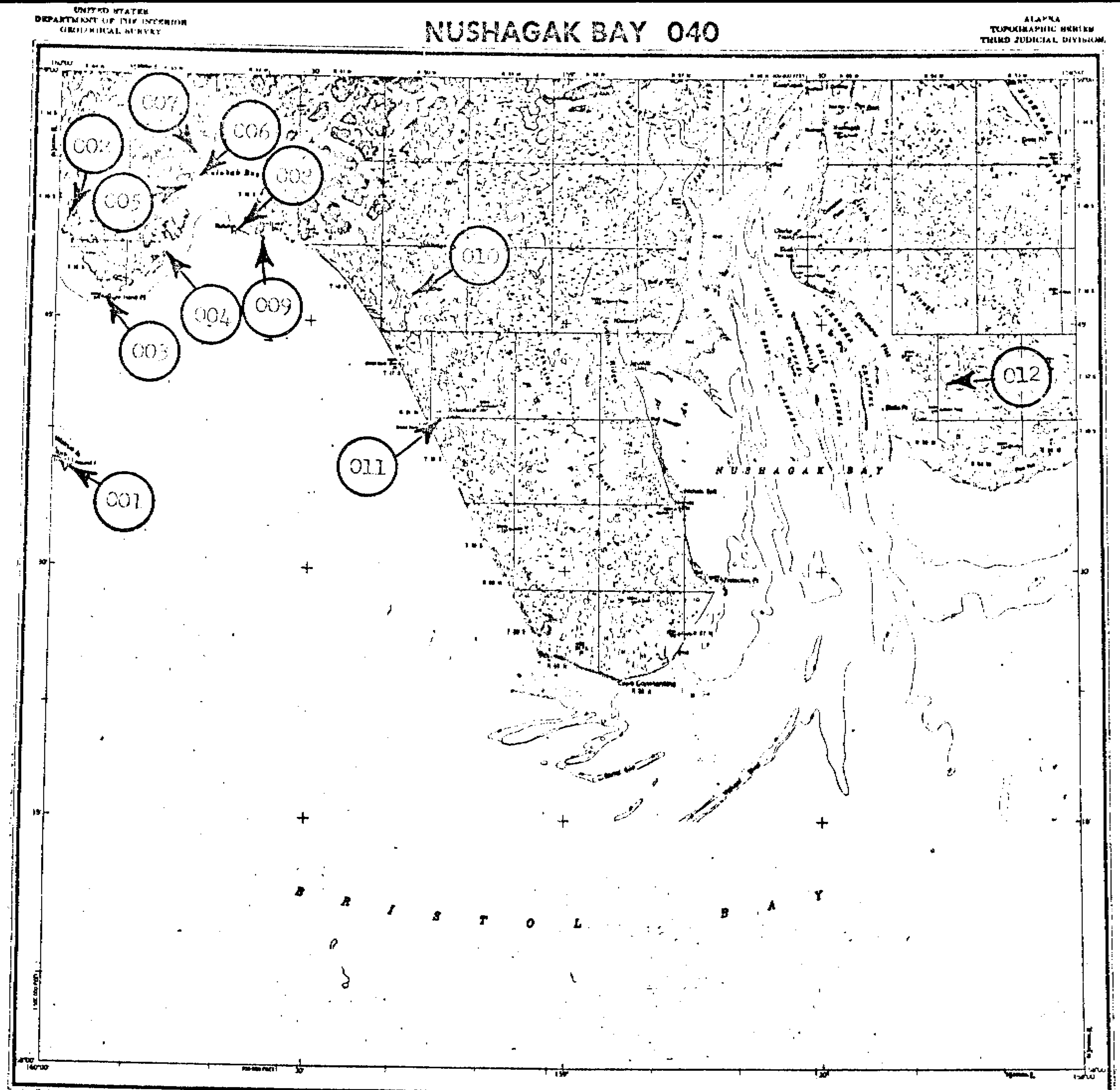

Figure 16. Locations of known seabird colonies in topographic area 040, Nushagak Bay.

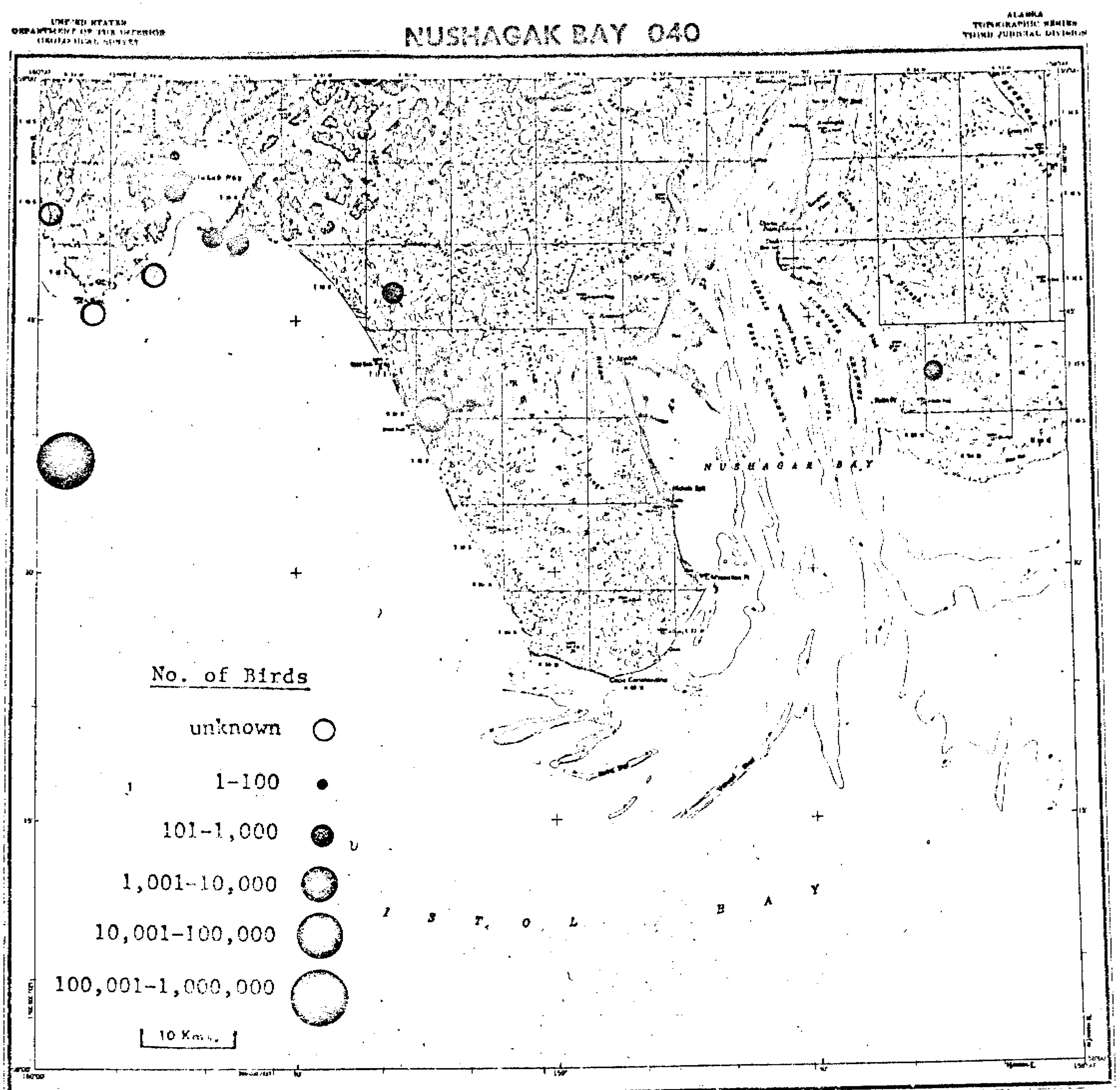

Figure 17. Comparative numbers of seabirds in colonies in topographic area 040, Nushagak Bay.

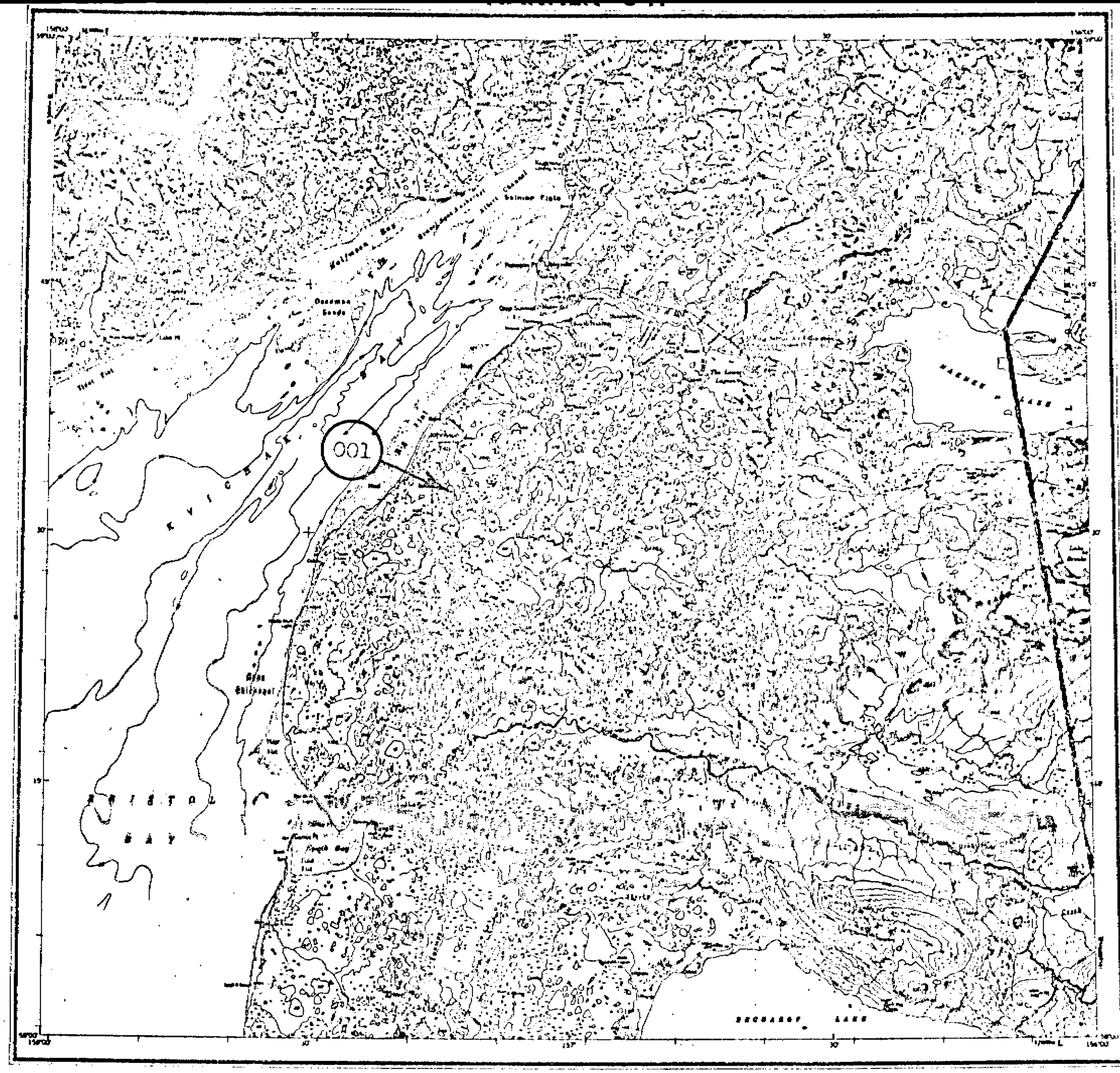

Figure 18. Locations of known seabird colonies in topographic area 041, Naknek.

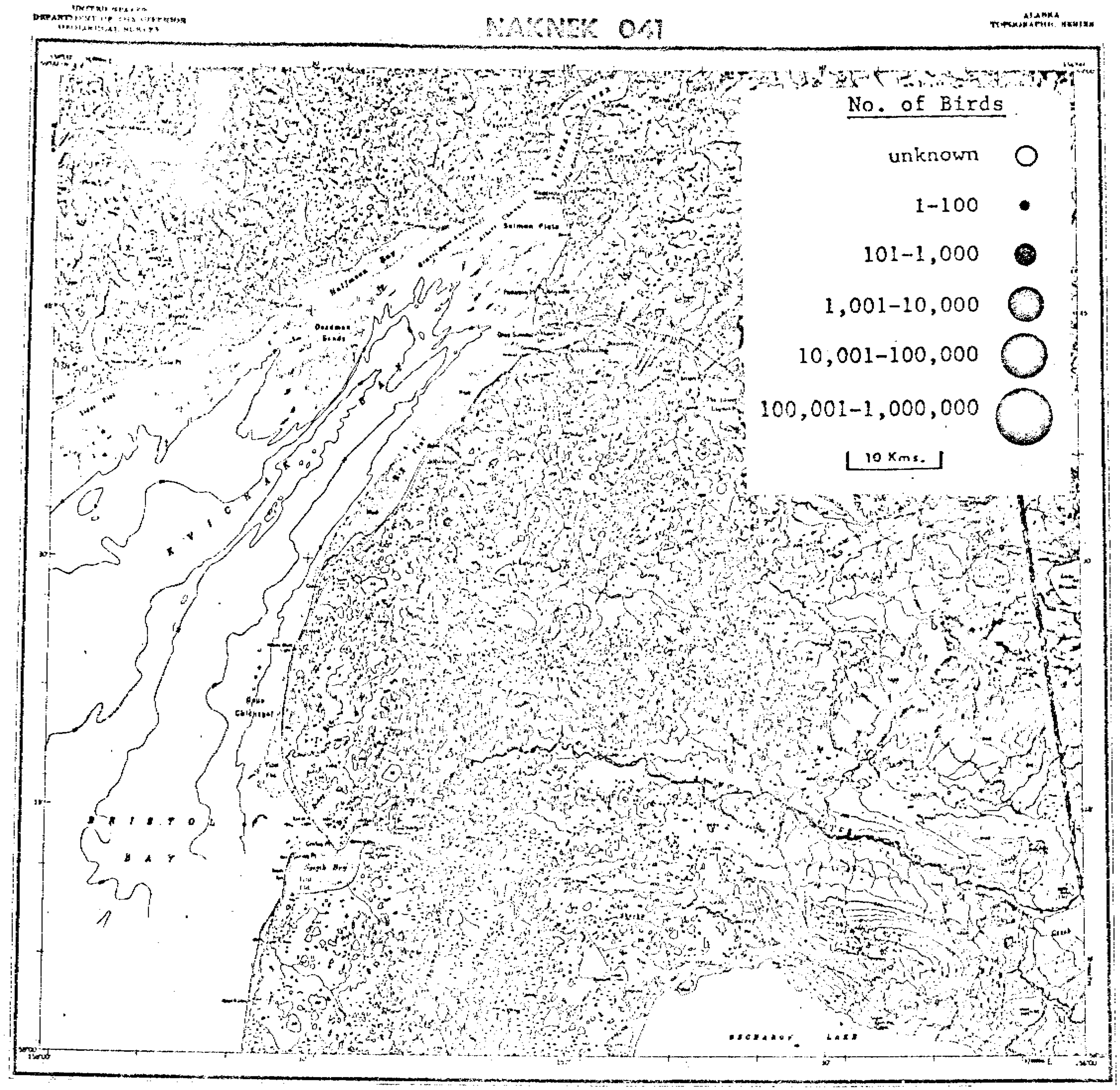

Figure 19, Comparative numbers of seabirds in colonies in topographic area 041, Naknek.

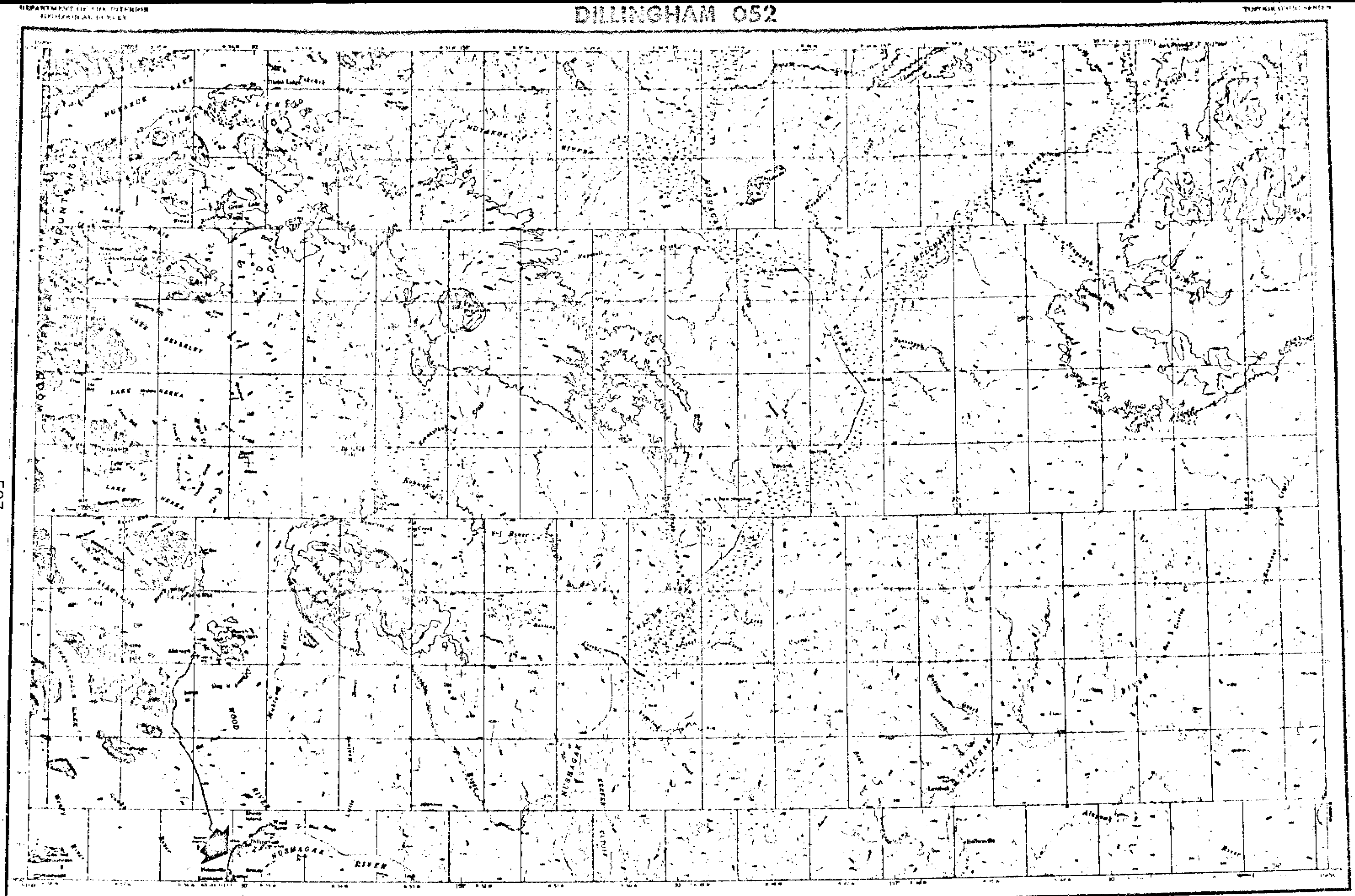

Figure 20. No reported colonies in topographic area 052, Dillingham.

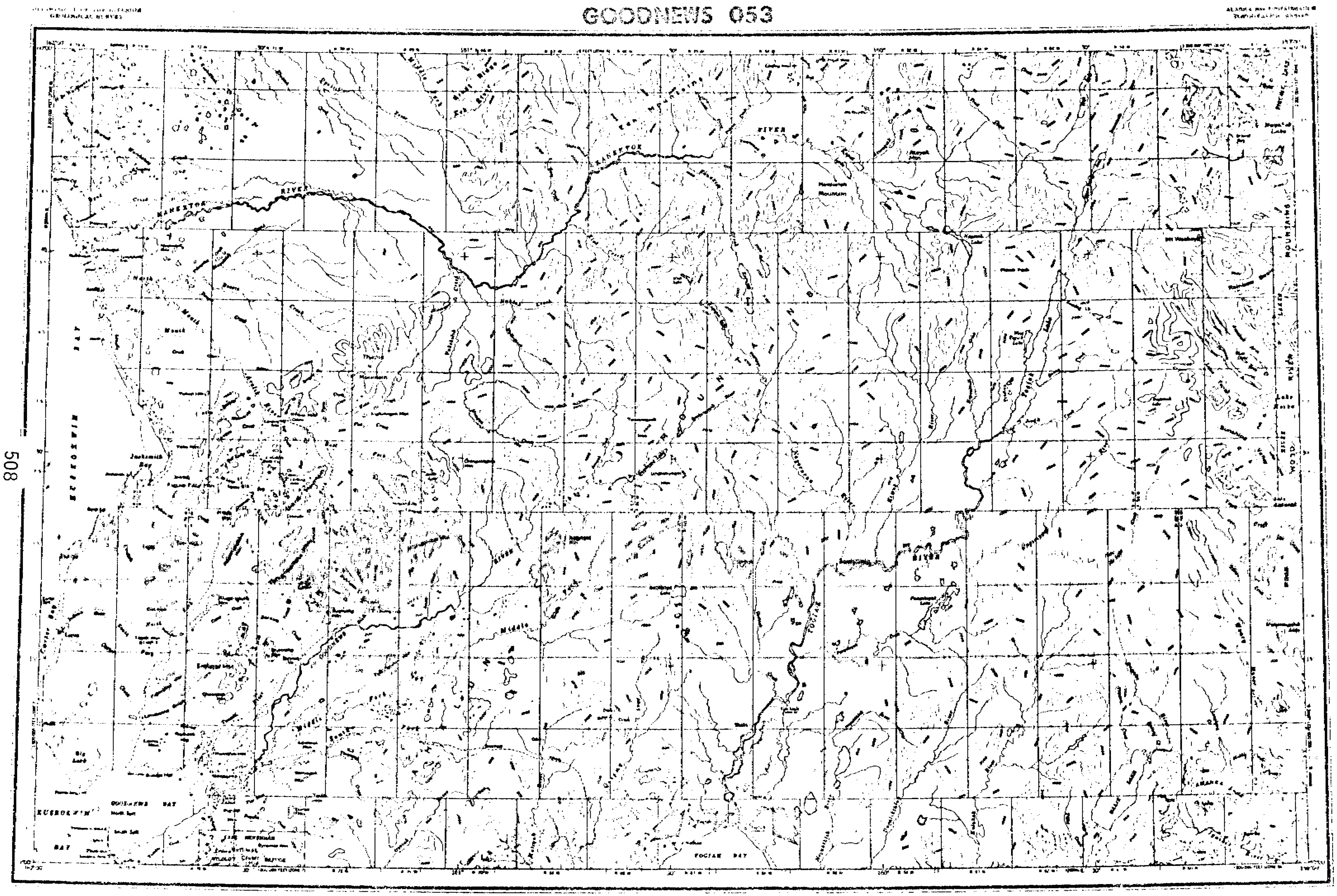

Figure 21. No reported colonies in the Bristol Bay portion of topographic area 053, Goodnews.

Table 1. Colony number, name and source of information for data on marine bird colonies in the Bristol Bay Basin (USF&WF, OBS-CE).

Colony No.	Colony Name	Information Source: Investigator	Information Source: Date
024004	Unimak I.	S. Hatch & C. Harrison	15 Aug 75
005	Unimak I.	" "	Aug 75
006	Sealion Pt. & vicinity	M. Phillips	May 76
007	Cave Pt.	"	"
008	Cape Mordvinof & Vicinity	A. Sowls et al.	5 Jun 76
028041	Is. in upper Nelson Lag.	R. Gill	Jun 76
042	Cannery I.	"	"
043	Lagoon Pt.	"	"
044	Kudobin Is.	"	"
045	Gull I.	"	"
046	Entrance Pt. (Port Moller Spit)	"	"
047	Egg I.	"	"
029001	Isanotski I.	R. Jones	No date
002	Amak I.	"	"
003	Sealion Rock (SE)	"	"
004	Sealion Rock (NW)	"	"
005	Unnamed I., Izembek Lagoon	"	"
030002	Cape Seniavin	J. Bartonek & G. Divoky	10 Jul 73
003	Cape NE from C. Seniavin	" "	"
004	Seal Is.	" & C. Evans	1 Jul 70
005	Crescent-shaped I.	" "	"
006	Chistiakof I.	" "	"
039001	Pinnacle Rock	" & G. Divoky	14 Jul 73
002	Castle Rock	" "	"
003	Cliff E of Bird Rock	" "	"
004	Bird Rock	" "	"
005	Cape Newenham	" "	"
006	Jagged Mt. Cliffs	" "	"
007	Oracle Mt. Cliffs	" "	"
008	Gap Mt. Cliffs	" "	"
009	Tokomanak Mt. Cliffs	" "	"
010	Cape Pierce	" "	"
011	Shaiak I.	" "	"
012	Pyrite Pt.	" & D. Cline	25 Jun 73
013	SW Hagemeister	" "	"
014	Calm Pt.	" "	"
015	S. Hagemeister	" "	"
016	Cliff "Hill 825"	" "	"
017	E. Hagemeister	R. Baxter	Jun 75
018	Offshore Rock, Hagemeister	J. Bartonek & D. Cline	25 Jun 73
019	Cliff E of "Hill 1348"	" "	"
020	Aeolus Mt. Cliff (s)	" "	"
021	Aeolus Mt. Cliff(N)	" "	"

Table 1. (Continued)

Colony No.	Colony Name	Information Source: Investigator	Date
022	Cliff "Hill 365"	J. Bartonek & D. Cline	25 Jun 73
023	Offshore I.	" "	"
024	High I. (S end)	" & G. Divoky	13 Jul 73
025	The Twins (little)	" "	12 Jul 73
026	The Twins (big)	" "	"
027	Black Rock	P. Arneson	20 May 76
028	Rock off Summit I.	J. Bartonek & D. Cline	25 Jun 73
029	Summit I.	R. Baxter	Jun 75
030	Cliff 1.5 mi. SE Nunavachak L.	J. Bartonek & D. Cline	25 Jun 73
031	Cliff 2.5 mi. SE Nunavachak L.	" "	"
040001	Round I.	" & G. Divoky	12 Jul 73
002	Cliff	" & C. Evans	5 Jul 70
003	Right Hand Pt.	" "	"
004	Metervik Bay, SW Pt.	" "	"
005	Rock in Kulukak Bay	" & D. Cline	25 Jun 73
006	Offshore I.	" "	"
007	Offshore I.	" "	"
008	Kulukak Pt.	" "	"
009	Promontory "Hill 835"	" "	"
010	Unnamed Lake, Nashagak P.	" & C. Evans	5 Jul 70
011	Kikertalik L.	" & J. King	Jun 70
012	Lake "57"	" & C. Evans	5 Jul 70
041001	Lake "110"	" "	3 Jul 70

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin.

SPECIES	Code No. (88+)	COLONY 024004	024005	024006	024007	024008
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000	50				
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600		200 r	700-800	1,000 +	p
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300					
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100					p
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000					
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200					
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100					p
Tufted Puffin	1010140100					p
Total		50	200 r	700-800	1,000 +	est. 10,000

r = roosting, P = present, p = probably nesting, pr = pairs

Table 2 Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY				
		028041	028042	028043	028044	028045
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000					
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300				3,900 pr	50 pr
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100					25 pr
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400		400-600pr	500 pr		
Aleutian Tern	1008070600					
Murre	1010030000					
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200					10-15pr
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100					12-18pr
Tufted Puffin	1010140100				15 pr	25 pr
Mew Gull		150 pr				
Total		150 pr	400-600pr	500 pr	3,915 pr	122 pr

pr = pairs

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY 028046	028047	029001	029002	029003
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000				P	P
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300		25pr			
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100				P	P
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400	200				
Aleutian Tern	1008070600	400-600pr		P		
Murre	1010030000				P	P
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200				P	
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100				P	P
Tufted Puffin	1010140100				P	P
Total		600pr	25pr	P	P	P

P = Present

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY 029004	029005	030002	030003	030004
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000	P		1,500	< 100	
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300					1,500 pr
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100	P		3,500	100	
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600		P			
Murre	1010030000	P				
Common Murre	1010030100			500	< 100	
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200					
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100	P				
Tufted Puffin	1010140100	P				
Total				5,500	> 100	1,500 pr

P = present, pr = pairs

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY				
		030005	030006	039001	039002	039003
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000	6 pr	50	p	120	110
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300	P	5,000-6,000			
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100					
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000					
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200					
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100				200	
Tufted Puffin	1010140100					10
Common Eider		p	p			
Total		?	5,050	p	320	120

pr = pairs, p = probably nesting, P = present

Table 1. Summary of data on marine bird colonies: Bristol Bay (cont'd).

SPECIES	Code No. (88+)	COLONY				
		039004	039005	039006	039007	039008
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000		110	210	180	70
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300	500	p			
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100	10,000	17,400	24,500	6,350	5,000
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000	200,000	30,300	41,500	15,300	10,000
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200		p			
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100		p			
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100		222	30		
Tufted Puffin	1010140100	5,000				
Total		215,000	48,032	66,240	21,830	15,070

p = probably nesting

Table 1. Summary of data on marine bird colonies: Bristol Bay (cont'd.).

SPECIES	Code No. (88+)	COLONY				
		039009				
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000	220				
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300					
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100	8,210				
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000	12,010				
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200					
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100					
Tufted Puffin	1010140100					
Total		20,570				

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY 039010	039011	039012	039013	039014
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000	453	276	p		100
Double-crested Cormorant	0404010200		P			
Pelagic Cormorant	0404010500		P			
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300	10	4,150			
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100	26,535	14,320		750	500
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000	35,320	53,800		1,000	
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200	100	190			
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100	120	230			
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100	262	50			
Tufted Puffin	1010140100	61	8,500			
Common Eider			200			
Total		62,861	81,716	p	1,750	600

P = present, p = probably nesting or roosting

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY				
		039015	039016	039017	039018	039019
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000	p	300	100	30	p
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300				20	
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100					
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000					
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200					
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100					
Tufted Puffin	1010140100					
Total		p	300	100	50	p

p = probably nesting

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY 039020	039021	039022	039023	039024
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000	200	500	250		472
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300			20	100	50
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100	300	1,000			42,400
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000					
Common Murre	1010030100					17,800
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200					2
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100					
Tufted Puffin	1010140100					
Bald Eagle						2
Total		500	1,500	270	100	60,726

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY 039025	039026	039027	039028	039029
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000	200	1,100	p	20	p
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300		450	p		p
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100	50,000	8,000	p		
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000	200,000	521,000			p
Common Murre	1010030100			10,000		
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200					
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100					p
Tufted Puffin	1010140100		4,100	p		
Total		250,200	535,150	100,000	20	p

p = probably nesting

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY				
		039030	039031	040001	040002	040003
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000			2,350	p	
Double-crested Cormorant	0404010200					
Pelagic Cormorant	0404010500	<100	<100			
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300			43		
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100			49,170		p
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000			72,030		
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200			44		
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100			534		
Crested Auklet	1010110100					
Least Auklet	1010110200			1,150		
Whiskered Auklet	1010110300			536		
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100					
Tufted Puffin	1010140100					
Total		<100	<100	125,857	p	p

p = probably nesting

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY 040004	040005	040006	040007	040008
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000	p	200			300
Double-crested Cormorant	0404010200				50 r	
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300			200 pr		
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100					
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000					
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200					
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100					
Tufted Puffin	1010140100					
Total		p	200	200 pr	50 r	300

p = probably nesting, pr = pairs, r = roosting

Table 2. Summary of data on marine bird colonies: Bristol Bay Basin (cont'd).

SPECIES	Code No. (88+)	COLONY				
		040009	040010	040011	040012	041001
Northern Fulmar	0302020100					
Fork-tailed Storm Petrel	0303020100					
Leach's Storm Petrel	0303020200					
Cormorant	0404000000	100	1			
Double-crested Cormorant	0404010200			800	100 pr	
Pelagic Cormorant	0404010500					
Red-faced Cormorant	0404010600					
Glaucous Gull	1008010100					
Glaucous-winged Gull	1008010300		75 pr	1,000 pr	100 pr	50
Herring Gull	1008010800					
Mew Gull	1008011300					
Black-legged Kittiwake	1008030100					
Red-legged Kittiwake	1008030200					
Sabine's Gull	1008050100					
Arctic Tern	1008070400					
Aleutian Tern	1008070600					
Murre	1010030000					
Common Murre	1010030100					
Thick-billed Murre	1010030200					
Pigeon Guillemot	1010050200					
Ancient Murrelet	1010080100					
Cassin's Auklet	1010090100					
Parakeet Auklet	1010100100					
Crested Auklet	1010110100					
Least Auklet	1010110200					
Whiskered Auklet	1010110300					
Rhinocerous Auklet	1010120100					
Horned Puffin	1010130100					
Tufted Puffin	1010140100					
Total		100	150 +	28,000	200 pr	50

pr = pair

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REVIEW AND ANALYSIS OF LITERATURE AND UNPUBLISHED DATA ON MARINE BIRDS

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INTRODUCTION

The objectives of this research unit are to provide an annotated bibliography of Alaskan marine birds and an analysis of the current status of information on marine birds of relevance to evaluating potential impacts from proposed developments of the Outer Continental Shelf.

PROJECT ACCOMPLISHMENTS

During this quarter we continued to collect and examine source documents for the comprehensive bibliography.

A bibliography of source information on bird resources in the Bristol Bay Basin (exclusive of St. George Basin) OCS lease sale area was prepared for the Service's response to the Bureau of Land Management's request for environmental data to be used in their deliberations on tract selection and deletion. Those references pertaining to birds are included in Appendix A.

A bibliography of bird resources of coastal and marine Alaska, with annotations as to regional significance, is anticipated to be completed by the end of next quarter.

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QUARTERLY REPORT

Contract: 01-6-022-11437
Research Unit: RU-340
Reporting Period: July 1, 1976 to
September 30, 1976
Number of Pages: 1 + 2

MIGRATION OF BIRDS IN ALASKA COASTAL AND MARINE HABITATS SUBJECT TO INFLUENCE BY OCS DEVELOPMENT

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October 1, 1976

INTRODUCTION

This report is a summary of efforts mainly during the quarter from 1 July through 30 September 1976 by U.S. Fish and Wildlife Service personnel, contractees, and collaborators to characterize the migration of birds in those Alaskan waters subject to petroleum development of the outer continental shelf. Information is presented on banding efforts, recent reports of sightings of banded birds, sea watch efforts, and a report of bird migration past Pt. Barrow during the fall of 1975.

The objectives of this research unit are to determine primarily migratory routes and secondarily patterns of seasonal density distribution of marine birds in those coastal and marine habitats of Alaska subject to impacts from outer continental shelf development. There are more than a hundred species of birds regularly frequenting these waters and coastal habitat, and each of those species has one or more populations with their own unique pathways and timing of migration. An understanding of these seasonal movements is necessary for resource managers to develop guidelines and schedule development activities such that adverse impacts do not occur at either critical localities, at critical times, or both. An understanding of affinities between wintering, breeding, summering and migrating populations of birds will permit an evaluation as to the potentially far-reaching effects of adverse impacts that could occur at a specific locality.

STUDY AREA

Contract stipulations limit the study areas to those Alaskan outer continental shelf areas being considered for oil and gas leasing. The U.S. Fish and Wildlife Service will ultimately characterize migration in all coastal regions, but we must place priorities on our regional reporting effort to be in sequence with the leasing schedule. Emphasis of our active acquisition of migration data is from the Gulf of Alaska to the southeastern Bering Sea where the majority of our field and shipboard studies are being conducted. Except for shipboard and aerial surveys, we have no field operations in the northeastern Bering Sea, Chukchi Sea, and Beaufort Sea; and, therefore, migration information from these areas will largely be passively acquired.

METHODS

This study is dependent upon observations of bird occurrence or lack of their occurrence at many locations throughout coastal Alaska throughout the year. Data are, in part, acquired through observations made during other research activities, especially Research Unit #342 dealing with population dynamics of marine birds and Research Unit #337 dealing with seasonal distribution and abundance of birds, from other OCSEAP investigators, and from other cooperators who are not affiliated with OCSEAP programs. Published and unpublished information on seasonal occurrence of birds are incorporated with the currently collected data. Banding data are filed with the U.S. Fish and Wildlife Service, Bird Banding Laboratory, Laurel, Maryland.

RESULTS AND DISCUSSION

Since reporting encounters of 12 banded glaucous-winged gulls in the Quarterly Report RU-340 (1 July 1976), 2 additional banded gulls have been reported. A glaucous-winged gull banded (USFWS #967-63031) as a chick on Kodiak Island by Matthew Dick and Irving Warner on 20 July 1975 was found dead at the Tsacawis River mouth, British Columbia, on 5 December 1975. Another glaucous-winged gull which was banded (USFWS #1047-82094) as a chick by Samuel Patten near Cordova on 15 July 1975 was found dead at Anchorage, Alaska, on 30 August 1975.

While a considerable amount of banding was done by personnel and cooperators at the various field camps, only a few of the banding schedules covering 400 banded birds were completed and submitted to the USFWS Bird Banding Laboratory by the end of this quarter. Bob Jones and Matt Kirchhoff banded 6 birds on the Yukon Delta; Marshall Howe and Dave Frazer banded 348 birds on Middleton Island; and Margaret Peterson and Marilyn Sigman banded 46 birds at Cape Peirce. Among the birds banded for which schedules have been submitted were: 10 cormorants, 7 glaucous-winged gulls, 290 black-legged kittiwakes, 1 common murre, 8 rhinoceros auklets, 51 tufted puffins, 6 Canada geese, 1 sandhill crane, 10 shorebirds, and 16 passerines. Many of these birds were color-marked to aid in the identification of individuals and known-age birds during subsequent years.

Although "sea watches" were largely terminated by early September when most field camps were closed, migrational information was intermittently collected through September at the Nelson Lagoon and Unimak Pass field camps (see Quaterly Report RU-341/342, 1 October 1976). Completed "sea watch" data forms were inspected prior to their submission for keypunching early next quarter.

QUARTERLY REPORT

Contract: 01-5-022-2538
Research Unit: RU-341, RU-342
Reporting Period: July 1, 1976 to
September 30, 1976
Number of pages: i + 11

FEEDING ECOLOGY AND TROPHIC RELATIONSHIPS OF ALASKAN MARINE BIRD (RU-341)

AND

POPULATION DYNAMICS OF MARINE BIRDS (RU-342)

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October 1, 1976

INTRODUCTION

Research Units RU #341 and 342 were designed to help satisfy the objectives of OCSEAP Task A-6 which are to describe the trophic relationships and the population dynamics of selected species at offshore and coastal study sites. Since personnel, coastal study sites, and ships, involved in RU #341 are largely identical with those involved in RU #342, the two research units are treated together in this report. This report contains a list of our activities related to these research units primarily during the quarter from 1 July to 30 September 1976.

STUDY AREA

Activities under these two research units were largely restricted to the Gulf of Alaska and the southeastern Bering Sea. Table 1 lists those field operations where data for these units were collected.

METHODS

See our Annual Reports for RU #341 and 342 of 1 April 1976.

RESULTS

Fourteen field camps from Forrester Island in extreme southeastern Alaska to the outer Yukon River delta were operated this quarter. Personnel and the approximate dates of arrival and departure at these field camps are presented in Table 1. Most study sites were selected because of the dominant species present, their unique habitat, the potential vulnerability of the locality to impact from OCS activities, or all (see our Annual Report RU #342, Tables 1 and 2, 1 April 1976). Information on both trophic relationships and population dynamics were collected at most of these sites.

Birds were collected during 4 cruises and at 14 field sites for determination of food habits (Table 1). Most of the detailed analyses will be done during subsequent quarters.

Throughout the quarter a concerted effort by Gerald Sanger, Claire Vita, Pat Baird and Pat Gould was directed towards "rough" processing the hundreds of birds collected by various personnel for food studies. The cumulative lab statistics through September are: 761 birds collected for food habit studies; 457 specimens accessioned into the collection; 154 specimens "rough" sorted and food items cursorily identified; and 26 specimens having been completely sorted and analyzed (Table 2). There are perhaps an additional 100 specimens that came into the lab in mid-September that are not accounted for in these numbers of specimens. Much of the sorting time was spent learning recognition of parts of animals and learning which of these are useful for determining the original size of the prey organisms.

Highlights of findings include: sooty shearwaters collected near Kodiak during both 1975 and 1976 were eating mainly capelin (Mallotus villosus) approximately 15 cm in length; arctic and Aleutian terns collected near Icy Bay were eating mainly euphausiids (Thysanoessa inermis) approximately 20 mm in length; and 25 percent of the samples specimens receiving "rough" sorting contained plastic particles of an unknown origin.

Table 3 shows the distribution of collecting effort for four of the more common marine birds of the region.

During the next quarter a greater proportion of time will be spent processing specimens and a lesser proportion of time spent collecting them.

The chartered F/V Nordic Prince resupplied five camps in the Gulf of Alaska during the first part of the quarter and picked up the personnel, equipment and supplies in early September. Weather, mechanical and other problems caused a delay in operation of the Nordic Prince, extending the charter a week beyond that of which we had budgeted. Despite some problems, we believe that chartering this vessel was both more job effective and cost effective than using NOAA-operated boats (assuming that our prorata cost of the NOAA vessel could be identified).

Data on production, mortality, habitat selection, growth rates, nest attendancy, beached bird surveys and other aspects of RU#342 were collected at most of the 14 field stations during this quarter (Table 1). During this quarter data are being inspected prior to their being keypunched. Most or all these data will be submitted to NOAA by the end of November 1976.

A progress report on activities by Scott Hatch (Field Operation FW76024) on Semidi Island during this summer is included as Appendix A.

Table 1. Log of U.S. Fish and Wildlife Service, Office of Biological Services - Coastal Ecosystems' field operations for the study of marine birds, 1 July to 30 September 1976. (■ = field operations associated with RU#341; ● = field operations associated with RU#342).

Date	Field Operation Number	Platform or Type of Study	Location[1/]	Personnel
■●22 Apr - 5 Aug	76022	Field Camp	Hinchinbrook I.	David Nysewander, Pete Knudtson
■●26 Apr - 9 Sep	76023	Field Camp	Cape Peirce	Margaret Peterson, Marilyn Sigman
■●29 Apr - 3 Sep	76024	Field Camp	Semidi Is.	Scott Hatch, Martha Hatch
■29 Apr - 7 Sep	76025 to 49	NORDIC PRINCE	Prince William Sound to Shimagin Is.	Art Sowls, Pat Gould, John Hall, Pat Baird, Kevin Powers, Ed Bailey
■●9 May - 1 Sep	76053	Field Camp	Forrester I.	Earl Possardt, Tony DeGange
■●11 May - 5 Sep	76054	Field Camp	Barren Is.	David Manuwal, Dee Boersma, Naomi Manuwal, Mike Amarel, Mary Nerini
■●16 May to date	76056	Field Camp	Nelson Lagoon	Bob Gill, Paul Jorgensen, Tony DeGange
■●20 May - 3 Sep	76059	Field Camp	Semidi Is.	Galen Burrell, Lora Leschner
■●20 May - 1 Sep	76060	Field Camp	Ugaiushak I.	Duff Wehle
■●20 May - 11 Jul	76061	Field Camp	Ugaiushak I.	Eric Hoberg, Kevin Powers
■●20 May - 3 Sep	76062	Field Camp	Big Koniuji I.	Bob Day
■●20 May - 3 Sep	76063	Field Camp	Big Koniuji I.	Ted Schad, Allen Moe

Table 1 (Cont'd). Log of U.S. Fish and Wildlife Service, Office of Biological Services - Coastal Ecosystems' field operations for the study of marine birds, 1 July to 30 September 1976.

Date	Field Operation Number	Platform or Type of Study	Location[1/]	Personnel
■● 1 Jun - 27 Sep	76069	Field Camp	Kodiak I.	Matt Dick, Jay Nelson
■● 6 Jun - 2 Aug	76073	Field Camp	Middleton I.	Marshall Howe, Dave Frazer
■●15 Jun - 23 Jul	76074	Field Camp	Yukon Delta	Bob Jones, Matt Kirchhoff
■22 Jun - 17 Jul	76075	MOANA WAVE	Leg VIII	Doug Forsell
●30 Jun - 16 Jul	76076	Field Camp	Unimak Pass	Mark Rauzon
15 - 16 Jul	76077	DISCOVERER	Seattle-Kodiak	Keith Metzner
■17 - 31 Jul	76078	DISCOVERER	NWGOA	Keith Metzner
■●27 Apr - 7 Sep	76080	Field Camp	Copper R. Delta	Stan Senner
■● 7 May - Sep	76081	Field Camp	Wooded Islands	Peter Mickelson, Bud Lenhausen
5 - 30 Jul	76082	LINDBLAD EXPLORER	GOA; APS, BS, HB	Colleen Handel, Sue Bates
23 - 31 Jul	76083	MOANA WAVE	NWGOA	Craig Harrison
■ 4 - 18 Aug	76085	DISCOVERER	Leg II	Keith Metzner
17 - 27 Aug	76086	Aerial Survey	Arctic Ocean, NE Bering Sea	Craig Harrison, Colleen Handel, Art Sowls, Radike (NMFS)

Table 1 (Cont'd). Log of U.S. Fish and Wildlife Service, Office of Biological Services - Coastal Ecosystems' field operations for the study of marine birds, 1 July to 30 September 1976.

Date	Field Operation Number	Platform or Type of Study	Location[1/]	Personnel
23 Aug - 2 Sep	76087	MILLER FREEMAN	Transit Seattle-Nome	Pat Baird
● 31 Aug - 19 Sep	76088	MOANA WAVE	Norton Sound, Hope Basin	Pat Gould
● 20 Sep to date	76089	MOANA WAVE	Bering Sea	Pat Gould
● 1 - 3 Sep	76090	SURVEYOR	GOA	Gerald Sanger
15 Sep to date	76091	Field Camp	Unimak Pass	Jay Nelson

Table 2. Summary of specimens collected and initial progress in food sample analyses in studies of marine bird trophic relationships by the U. S. Fish and Wildlife Service, through September 1976.

Species	Number of Specimens Collected	Number of Food Samples: Logged In	Rough Sorted	Final Sorted	With Plastic Particles
Laysan Albatross	1	1	1		
Northern Fulmar	29	26	7	1	5
Sooty Shearwater	46	41	14		8
Short-tailed Shearwater	40	37	27	1	20
Fork-tailed Storm Petrel	9	4	1		1
Leach's Storm Petrel	5	1			
Pelagic Cormorant	8	5			
Red-faced Cormorant	2	1			
Pintail	2				
Oldsquaw	2	1			
Harlequin	3	1			
White-winged Scoter	1	1			
Semipalmated Plover	1				
Rock Sandpiper	5				
Wood Sandpiper	1	1			
Wandering Tattler	1				
Lesser Yellowlegs	1				
Dunlin	5				
Northern Phalarope	4	1			
Pomerine Jaeger	3	1			
Glaucous Gull	7	2	1		1
Glaucous-winged Gull	45	21			

Table continued

Table 2 (continued)

Species	Number of Specimens Collected	Number of Food Samples			
		Logged In	Rough Sorted	Final Sorted	With Plastic Particles
Glaucous-winged X Herring Gull	1	1			
Herring Gull	4	4			
Mew Gull	3	3	2		
Bonaparte's Gull	1	1			
Ivory Gull	2	1			
Black-legged Kittiwake	81	53	8	1	
Red-legged Kittiwake	4	2	2		
Sabine's Gull	1	1			
Arctic Tern	20	20	19	18	
Aleutian Tern	5	5	3	3	
Common Murre	58	33	10	1	
Thick-billed Murre	56	46	31		2
Pigeon Guillemot	13	4			
Marbled Murrelet	32	26			
Kittlitz's Murrelet	9	7			
Ancient Murrelet	11	8	1		
Cassin's Auklet	5	5			
Parakeet Auklet	18	1			
Crested Auklet	15	6	1		
Least Auklet	5	2	1		
Rhinoceros Auklet	44	19			
Horned Puffin	37	10	4		1
Tufted Puffin	115	54	23	1	1
TOTALS	761	457	156	26	38

Table 3. Times and geographical locations from which shearwaters and murres have been collected for food habits studies by U. S. Fish and Wildlife Service as of September 1976.

Location[1]	Sooty Shearwater			Sht-tld Shearwater			Common Murre			Thick-billed Murre		
	pre1975	1975	1976	pre1975	1975	1976	pre1975	1975	1976	pre1975	1975	1976
Beaufort Basin												
Hope Basin												
Norton Basin									1			
Eastern Central Bering Sea												
Navarin Basin												3
Bristol Bay					2	4			6		1	
St. George Basin					6	1	2		1	7		1
Oceanic Aleutians	5			8					5	5		3
Umnak Basin					1	1		1		3		
Alaskan Peninsula South						5						
Kodiak Basin		8				3			14			9
Shelikof Strait									3			5
Lower Cook Inlet									3			
Northwest Gulf of Alaska		2	4			3			6			2
Northeast Gulf of Alaska			19						2			
Oceanic Alaskan Pen. South	3			2						16	1	
Oceanic South Kodiak				4								

Number of Specimens

[1] Please refer to Annual Report# 341, 1 April 1976, p. 19, for a description of the locations.

APPENDIX A

POPULATION ECOLOGY AND BREEDING BIOLOGY OF FULMARS AT SEMIDI ISLANDS, ALASKA[1]

A Progress Report submitted by Scott Hatch, September 11, 1976.

A study on the population of the Pacific fulmar (Fulmarus glacialis rodgersii) breeding at Semidi Islands, Alaska has been undertaken with the following primary objectives:

1. To determine the distribution and abundance of fulmars at Semidi Islands.
2. To describe the nesting habitat utilized by fulmars at Semidi Islands and characterize its relationship to other seabirds.
3. To determine the breeding phenology of fulmars during the 1976 and 1977 seasons.
4. To obtain information on breeding biology, productivity and factors affecting productivity of fulmars at Semidi Islands.

The 1976 field work schedule extending from 6 May to 3 September proved adequate in most respects, notwithstanding the protracted breeding cycle of the fulmar which, including the fledging of young beginning about mid-September and re-occupation of the colony during winter may span the better part of each year.

Troyer (Wilderness Record, Semidi Wilderness Proposal, USFWS, Anchorage, Alaska, 1972) estimated the Semidi Islands population of fulmars to be 386,000 during a May, 1972 visit. In the present study fulmars were censused along approximately 2 km of cliffs on the western side of Chowiet Island from 23 June to 8 July. Numbers of pairs, singles, light phase individuals and incubating birds were counted. These data are to be interpreted with reference to concomitant data on daily changes in colony attendance, survivorship of eggs, and the proportions of breeding and nonbreeding birds at the colony. A preliminary analysis indicates the number of prospective and actual breeders utilizing the census area is probably not less than 30,000. The area censused comprises approximately one half of a colony to which Troyer (loc. cit.) attributed 10,000 birds. This does not imply that the figure 386,000 underestimates the actual Semidi Islands population by 600 percent since other of the previous observer's component estimates are probably considerably more accurate. Attendance of fulmars at their breeding ledges during May can fluctuate drastically from day to day.

Fulmars utilize cliffs along most of the total shoreline of the Semidi Islands. Extensive photographic coverage of colonies in both color and black and white film was obtained from the water during July and August for the purpose of delineating nesting areas and documenting the current usage of the islands by fulmars and associated cliff nesting birds. The shorelines of Kateekuk, Anowik, Kaliktagik, Suklik and Aliksemit Islands were covered in their entirety, along with all cliffs occupied by fulmars on Chowiet Island.

Habitat data collected for all study plots and individual

[1] U. S. Fish and Wildlife Service, Office of Biological Services - Coastal Ecosystems, Anchorage, Alaska, Field Report 76024.

nestsites included identification and percentage cover of dominant vegetation, slope, exposure, elevation, substrate and distance to the nearest neighboring nestsite.

Attendance at the colony was monitored throughout the season through daily observations of 5 study plots in May and later on 12 separate plots comprising about 800 nestsites altogether. Numbers of pairs, singles, light phase individuals and active nests, i.e., those containing an egg or chick, were recorded along with appropriate weather data.

Altogether, over 575 individual nestsites were monitored for all or part of the season. These have been located either photographically or marked on the ground in such a manner that they can be relocated in subsequent years. Observations made on these sites were as follows:

255 sites--located photographically prior to egg laying and checked daily from mid-May to 3 September to determine the distribution of egg laying dates, incubation period and survival rates of eggs and young.

150 sites--numbered and marked on the ground; a plot established prior to egg laying and not revisited until after all young were hatched in late August.

61 sites--added as eggs were laid and checked daily thereafter.

34 sites--active nests of light phase-dark phase pairs added just prior to the onset of hatching and checked daily thereafter.

26 sites--selected during the hatching stage for growth studies. 13 chicks survived as of 3 September. Growth data were obtained every other day from hatching.

50 sites--"successful" sites recorded photographically in late August.

Continued observations on nestsites in which eggs were never laid and on failed sites after failure were maintained along with active sites. These data are being analyzed in conjunction with data on colony attendance with the aim of describing the movements of the various categories of breeding and nonbreeding birds.

Glaucous-winged gulls (Larus glaucescens) are the principal predators on eggs of fulmars at Semidi Islands and took an extremely heavy toll in 1976. Losses to the predator were monitored in a 1000 m^2 plot established within a gull nesting area. From 3 June to 9 July fulmar egg shells were collected from the plot at two-day intervals, washed, dried and weighed.

The percentage of birds present at the colony undergoing primary molt was determined daily from 30 June to 3 September. This varied from 1 to 78 percent and the data contribute to an understanding of patterns of colony attendance in breeders, failed breeders and pre-breeders.

110 chicks were banded this season. A large scale banding program for fulmars at Semidi Islands would not be impractical.

Twelve adult fulmars were collected, four in each of the three months June, July and August. Stomach contents were preserved and study skins were prepared from all specimens. An effort was made to obtain a series representative of the color phases of fulmars found at Semidi Islands.

Quarterly Report

Contract #03-5-022-56
Research Unit #441
Reporting Period 7/1 - 9/30/76
Number of Pages 22

AVIAN COMMUNITY ECOLOGY AT TWO SITES ON ESPENBERG PENINSULA IN KOTZEBUE SOUND, ALASKA. A COMPOSITE STUDY OF: 1) HABITAT UTILIZATION AND BREEDING ECOLOGY OF WATERBIRDS, 2) HABITAT UTILIZATION AND BREEDING ECOLOGY OF SHOREBIRDS AND NON-WATERBIRD SPECIES, AND 3) HABITAT UTILIZATION, BREEDING ECOLOGY, AND FEEDING ECOLOGY OF PREDATORS OF BIRDS

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October 1, 1976

I. Task Objectives

1. To determine phenology of events from spring arrival through departure of birds.,
2. to determine the distribution and abundance of birds and their predators,
3. to describe habitat utilization of birds and their predators during migration, the nesting season, and the brood rearing season,
4. to estimate production of all avian species nesting on the Espenberg Peninsula,
5. to determine the abundance of small mammals which are utilized by avian and mammalian predators,
6. to describe availability of food and utilization by shorebirds,
7. to determine distribution and abundance of sea mammals,
8. to provide recommendations to lesson the impact of developments on the avian community and avian habitat at the Espenberg Peninsula, and
9. to establish baseline study plots to evaluate the impact of developments on the avian community and avian habitat at the Espenberg Peninsula.

II. Field Activities

A. Field trip schedule

The time investigators spent in the field is indicated below.

Investigator	Days in Field	Dates 1976
Peter Mickelson	54	14 June -- 6 August

Douglas Schamel	103	4 June -- 15 September
Diane Tracy	103	4 June -- 15 September
Anne Ionson	89	4 June -- 1 September
Steven Long	63	14 June -- 15 August

One special trip to evaluate avian activities on islands in Kotzebue Sound southeast of Cape Espenberg was taken in the private boat of Fred Goodhope, Jr. on July 23.

B. Scientific Party

Name	Affiliation	Role
Peter Mickelson	Institute of Arctic Biology	Principal investigator
Douglas Schamel	Institute of Arctic Biology	Research associate
Diane Tracy	Institute of Arctic Biology	Research associate
Anne Ionson	Institute of Arctic Biology	Graduate student
Steven Long	Anchorage Public School System	Student assistant

C. Methods

Waterfowl Nesting Plots

Two one-square-kilometer study plots located in sections 27 and 28 (plot 1) and 32 (plot 2), T14N, R24W Kateel River Meridian were established (Fig. 1).

Each plot was systematically searched for waterfowl nests. Plot 1 was searched with a 50 m rope. With one person at either end of the rope and another positioned at the 25 m mark, the investigators walked easterly

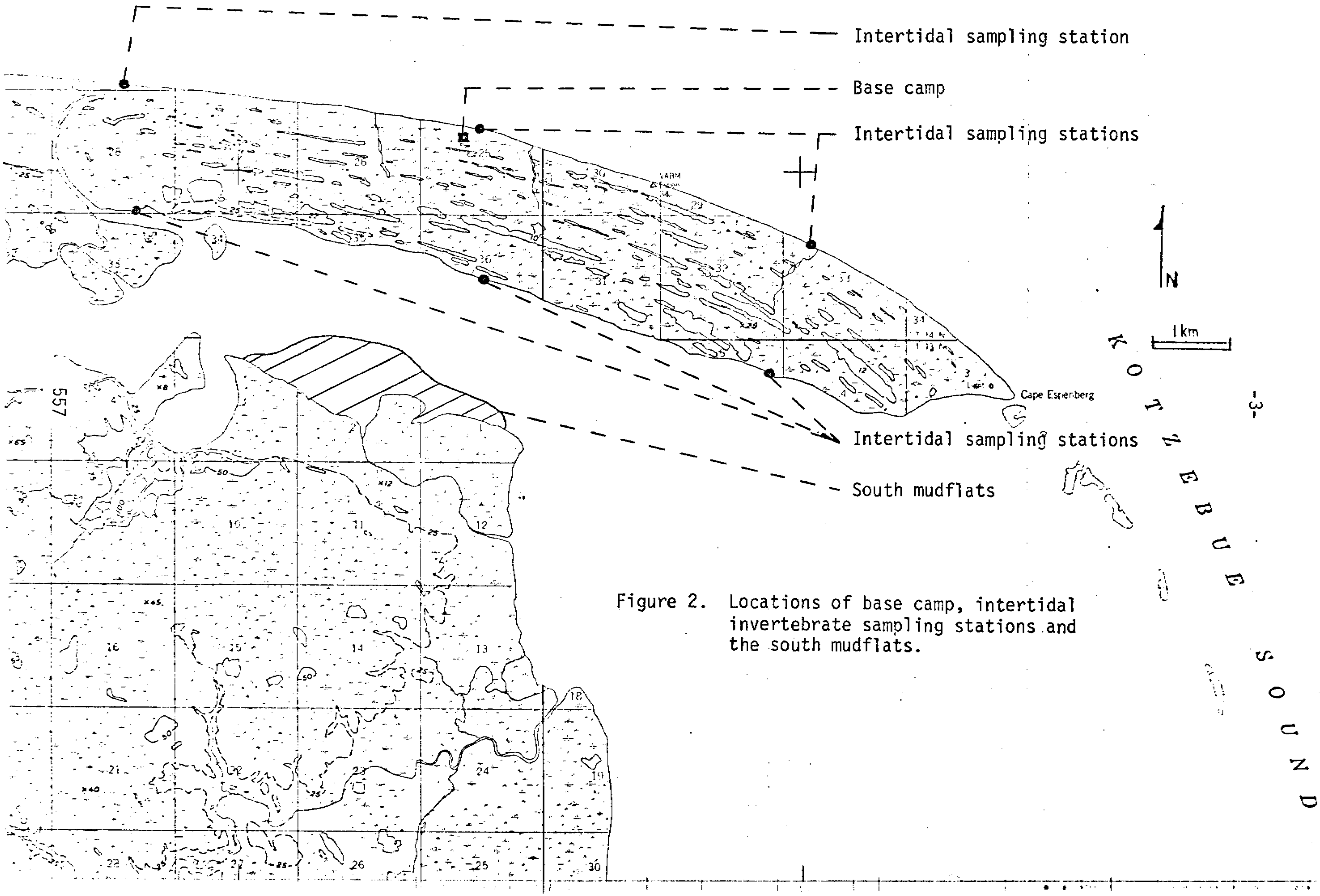

Figure 2. Locations of base camp, intertidal invertebrate sampling stations and the south mudflats.

and westerly covering a 50 m wide swath. When a bird was flushed, the immediate area was searched for a nest. Each nest was assigned a number and the date, species, number of eggs, and location recorded. Nests were marked by tongue depressors inscribed with all the above information except location.

The search of plot 2 was conducted without a rope. Instead, two or three people, positioned 7-12 m apart, walked abreast until the plot was covered. Nests were marked and the same information collected as for plot 1.

Nests in both plots were visited repeatedly during incubation. During each visit, investigators recorded the number of eggs, stage of incubation, date of hatch, and number of eggs hatched.

The percent cover of plant species within a 0.5 m radius of the nest bowl center was determined for approximately 80 nests located in plot 1.

A dense concentration of nesting Common Eiders was discovered on a small island (ca. 10 m x 100 m) in one of the larger ponds on the Cape. This island was searched on several occasions and most nests were located. The standard nest site and fate information was recorded.

Waterfowl broods were counted whenever encountered and the habitat and location were recorded.

Shorebird Nesting Plots

Two 0.25 km^2 shorebird nesting plots were selected (Fig. 1). One was placed in fairly uniform marsh habitat while the other was placed in an area of mixed habitat including dunes, major dry ridges, tussock tundra, and marsh. A grid system was set out in both plots using wooden stakes marked with coordinate numbers. In the marsh plot, stakes were 50 m apart, while in the mixed habitat plot, they were 100 m apart. These stakes increased the ease and accuracy of 1) relocating nests, 2) mapping nest locations within each plot, 3) recording the movements of banded adults and broods, and 4) developing vegetation-habitat maps of the plots.

Throughout the nesting season, these plots were regularly searched for nests of all birds. Nesting shorebirds were recognized by their behavior and observed until the nest location was revealed. We attempted to color-band adult shorebirds at all known nests so that breeding pairs from unlocated nests could be identified and their nests found. Both plots were systematically searched for nests once by three people dragging a 25 m rope over the entire area and searching areas from which birds had flushed. All nests were assigned numbers and marked with tongue depressors to aid in relocating them. These nests were visited at least once weekly. As hatching time approached, nests were visited every other day. At each nest we recorded the following data: 1) general habitat type, 2) distance to nearest water, 3) type of nearest water, 4) height above water, 5) distance to nearest hummock and ridge (if nest located on a hummock), 6) percent cover of plant species, 7) percent cover over the nest, and 8) distance to two grid stakes. The grid stake distance will be used to plot nest locations on a map and this map used to determine distance to nearest neighbor and nearest conspecific nest. Inter-nest distances were measured in the field when nests were close together (less than 10 m). A general vegetation-habitat map was prepared for both shorebird plots for: 1) comparison with nest distribution, 2) estimation of the percentage of various habitat types, and 3) a ground-truth for the aerial photography. Percent cover of plant species at nest sites was determined within a 15 cm radius of the nest for shorebird, Arctic Tern, and Sabine's Gull nests. A 50 cm radius was used for waterfowl, Willow Ptarmigan, Sandhill Crane, and Glaucous Gull nests.

Chicks of shorebirds, Sabine's Gulls, and Arctic Terns that hatched in the study area were banded, weighed, and measured at the nest whenever possible. Banded chicks were recaptured at irregular intervals. They were weighed and measured to determine growth rates. We recorded the location and habitat of all recaptured chicks.

Banding, Tagging, and Marking

Nesting shorebirds were nest-trapped, weighed, measured, and banded. Adult Red and Northern phalaropes were also captured with a hoop net and banded. Each bird was banded with a standard aluminum U.S.F.W.S. band and three color bands. Bands were placed above the tarsal joint of each leg. This reduces the overwinter fading of color bands and corrosion of aluminum bands. The following colors were used: red, yellow, blue, and green. Chicks were captured at nests and opportunistically. Each chick was banded with an aluminum band and a single color band, coded for hatching year. The following color code was used: Semipalmated Sandpiper chicks -- red; Western Sandpiper chicks -- yellow; and Dunlin, Ruddy Turnstone, Northern Phalarope, and Red Phalarope chicks -- green. Adult Arctic Terns were banded above the tarsal joint with aluminum on the left and a single green color band on the right. Arctic Tern chicks were banded above the tarsal joint with aluminum bands only. Sabine's Gull chicks were similarly banded.

Nesting Parasitic Jaegers were nest-trapped and banded with aluminum bands. They were also color-marked with pink dye. Young Emperor Geese were web-tagged at nests with size 10 monel tags. Several nesting Glaucous Gulls were color-marked with pink dye by placing cotton soaked with dye in their nests. The location, habitat, and activities of color-marked birds were recorded whenever encountered.

Predator Distribution and Numbers

The entire Cape area, including section 28, T14N, R24W Kateel River Meridian and eastward to the tip of the Cape, was systematically searched for fox dens. The search was made by a varying number of persons walking abreast within view of each other and searching all available denning habitat. The location of each den site was marked on a map and the following information was recorded: 1) general habitat, 2) distance to and type of nearest water, 3) vegetation, 4) slope and degrees of view, and 5) number of holes. An attempt was made to determine which den sites were active during this summer and the number of pups present. All observations of foxes were recorded, accompanied by a description of the animal, the location, and its behavior.

In early July, the entire Cape was searched for Glaucous Gull colonies. The search was conducted using a spotting scope and binoculars from a series of high dunes running the length of the Cape. Colony locations were recorded on a map and the approximate number of birds in each determined. The laying and hatching dates, clutch size, and nest fate of 30 Glaucous Gull nests near the marsh plot were recorded.

An attempt was made to locate all Parasitic Jaeger nests on the Cape. The location, clutch size, and fate of each was recorded.

Predator Pellet and Scat Collection

Twenty-nine Glaucous Gull nests near the shorebird marsh plot were selected as gull pellet collection sites. All pellets in the vicinity of these nests were collected twice monthly (at the middle and end of each month). Collections were made from mid-June through mid-September.

Fox scats were collected at all active den sites. At two dens, collections were made in late July and again in mid-September. This will provide seasonal food habit information.

A few pellets from Parasitic Jaegers and Snowy Owls were collected opportunistically.

All pellets and scats are stored at the University of Alaska, where analysis will begin shortly.

Small Mammal Trapline

To determine species present and relative abundance of alternative prey for foxes and avian predators, small mammals were trapped in and near the shorebird nesting plots using Sherman live traps. Traps were set in lines. Each line consisted of 20 traps, located 25 m apart, placed at microtine runways, holes, or natural runways. Traps were baited with peanut butter and checked at 6-8 hr intervals. The following information was collected for each captured animal: 1) species, 2) age, 3) sex, 4) weight, and 5) body and tail measurements. Animals were marked for later identification and released. Eighty trap-days were completed in four habitats: Elymus-dunes, dwarf shrub-dunes, sedge-pond edge, and moist ridge. In marsh habitat, 160 trap-days were completed. Additional trapping was conducted at various locations where microtine activity was suspected. (One trap-day is equal to one trap set for 24 hr.)

Sticky Boards

Relative insect abundance was monitored from 23 June through 8 September using sticky boards (a 10 cm x 50 cm masonite board coated with Stikem Special). A total of five sticky boards were used. They were located 50 m apart along one north-south stake line in the marsh plot. Insects on boards were counted and the boards re-set at three-day intervals. A chicken wire mesh canopy was placed over each board to prevent birds from removing insects or becoming entangled.

Intertidal Invertebrate Collection

A total of 115 intertidal invertebrate samples were collected from six locations on the Cape, three along the sea coast and three along the bay (Fig. 2). Twenty samples were taken at each of five sampling areas: five replicates each from 1) 2 cm deep water, 2) the water edge, 3) mid-way from the water's edge to the summer high tide mark, and 4) the summer high tide mark. The sixth sampling area was located near a salt marsh and only 15 samples were taken. The high tide mark here was on the tundra and no samples were taken from it. An additional 10 samples were taken from the mudflats across the bay to the south (Fig. 2). These were taken from the

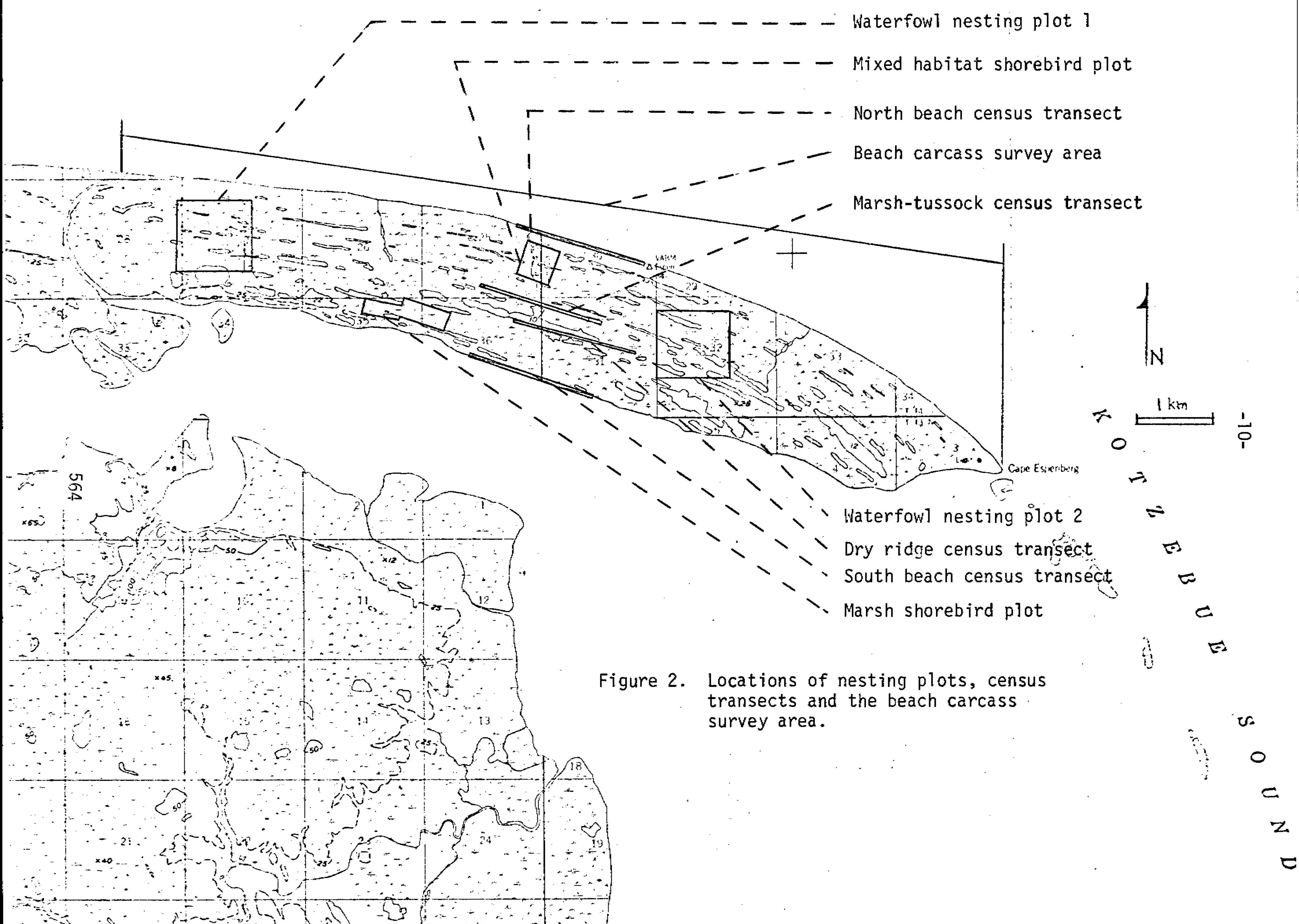

Figure 2. Locations of nesting plots, census transects and the beach carcass survey area.

water and water's edge.

Sampling was accomplished by means of a 10 cm x 20 cm metal frame and a garden trowel. Mud was collected to a depth of 4 cm. Samples were screened in the field, placed in a Whirl-paks or glass vials (dependent upon size) and preserved with 10% buffered formalin. The samples are presently stored at the University of Alaska, where processing will soon begin.

Shorebird Stomach Analysis

A total of 13 shorebirds were collected for stomach analysis: 9 Dunlin, 3 Western Sandpiper, and 1 Sanderling. In all cases except the Sanderling, birds were observed for 15 minutes prior to collection. Their feeding habitat is therefore known. Five Dunlin and three Western Sandpipers were collected on the south side of the Cape, near the slough. Four Dunlin were collected on the mudflats across the bay. The Sanderling was taken on the north coast near camp. All birds were weighed and measured. Sex was determined by dissection. Immediately after collection, formalin was induced into the stomach of each bird, using an eye dropper and plunger. At camp, the esophagus-proventriculus-stomach was removed and preserved in 10% formalin.

Beach Carcass Surveys

The north beach was searched from the slough in section 21 to the tip of the peninsula for dead birds and mammals (Fig. 1).

Species, extent of decay, and amount of oil on the plumage were recorded.

The census was conducted on foot about once per week.

Bird Census Transects

Four bird census transects (50 m x 2000 m) were established on the Cape (Fig. 1). The transects were marked with numbered wooden stakes at 50 m intervals. Each transect was located in a particular habitat type, as follows: 1) north beach, 2) marsh-tussocks, 3) dry ridge, and 4) south beach. The beach transects included 25 m on both sides of the water's edge. Transects were walked once each week from mid-June to mid-September. An observer walked a transect at a speed of approximately 50 m/1.5 min. Time-of-day was kept constant (morning through mid-day). Tide levels and weather conditions were recorded, as well as species, number, location, habitat, and activity of all birds sighted.

Mudflats Survey

A large mudflat, important as a staging and feeding area for several species of waterfowl and shorebirds, was discovered across the small bay south of the Cape (Fig. 2). Smaller mudflats occurred on the Cape in sections 33 and 34, T14N, R24W Kateel River Meridian. Estimates of the numbers of birds using these mudflats were made on several occasions. These mudflats were visited twice using a small 2-man rubber raft. During these visits species and numbers were recorded.

Avian Phenology

Investigators made daily records of avian species and relative abundance throughout the field season.

Aerial Vegetation and Habitat Mapping

A series of aerial photographs were taken. These photos will be used to create a vegetation-habitat map for the Cape.

Plant Phenology and Floristics

Flowering plants were collected, pressed, and tentatively identified. Dates of flowering were recorded by several of the investigators.

Marine Mammals

The presence of pinnipeds on the ice and in the ocean was recorded whenever they were sighted. No pinnipeds used the Cape beaches for hauling out.

Native and Reindeer Use

Local natives visited the Cape only once for subsistance activities. Only one reindeer (*Rangifer tarandus*) was seen on the Cape.

Weather

Our max-min thermometer broke while we were attempting to establish the weather station, precluding temperature records. Our wind meters did not arrive until late July. As a result, we have only general weather estimates for most of the summer. Weather data from Kotzebue and Shishmaref will be obtained and used with caution.

D. Sample Localities

The locations of nesting plots, census transects, and the beach survey area are shown in Figure 1. The locations of the base camp, intertidal invertebrate sampling areas, and the south mudflats are given in Figure 2.

E. Samples Collected

1.	Glaucous Gull pellets	ca. 3000-4000
2.	Snowy Owl and Parasitic Jaeger pellets	ca. 25
3.	Red fox scats	ca. 800
4.	Intertidal invertebrate samples	125
5.	Bird stomachs	
	Sanderling	1
	Western Sandpiper	3
	Dunlin	9

III. Results

A list of the 68 species of birds seen on Cape Espenberg in 1976 and the breeding status of each is given in Table 1. Those birds listed as "common" nesters were abundantly breeding throughout the Cape. "Moderate" nesting species were either found in moderate breeding densities throughout the Cape or were locally abundant only. When only a few nests of a species were found, the bird was given the "uncommon" status. "Probable" nesters are those species that established and defended territories or acted "broody" but for which neither nests nor broods were found. All other birds were placed in the "not nesting" category.

Table 1. Birds Observed at Cape Espenberg, 1976

NESTING STATUS	SPECIES
pn	Yellow-billed Loon (Gavia adamsii)
n	Arctic Loon (Gavia arctica)
cn	Red-throated Loon (Gavia stellata)
o	Whistling Swan (Olor columbianus)
un	Canada Goose (Branta canadensis)
un	Black Brant (Branta nigricans)
n	Emperor Goose (Philacte canagica)
o	Snow Goose (Chen caerulescens)
o	Mallard (Anas platyrhynchos)
un	Pintail (Anas acuta)
un	Green-winged Teal (Anas crecca)
o	American Wigeon (Anas americana)
n	Greater Scaup (Aythya marila)
n	Oldsquaw (Clangula hyemalis)
cn	Common Eider (Somateria mollissima)
un	King Eider (Somateria spectabilis)
un	Spectacled Eider (Somateria fischeri)
o	Surf Scoter (Malanitta perspicillata)
o	Red-breasted Merganser (Mergus serrator)
o	Goshawk (Accipiter gentilis)
o	Rough-legged Hawk (Buteo lagopus)
o	Marsh Hawk (Circus cyaneus)
n	Willow Ptarmigan (Lagopus lagopus)
cn	Sandhill Crane (Grus canadensis)
o	American Golden Plover (Pluvialis dominica)

Table 1: continued 1

NESTING STATUS	SPECIES
o	Black-bellied Plover (*Pluvialis squatarola*)
n	Ruddy Turnstone (*Arenaria interpres*)
un	Black Turnstone (*Arenaria melanocephala*)
o	Common Snipe (*Capella gallinago*)
o	Whimbrel (*Numenius phaeopus*)
o	Bristle-thighed Curlew (*Numenius tahitiensis*)
o	Red Knot (*Calidris canutus*)
o	Sharp-tailed Sandpiper (*Calidris acuminata*)
pn	Pectoral Sandpiper (*Calidris melanotos*)
o	Baird's Sandpiper (*Calidris bairdii*)
o	Curlew Sandpiper (*Calidris ferruginea*)
n	Dunlin (*Calidris alpina*)
cn	Semipalmated Sandpiper (*Calidris pusilla*)
cn	Western Sandpiper (*Calidris mauri*)
o	Sanderling (*Calidris alba*)
n	Long-billed Dowitcher (*Limnodromus scolopaceus*)
o	Bar-tailed Godwit (*Limosa lapponica*)
o	Hudsonian Godwit (*Limosa haemastica*)
n	Red Phalarope (*Phalaropus fulicarius*)
cn	Northern Phalarope (*Phalaropus lobatus*)
o	Pomarine Jaeger (*Stercorarius pomarinus*)
cn	Parasitic Jaeger (*Stercorarius parasiticus*)
o	Long-tailed Jaeger (*Stercorarius longicaudus*)
cn	Glaucous Gull (*Larus hyperboreus*)

Table 1: continued 2

NESTING STATUS	SPECIES
o	Mew Gull (Larus canus)
o	Black-legged Kittiwake (Rissa tridactyla)
n	Sabine's Gull (Xema sabini)
n	Arctic Tern (Sterna paradisaea)
o	Aleutian Tern (Sterna aleutica)
o	Common Murre (Uria aalge)
o	Thick-billed Murre (Uria lomvia)
o	Horned Puffin (Fratercula corniculata)
o	Tufted Puffin (Lunda cirrhata)
o	Snowy Owl (Nyctea scandiaca)
pn	Short-eared Owl (Asio flammeus)
o	Common Raven (Corvus corax)
o	Wheatear (Oenanthe oenanthe)
o	Arctic Warbler (Phylloscopus borealis)
o	Yellow Wagtail (Motacilla flava)
un	Redpoll (Acanthis sp.)
un	Savannah Sparrow (Passerculus sandwichensis)
o	White-crowned Sparrow (Zonotrichia leucophrys)
n	Lapland Longspur (Calcarius lapponicus)

cn - common nesting, n - moderate nesting, un - uncommon nesting, pn - probable nesting, but no nests or broods seen, o - not nesting

The complete results of our banding operation is presented in Table 2. During 1976 616 birds were banded.

A list, by species, of nests located in the four nesting plots is given in Table 3. Difficulties with nest markers (see "Problems Encountered") has temporarily postponed a final figure for Waterfowl Plot 1. This figure should be available within two weeks. Since the Waterfowl plots were only qualitative for shorebirds, numbers of these nests were deleted from Table 3.

IV. Preliminary Interpretation of Results

Twenty-nine species of birds nested on Cape Espenberg in 1976, of which 20 species were either "common" or "moderate" nesters. An additional three species were considered probable nesters.

Most bird species had clumped nesting distributions, according to habitat type. Several species are colonial or semi-colonial nesters (Glaucous Gull, Sabine's Gull, and Arctic Tern) or are occasionally so (Common Eider). These species make extrapolation from nesting plots dangerous, at best. Before viable production figures from the Cape can be determined, we must examine the habitat patterns within the nesting plots and compare them with the aerial photos of the entire Cape.

V. Problems Encountered/Recommended Changes

Funding for this project was not available to the investigators until May 15, 1976 and this caused a variety of problems. We had intended

Table 2. Numbers of Birds Banded at Cape Espenberg, 1976

SPECIES	NUMBER BANDED ADULTS	LOCAL YOUNG	TOTAL
Sandhill Crane	0	7	7
Ruddy Turnstone	6	2	8
Dunlin	28	68	96
Semipalmated Sandpiper	33	66	99
Western Sandpiper	26	50	76
Long-billed Dowitcher	0	7	7
Red Phalarope	29	48	77
Northern Phalarope	46	75	121
Parasitic Jaeger	24	1	25
Glaucous Gull	0	30	30
Sabine's Gull	0	13	13
Arctic Tern	5	45	50
Lapland Longspur	1	6	7
TOTAL	198	418	616

Table 3. Nests Located in Nesting Plots

SPECIES	NUMBER OF NESTS			
	Shorebird Marsh Plot ($0.25\ km^2$)	Shorebird Mixed Habitat Plot ($0.25\ km^2$)	Waterfowl Plot 1 ($1.0\ km^2$)	Waterfowl Plot 2 ($1.0\ km^2$)
Arctic Loon	1	1	0	1
Red-throated Loon	5	1	13	10
Black Brant	0	0	1	0
Emperor Goose	1	0	3	1
Greater Scaup	4	1	1	0
Oldsquaw	21	1	3	0
Common Eider	34	13	65[a]	59
King Eider	1	0	0	0
Spectacled Eider	1	0	1	0
Willow Ptarmigan	0	1	---	---
Sandhill Crane	1	0	---	---
Black Turnstone	1	0	---	---
Dunlin	5	4	---	---
Semipalmated Sandpiper	15	1	---	---
Western Sandpiper	15	1	---	---
Long-billed Dowitcher	1	1	---	---
Red Phalarope	18	0	---	---
Northern Phalarope	26	8	---	---
Parasitic Jaeger	0	0	1	0
Glaucous Gull	0	1	27[a]	47
Sabine's Gull	11	0	---	---
Arctic Tern	27	0	---	---
Savannah Sparrow	0	1	---	---
Lapland Longspur	6	3	---	---
TOTAL NESTS LOCATED	194	39	140[a]	133

[a]Minimum number found; final figure not yet available.

to be in the field by 15 May, but had to spend time buying and preparing supplies and equipment and were not able to get out in the field until June 4. Some equipment which had to be ordered by mail did not arrive in time for use during the 1976 field season. Most of the birds had arrived on the Cape before the investigators arrived so that very little information was gathered on spring migration. Since this is a 2-year study and funding is already available for the coming year, we should have no difficulties arriving in the field earlier in the spring of 1977.

A problem of nest marking was encountered in the waterfowl plots. The tongue depressor markers were placed at the edge of the nests and were frequently pulled out and displaced by the nesting birds. In the shorebird plots, markers were placed further from nests and loss of markers was not a problem. This technique will be corrected in 1977.

Our observations of the south mudflats area was sufficient to convince us of its importance to local and migrating waterbirds. We feel that regular numerical estimates of birds using this area should be attempted throughout the season. Additional invertebrate samples should also be collected.

Emperor Goose broods left the Cape area almost immediately after departing from the nest. We would like to know where the brood rearing areas are for these birds. This could be most easily accomplished by chartering air time in late July. Simultaneous with this brood check, we would like to look at waterbird distribution in the nearby Kotzebue Sound area, to compare with the local mudflat counts. An additional aerial survey of the nearby Sound area in late August is also recommended.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 27

PRINCIPAL INVESTIGATOR: Dr. P. G. Mickelson

We are currently batching data collected during the '76 field season. We will shortly submit a Draft Data Management Plan, with the data batches listed, accompanied by a schedule for data submission.

TO: NOAA Environmental Research Laboratories, Boulder, Colorado; OCSEA Project Offices, Juneau and Fairbanks, Alaska.

FROM: Principal Investigator, William H. Drury
Organization: College of the Atlantic
Eden Street
Bar Harbor, Maine 04609

SUBJECT: Six months report on fieldwork for 1976.
Contract: 03-6-022-35208 Task#447
Period: 15 May 1976 - 1 October 1976

TITLE: Studies of Populations, Community Structure and Ecology of Marine Birds at King Island, Bering Strait Region, Alaska.

I. Task Objectives

1. To determine the number and distribution of each species relative to other species, to periods of the breeding season, and to characteristics of available habitat within the colony or study area.
2. To provide estimates of nesting success of principal species.
3. To establish and describe sampling areas which may be utilized in subsequent years or by other persons for monitoring the status of populations.
4. To determine the amount and kinds of foods utilized by the principal species, and to describe daily foraging patterns when possible, to determine the relationship of food selected to that available.
5. To describe the chronology and phenology of events in the biology of breeding birds, including changes in population from the beginning of site occupation in the spring through departure in the fall.
6. To provide comparison of current data with recent historical data.

II. Field Activities - King Island

A. Field Schedule

May 27 - first party arrived in Nome
June 4 - survey of Chirikov Basin by plane.
June 10 - U.S. Coast Guard Helicopter flew party to King Island.
June 12 & 13 - walked most of the perimeter of King Island on the shore fast ice.
June 21 - shore fast ice broke up.
June 27, 28, 30, July 2,5,- Censuses of Seabird Cliffs
July 5,6 - party returned to Nome via ADF & G Boat
August 5 - transects of SE Chirikov Basin
August 6 - party put on island from OSS Surveyor
August 6,7 - transects of SE Chirikov Basin
August 6,9,10,11 - censuses of Seabird Cliffs
August 13 - party removed
transects of East Chirikov Basin

B. Scientific Party

William Drury, Principal Investigator, present 27 May-26 August.

John French, party leader at Bluff, undergraduate the University of Wisconsin; present 4 June - 20 August.

Benjamin Steele, party leader, graduated Harvard College, present 27 May - mid October.

Robert Crawford, field assistant, undergraduate the Evergreen State College, present 3 June - 27 August.

John Drury, field assistant, undergraduate the Lincoln-Sudbury Regional High School, present 8 June - 25 August.

Mary Drury, field assistant, graduated Vassar College, present 30 June - 10 September.

Peter Drury, field assistant, undergraduate, the Evergreen State College, present 3 June - mid-October.

Catherine Ramsdell, field assistant, undergraduate College of the Atlantic, present 8 June - 27 August.

C. Methods

1.
   - a) Surveys.
     Air reconnaissance transects were made of the Chirikov Basin.
     Surface surveys were made of the Seabird Cliffs at King Island.
   - b) Transects 10 minute watches were made over the southeastern part of the Chirikov Basin on OSS Surveyor.

2. At Bird Cliffs
   - a) Censuses by small boat of the entire perimeter of the island were made at several times of day in late June - early July and in early August.
     Censuses of part of the island were made from OSS Surveyor whale boat as a basis for "calibrating" data gathered at those other cliffs at which we lacked "control" data.
     Five on-foot surveys of the Auklet nesting skree on the sides and tops of the island to estimate population size in nesting auklets.
   - b) A photographic record was made of study sites.
   - c) Seven study sites were established and visited at least twice in July and August.
     At these sites we made counts, did observations of species present, drew a sketch map of the area and where useful, showed the location of occupied nests.
   - d) We made observations of food brought to the cliffs.
   - e) Twenty birds were shot at King Island to discover content of gut, but all were found to be empty.

D. Sample Localities

1. Seven study sites were established.
2. Three air transect routes were followed in the SE Chirikov Basin. Five surface transect routes were followed in the SE Chirikov Basin.

III. Results

A. Data Collected. These figures are approximate.
Surveys of the island from the shore fast ice - 3
Survey censuses of cliff - 9
Censuses of Auklets in early morning - 7
Visits to study sites - 23 stakes and 35 porch counts
Nautical miles of transects - 120
Ten minute watches for distribution at sea - 80
Air surveys in transit - 1
Air transects - 3
Trips in small boats - 10
Trips collecting food - 3
Bird specimens examined for food - 18

B. Species numbers and distribution

1. Estimates for species at King Island
Pelagic cormorant 65 nests 150 individuals
Glaucous Gulls 45 nests, 130 individuals
Black-legged Kittiwake 2500 - 6000 individuals
Murres, about 50% common 100,000 individuals
about 50% Thick-billed
Dovekie 1
Pigeon Guillemot 800 - 1,000 individuals
Parakeet Auklet 35,000 - 50,000 individuals
Crested Auklet 15,000 - 30,000 individuals
Least Auklet 60,000 - 100,000 individuals
Horned Puffins 3,000 - 5,000 individuals
Tufted Puffins 700 - 1,500 individuals
The numbers of Murres, Puffins, and Auklets vary greatly from hour to hour and day to day. Probably at least 5 censuses are needed before a mean value can be established. We should acknowledge that numbers change so much that our estimates should be put on a logarithmic scale.

2. According to air and sea transects, sea birds were gathered in large numbers within two miles of the nesting cliffs and unexpectedly sparce between 3 miles and 20 miles. They were unexpectedly numerous between 40 miles and 75 miles from the cliffs. The observations made on ocean transects should be repeated because behavior relative to the ship seems to vary with species, visibility and the state of the sea.

C. Schedule
On June 4 , when we flew around King Island, Kittiwakes had gathered on ice pans and Murres were crowded in flocks on leads. Only Glaucous Gulls and Cormorants were on the cliffs.
On June 10, when we arrived at King Island, Kittiwakes and Murres were visiting the cliffs. Pelagic Cormorants were carrying nesting material 12 June. Glaucous Gull eggs were seen on our first excursions, but their clutches were not complete. Glaucous Gulls had completed clutches by the middle of June. Eggs began to hatch 2-5 July and chicks began to fledge in mid August.
Although Kittiwakes occupied nest sites during the middle of June, activity at nests did not progress to egg laying and very few eggs were seen, even in early July.

Common Murres became conspicuous between 15 and 25 June, and then seemed to decrease as Thick-billed Murres became conspicuous and began to lay eggs about 25 June. We did not stay long enough into July to see when or whether the Common Murres came back. Our observations suggest that the Murres go to sea for a week or so before the female lays eggs. The Thick-billed Murres seem to have done so in mid June and the Common Murres in late June-early July.

Auklets became conspicuous on the second day after we arrived. Crested and Least Auklets seemed to arrive before the Parakeet Auklets.

Intense courtship among Auklets was conspicuous between 12 June and 16 June and a few eggs appeared about July 1. Auklet chicks were still in their nesting sites in early August. We were not on King Island when auklet chicks went to sea.

D. Trophic Relations including measurements of reproductive success.

1.

a) Reproduction in Kittiwakes seemed to be extremely low as it was at other sites in Norton Sound. Kittiwakes were seen feeding on small items of food where ice pans were bumping together as ice moved. They gathered to feed in the brash ice in front of the village as the shore-fast ice broke up. A pink tinge to the white flag of excrement below territorial sites suggested that they were feeding on crustacea in mid June. Kittiwakes gathered in feeding mélés east of King Island in August and were joined by Murres and a few Puffins. Minke whales were part of these feeding Meles.

b) Murres droppings along the nesting ledges had a pink tinge in late June and July indicating that the birds were feeding on crustacea. The food seen in August included Pricklebacks (Stichaeids Lumpenus).

2. Distribution while feeding

Cormorants seemed to feed right next to the island. Glaucous Gulls were seen feeding along the island shores and far at sea.

Kittiwakes dispersed widely at sea around King Island. Many were seen feeding right at the cliff bases and many seemed to feed in the shallower water to the east towards the Seward Peninsula.

Murres were seen feeding between 15 and 75 miles to the south of King Island. They were most numerous in an area 30-60 miles from both King Island and Sledge Island. Our transects covered only a small area of the total feeding grounds of the Murres from King Island.

Horned Puffins were most numerous between 3 and 10 miles and up to 30 miles from King Island.

Tufted Puffins fed at greater distances than Horned Puffins - that is 10-35 miles, but our observations are few.

We saw a few auklets feeding within 10-15 miles of the island. We saw a few Least Auklets on transects at

IV. Preliminary synthesis of data and interpretation.

A. Distribution

1. Pelagic Cormorants and Glaucous Gulls are represented at King Island by numbers comparable to those of other colonies.
2. Black-legged Kittiwakes were found to be in smaller numbers than were expected, according to the area of cliffs available. Their nesting success was low also.
3. Common Murres were found in large numbers, but Thick-billed Murres were also conspicuous. The large numbers of Thick-billed Murres at King Island contrasts with the situation in Norton Sound where very few Thick-billed Murres are found at any cliff.
4. Horned and Tufted Puffins occur in larger numbers at King Island than at the colonies in Norton Sound.
5. The largest numbers of Pigeon Guillemots and Parakeet Auklets are at King Island, although small numbers nest in Norton Sound.
6. Crested Auklets and Least Auklets nest only at King Island.

B. Relation to Sea Ice

Seabirds of all kinds appeared to be attracted to the edges of the "windrows" of floating ice as the ice broke up. They seemed to travel along the edges of the massed ice pans, to feed at the edges and in leads between the pans. In comparison, few sea birds were seen in the areas of open water between the "windrows".

C. Schedule

1. Pelagic Cormorants and Glaucous Gulls were already established and in the early stages of nest building and egg laying on June 10.
2. Black-legged Kittiwakes and the two species of Murres had arrived at the Island, but left their ledge territories undefended for long periods, i.e. they had not settled in for the start of breeding when we arrived on June 10.
   a) Even though Kittiwakes laid very few eggs (less than an egg for 30-40 nests) they persisted at the nest sites, performing "long calls" and "choking".
   b) The first Murre eggs were seen on June 25, which is about 10 days later than usual.
      It may be useful to speculate that the number of Kittiwakes and Murres at the bird cliffs in these first weeks represents the highly motivated breeders. A much larger number of Murres occupies the cliffs in July, but as we have commented elsewhere, few of these seem to have a attachment to the ledges or to lay eggs.
      Thick-billed Murres laid eggs earlier than did Common Murres at King Island this year.
3. Pigeon Guillemots and Horned Puffins arrived at the cliffs in mid-June, after the Cormorants, Gulls and Murres. Their numbers increased until about June 25. Tufted Puffins numbers increased throughout June to a maximum in early July.

Horned Puffins occupy all levels of the steep grassy slopes on King Island, but their numbers seem to be largest on the lower and middle slopes. Tufted Puffins and Pigeon Guillemots nest on the lowest slopes.

D. Trophic Relations

1. It may be possible to measure the size of the "effective" breeding population of Kittiwakes and Murres by counting the arrivals in early June.
2. The disastrous reproductive performance of Kittiwakes in 1976 should allow us to look for factors that influence success.
3. Observations during bad weather from the village indicate that the numbers of Murres and Puffins drop sharply during strong winds and continue to drop off as bad weather persists for several days. The cliff may be virtually empty of birds after 6 days of bad weather. When the weather improves, the birds return in skeins, especially in the early evening 1600-2000.
   A period of storm from June 20-June 25 nearly emptied the cliffs visible from the village at King Island and may have affected the egg laying in Kittiwakes.

V. Relation to Development

1. The village of Ukivok on King Island, which is an awesome monument to human ingenuity, lies unprotected from frivilous but damaging visits by unsympathetic or hostile people (both native and non-native) who can now travel freely in the Chirikov Basin.
   A few passing visitors will perhaps request permission from the King Island Native Corporation for access to the island, but these are not the people one needs to worry about. More serious problems will probably come from visits by parties from ships whose personnel are seeking diversion from shipboard boredom. Most such parites will not bother to ask permission or notify the Island Corporation and they,like some recent native visitors, can be expected to be responsible for serious vandalism. Unfortunately the animosities that exist between factions within the King Island community make this problem worse.

VI. Problems

A. Biological Problems

1. Measuring breeding success
   a) We are more or less satisfied with systems for measuring breeding success for Pelagic Cormorants, Glaucous Gulls and Black-legged Kittiwakes, but access to nesting sites is very difficult at King Island, and as a result, we question whether the study sites we can reach are representative.
   b) The same problem exists for Murres, with the additional problem that most cliffs accessible from the village are only recently reoccupied and are suspect of being unrepresentative.

c) Measuring breeding success in Horned Puffins, Tufted Puffins, and Pigeon Guillemots will require extensive effort.
d) Our first results indicate that attempts to reach the nests of Auklets will result in the nest destruction or abandonment.

2. Getting Food Samples
   a) We can see the food brought to the nest by some parents. We shot a few birds in 1976 and looked at others killed in other ways and found all had guts empty.
   b) We need to take samples of feeding birds on the feeding grounds in order to learn what food the parents use themselves.
   In order to get samples of birds on the feeding grounds (as much as 80 miles from the cliffs) we will need special small boat travel.
   We need to visit feeding grounds during each phase of the breeding cycle. It may be that we can sketch out the feeding grounds and their changes by air reconnaissance.
   We will, perhaps, be able to get these data by cooperation with other NOAA parties.

3. Travel
   a) We will need cooperation from NOAA ships and U.S. Coast Guard to get to King Island another year. Ideally, visits should be made 25 May - 15 June, 15 July - 1 August, 20 August - 1 September, and 15 September - 1 October. Such visits will require ship time and support from a large helicopter, such as those used by the U.S. Coast Guard.
   b) We will want to expand our air coverage of the sea in the Chirikov Basin to make transects in May, June, July, August and September.

B. Problems related to other OCSEAP activities
1. Travel. Someone should visit Little Diomede Island and Fairway Rock to repeat Kenyon's 1950 estimates and estimate reproductive success. If no one else is doing this, our party might undertake to do this.
2. Trophic studies. In order to relate our studies at Seabird Cliffs to "trophic dynamics" of the Norton Basin, we need data taken from sampling on the feeding grounds including a) numbers and kinds of birds per unit area, b) samples of food being taken by the birds, c) distribution and abundance of prey species. One of the major needs of the OCSEA Program is to study the physical, chemical and biological structure of the sea in the Norton Basin between 3 meters depth and 50 meters depth. Another is to learn of the life histories, movements and productivity of major prey species, such as Amphipods, Copepods, Euphausiids, Pandalids, and the Teleost fishes: Ammodytes, Gadus (S.L.), Lumpenus, Mallotus and Osmerus. We need to discuss whether this work can be undertaken and, if it can be, how we can help and have access to the data.

3. Helicopters and sea birds. It is clear that helicopters cause unusually severe panic among seabirds. Thus, we found helicopters not very useful in making transects because birds dived well ahead of us. We also noted the major panics were created when helicopters passed over sea bird cliffs to drop off shore parties.
   The effects of helicopters on nesting seabirds must be considered seriously in plans for other OCSEAP operations and any operations related to development. I expect, for instance, that frivilous visits to bird nesting islands will increase markedly unless effective steps are taken to control them.
4. Money matters. It has proven difficult for our small organization, College of the Atlantic, to assume a deficit of nearly $30,000. in financing the field work. This deficit comes on top of an annual operating budget deficit of about the same size, at the time of most severe cash flow problems at the College. We need to find some way of mitigating the effects of this deficit and the added costs of borrowing the money ahead.
5. As I have suggested before, living space and storage space are in short supply in Nome. If and when NOAA's OCSEAP has many ships and parties working in Norton Basin, it will be important to make special arrangements for housing and space. Otherwise, NOAA's presence will exaggerate the outrageous profiteering that local entrepreneurs are able to get away with.
6. One problem facing my project is the attitude taken by the King Island Village Corporation members that I have unlimited funds to pay for the "use" of King Island. As a further complication, there are several factions within the King Island Village which regard each other with some suspicion. As a result, almost any arrangements I make will probably be vigorously disapproved of by some group.
7. A major problem is the physical structure of the King Island Village. At present, it is in danger of rotting and falling apart. At this time, the King Islanders don't seem to see the need for preservation of the village site in the way that we do. It seems to be difficult for the Village as a whole to cooperate on a policy or plan. King Island Village is a national monument comparable to Williamsburg in its own way. It is a example of creativity and ingenuity which should preserved.

ESTIMATED EXPENDITURES
447

This is a preliminary accounting.

C.P.F. 1	Salaries	$2,750.
		1,500.
	Fringe Benefits	700.
	Overhead	1,560.
C.P.F. 2	Travel and per diem	
	To Alaska	1,820.
	Local Surveys	475.
	Local Travel	175.
	Per diem camp	460.
C.P.F. 3	Equipment	2,225.
C.P.F. 4	Other direct costs	95.
	Telephone	
	Film	
Total		$11,790.

Quarterly Report

Contract #03-5-022-56
Research Unit #458
Reporting Period 7/1 - 9/30/76
Number of Pages 2

AVIAN COMMUNITY ECOLOGY OF THE AKULIK - INGLUTALIK RIVER DELTA, NORTON BAY, ALASKA

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and
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October 1, 1976

Quarterly Report

I. Task Objectives

To define the ecology community structure and populations of marine birds of the Akulik - Inglutalik Delta area, Norton Bay, Alaska.

II. Field Activities

This quarter saw the completion of the 1976 field season for the Inglutalik River study area. Field data was obtained on the numbers and distribution of the birds utilizing the study area, their nesting density, their clutch sizes, and their hatching success.

A preliminary description of the habitat on the study area was started with a collection of all the plants found in the area and the drawing of a map of the study area outlining the general features and distribution of the various plant communities.

A survey of the invertebrates available, as a food source for the birds was taken with the collection of samples from the different sites used as feeding areas, i.e., tidal flats, pond bottom, shore, and various plant communities.

Weather data was recorded for the months of July and August.

The last field data was obtained on August 24th. The camp was dismantled on August 25 and 26th and moved to the village of Koyuk where storage space was obtained for the winter.

III. Results

None available this quarter.

IV. Problems Encountered

A late break-up in the study area prevented the expected spring start of this study. Due to this, much information concerning early migration in the area which was expected to have been valuable was not taken. In order to fill this gap it is requested that helicopter support be provided next spring in order to set up camp prior to the migration. A request, in detail, for such support will be sent separately to the logistics staff of the project offices.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1976

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 28

CO-PRINCIPAL INVESTIGATORS: Dr. G. F. Shields and Mr. L. J. Peyton

We are currently batching data collected during the '76 field season. We will shortly submit a Draft Data Management Plan, with the data batches accompanied by a schedule for data submission.

A COMPARATIVE SEA-CLIFF BIRD INVENTORY
OF THE CAPE THOMPSON VICINITY, ALASKA
(Contract 03-6-022-35210)

RU# 460/461

Quarterly Report
30 September, 1976

RENEWABLE RESOURCES CONSULTING SERVICES, Ltd.

Principal Investigators

David G. Roseneau
Alan M. Springer

I. Field Activities.

Cape Thompson field work was concluded on 25 August, 1976. Two people and field equipment were transported to Cape Lisburne to perform a five-day reconnaissance of the sea cliffs there, while the other personnel returned to Fairbanks. The introduction to the seabird colonies at Cape Lisburne at the end of this field season is expected to facilitate the work planned in that area during the summer of 1977.

Facilities at Cape Lisburne Air Force Base were made available to us during our stay. All field equipment was stored in a warehouse there for the winter.

II. Laboratory Activities.

Identification of stomach contents from murres and kittiwakes collected at Cape Thompson is nearly complete. Field data is being transformed and formatted for archiving. No comparisons with data from other studies can be made at this time.

III. Selected Observations, Cape Thompson.

A. Murres

Estimates of the murre population at Cape Thompson will not be finalized until direct counts and counts from photographs can be composed. It appears, however, that the total population was lower by at least 42% than in 1960, the year in which Swartz made his most complete census (393,000) of these colonies. In 1961, Swartz estimated that there were approximately 30% fewer murres than in 1960, or at least 12% more than we found there this year.

The first egg was seen this summer on 4 July, and a burst of laying activity appeared to occur between 7 - 13 July. The first chick was seen on 9 August. These dates are all about 7 - 10 days later than those recorded for the same phenomena in both 1960 and 1961; however, they are comparable to 1959 dates. No fledglings had been observed by 25 August. Counts of individual murres yielded a ratio of 57% thick-bills to 43% commons, which supports the 60/40 ratio recorded by Swartz.

B. Black-legged kittiwakes

This summer we recorded an essentially complete reproductive failure for kittiwakes at Cape Thompson. The majority of the birds present at the cliffs occupied territories and many were paired; however, normal breeding activities appeared to progress no further. Nest building occurred in only a few cases, and these nests were much smaller than typical nests. Copulation was not observed. We were able to locate very few eggs.

Because of the absence of nesting birds, the population size was difficult to determine. Nest site attendance on a colony-wide basis was erratic, even though individual territories were generally vigorously defended whenever the occupant was present. Furthermore, it was impossible to determine whether sites were occupied by single birds or by pairs if both birds were not present during censusing periods. We counted approximately 10,500 kittiwakes at Cape Thompson this summer.

C. Horned puffins

Horned puffins did not arrive at the cliffs in large numbers until approximately the first week of July, although a few were present when we arrived on 19 June. A final tally has not been made, but the population of horned puffins this year was near the number of 1,902 birds Swartz found in 1960.

Nine nests were accessible for observation, each containing one egg. One egg was laid between 16 and 20 July and another was probably laid after 20 July. These dates are also about ten days later than 1960 and 1961. No eggs had hatched by 25 August.

D. Glaucous gulls

Fewer gull nests were found this year than in 1960 and 1961; however, the reproductive success per nesting attempt this year may have been better than in previous years. The difference may be due to a near absence of foxes at Cape Thompson this summer. Loss of eggs and chicks to foxes in 1960 was heavy, with as many as 60 nests being destroyed at one colony alone. Only four nests containing a total of eight eggs are known to have been depredated during this study.

IV. Selected Observations, Cape Lisburne.

The murre population at Cape Lisburne was about the same as at Cape Thompson, although breeding appeared to be advanced at Lisburne. Uncompensated counts yielded 130,800 birds. Most eggs had hatched by the time we arrived, and the first major fledging probably occurred on 28 August.

Counts of the kittiwakes were not made. Reproductive success at Cape Lisburne, although also poor, was noticeably better than at Cape Thompson. Many more nests had been constructed and were much larger than those at Cape Thompson. More chicks were observed in the nests, including a higher number of dead ones. Live chicks observed appeared to be a week older than those at Cape Thompson.

V. Discussion.

It would appear premature to speculate upon the reasons why the kittiwakes failed to breed at Cape Thompson this year. Factors which are known to result in poor reproductive success in other species are food availability and weather. That the schedule of nesting activities was generally late in most species this summer suggests the possibility of a particularly late winter and spring. Feeding melees of kittiwakes which are frequently seen in other populations were seldom observed at Cape Thompson; this may suggest a lower food supply. We hope that insights into these and other questions concerning the biology of cliff-nesting sea birds will be gained at the OCS meetings which will be held next month in Anchorage.

Literature Cited

Swartz, L.G. 1966. Sea-cliff birds, p. 611-678. In: Environment of the Cape Thompson Region, Alaska. N.J. Wilimovsky and J.N. Wolfe (Eds.) U.S. Atomic Energy Commission, Div. of Tech. Information, U.S. Dept. of Commerce, Springfield, Virginia. 1250 pp.

QUARTERLY REPORT

Contract: 01-6-022-15670
Research Unit: RU-488
Reporting Period: July 1, 1976 to
September 30, 1976
Number of Pages: i + 2

CHARACTERIZATION OF COASTAL HABITAT FOR MIGRATORY BIRDS: NORTHERN BERING SEA

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October 1, 1976

CHARACTERIZATION OF COASTAL HABITAT FOR MIGRATORY BIRDS:

NORTHERN BERING SEA

INTRODUCTION

This project was initiated during the current reporting period and is an extension of work being conducted as part of Research Unit 3/4 in the Southern Bering and Chukchi Seas under the direction of Paul Arneson and George Divoky, Alaska Department of Fish and Game. The area covered by this study extends from Cape Newenham to the Bering Straits and relates most directly to proposed developments in Norton Sound.

The objective of the study are to:

1. Characterize coastal habitat utilized by marine birds by:

    a. Describing extent and characteristics of unvegetated intertidal beaches.
    b. Describing extent and characteristic of intertidal plant communities.
    c. Identifying, where possible, the maximum limit of tidal influence on terrestrial habitat by mapping the occurrence of drift lines.
    d. Identify ownership status (private or public) and responsible land management agency.
    e. Identify and quantify existing land uses.

2. Characterize use of habitat by birds including:

    a. Identification of principal species.
    b. Identification and/or description of habitat use or dependencies by principal species.
    c. Identify relative and/or approximate numbers of birds utilizing habitats seasonally.

3. Identify habitats which may be considered of unique or critical importance to any species considering overall populations of the species relative to the number present, and the availability of similar alternative habitat.

METHODS

Methods utilized for this study are similar to those described by Arneson in his annual report (April 1976) for RU 3/4. The study will depend substantially on the review and analysis of existing published and unpublished information and on the results of ongoing studies within the region by the Fish and Wildlife Service as well as other OCSEAP

Research Units, most particularly RU 341/342 (Lensink and Bartonek) which includes intensive studies of birds on the Yukon Delta and with which field work may be coordinated, RU 237/238 (Drury) which consists of intensive surveys and site specific studies of birds on the Seward Peninsula, Shield's study of water birds on upland in extreme north-eastern Norton Sound and RU 209 (Dupre and Hopkins) which considers the effect of tides, waves, sea-ice, and river input in relation to morphology and coastal stability of Yukon Delta, both of which directly relate to specific characteristics of the habitat (mud flat foraging areas, vegetative type) and the composition, distribution and abundance of avian populations. Aerial and ground surveys will be utilized as necessary to verify or extend existing data and to establish common basis for its interpretation.

ACTIVITIES AND ACCOMPLISHMENTS

Primary effort during the quarter was devoted to field studies on the Yukon Delta north and west of Kotlik. Although considered of major importance to both nesting and migrant pupulations of birds, habitats of this area are least known of those within the region encompassed by our study. Additionally, this portion of the Yukon Delta, which is adjacent to Norton Sound, is most likely to be affected by OCS development. Field work was conducted under the direction of R. D. Jones who was assisted by Matt Kirchhoff. A field report is nearing completion.

Other work conducted as a part of this study included the collection and evaluation of existing source materials.

WORK PLANNED

Work planned for the quarter October 1, 1976 to December 31, 1976 includes:

- Completion of field report for studies conducted during current quarter.

- Complete evaluation of existing data and prepare report containing maps, charts, tables, and all other elements of the final report.

☆U.S. Government Printing Office: 1976-777-562/45 Region 8