Environmental Assessment of the Alaskan Continental Shelf

VOLUME 1

RECEPTORS – [illegible]
[illegible]
[illegible] BIRDS
[illegible]
CONTAMINANT BASELINES

VOLUME 2

RECEPTORS – [illegible]
FISH
MICROBIOLOGY

VOLUME 3

TRANSPORT
HAZARDS
DATA MANAGEMENT

Environmental Assessment of the Alaskan Continental Shelf

July-September 1977 quarterly reports from Principal Investigators participating in a multi-year program of environmental assessment related to petroleum development of the Alaskan Continental Shelf. The program is directed by the National Oceanic and Atmospheric Administration under funding from and for use by the Bureau of Land Management.

ENVIRONMENTAL RESEARCH LABORATORIES
Boulder, Colorado
December 1977

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VOLUME 3

CONTENTS

TRANSPORT

TRANSPORT

TRANSPORT

Research Unit	Proposer	Title	Page
259	W. M. Sackinger R. D. Nelson U. of Alaska	Experimental Measurements of Sea Ice Failure Stresses Near Grounded Structures	305
261	W. R. Hunt C. M. Naske U. of Alaska	Beaufort Sea, Chukchi Sea and Bering Strait Baseline Ice Study	308
265	L. H. Shapiro R. D. Nelson U. of Alaska	*In Situ* Measurements of the Mechanical Properties of Sea Ice	310
267	A. E. Belon U. of Alaska	Operation of an Alaskan Facility for Applications of Remote-Sensing Data to OCS Studies	312
289	T. C. Royer IMS/U. of Alaska	Circulation and Water Masses in the Gulf of Alaska	317
347	J. L. Wise U. of Alaska	Marine Climatology of the Gulf of Alaska and the Bering and Beaufort Seas	321
351	E. R. Dieter IMS/U. of Alaska	Logistics I	323
367	R. M. Reynolds PMEL/NOAA	Coastal Meteorology	325
435	J. J. Leendertse Shiao-Kung Liu RAND	The Bristol Bay and Norton Sound Models--A Progress Report	326
499	J. S. Mattson EDS/NOAA	Modeling Algorithms for the Weathering of Oil in the Marine Environment	420
519	F. Carsey U. of Washington	Coastal Meteorology of the Alaskan Arctic Coast	420
526	J. B. Matthews U. of Alaska	Characterization of the Nearshore Hydrodynamics of an Arctic Barrier Island-Lagoon System	424

TRANSPORT

See page 810 for reference to publication entitled "Index of Original Surface Weather Records for Stations in Alaska, available from the National Climatic Center, Asheville, North Carolina.

HF SURFACE-CURRENT MAPPING RADAR

1977 ALASKAN OPERATIONS — LOWER COOK INLET

RESEARCH UNIT #43

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SUMMARY

The objectives of our initial Alaskan experiments in the summer of 1977 were twofold: (1) to demonstrate the feasibility and utility of a transportable HF radar system for operational near-real-time mapping of surface currents in remote coastal areas, and (2) to gather environmental baseline data on surface circulation around Kachemak Bay in the Lower Cook Inlet.

This brief report answers primarily the first objective. By presenting sample radar-produced current maps at two opposing periods in the tidal cycle and comparing these data with drifter buoy velocity measurements, we herein establish the credibility of the claim that such systems can play a major role in future coastal current-data gathering studies of this nature. In particular, our results show that: (1) a single current-vector map covering thousands of square kilometers can be produced after 15 minutes operation; (2) at least three orders of magnitude more data can be gathered in a given twelve-hour period than by any alternative technique; (3) the system rms error is at worst one-half knot (current velocity), and most likely considerably better.

I. SITE LOGISTICS AND LOCATIONS

The radar equipment for both sites was transported to Alaska in our Aspen trailer, pulled by our Dodge van; this gear left Boulder for Seattle on May 23. From Seattle these two vehicles were transported by ferry, arriving Anchorage on June 2. In Anchorage a four-wheel-drive vehicle was rented, along with an additional house trailer. The radar system was given a preliminary inspection before leaving Anchorage to verify that no obvious damage had been incurred in shipping. Arrangements were made to have a Sears utility shed (approximately $300 retail cost) shipped to Anchor Point to provide additional operating space in the field.

The vehicles and equipment then left Anchorage June 6 for Anchor Point on the Kenai Peninsula (about 20 miles north of Homer). The Sears shed was erected at this site. Fig. 1 shows a photo of this site during operations. All of the radar and computer gear were exercised at Anchor Point for several days, verifying proper performance. Then the Aspen trailer — pulled by the rented vehicle — left for Homer; from there this equipment was transported by ferry to Seldovia on June 14. Hardware and software engineers went through a series of tests; these are necessary to ensure that subsequent radar operations and data gathering will produce valid results. The location of the Anchor Point site was Lat. 59°46'12"N, Long. 151°51'53.4"W; that of Seldovia was Lat. 59°27' 27.5"N, Long. 151°42'30"W. Figure 2 is a general map of the area, showing the two sites (as dots) at Anchor Point and Seldovia.

A Mini-Ranger system was rented and installed at three sites in this area; this was necessary for later comparisons of radar-deduced surface currents with simultaneous drifter measurements. These sites were surveyed in by LCDR. John Murphy of the NOAA Corps. They were located near Anchor Point (Lat. 59°46'11.148"N, Long. 151°51'53.411"W); at Bluff Point (Lat. 59°39'37.645"N, Long. 151°39'44.972"W); and near Seldovia (Lat. 59°27'09.854"N, 151°43'08.282"W). The Mini-Ranger system was used in conjunction with ships tracking drifters during the week of June 26; the system was dismantled and returned to the owner on July 3.

Operations at the two HF radar sites continued through July 15. Beginning on July 16 the gear was repacked for transportation back to Boulder. All of the gear had arrived safely in Boulder by July 28.

II. DATA COLLECTION AND PROCESSING

The first collection of "simultaneous" two-site sea-echo data* commenced on June 18, and continued intermittently through July 15. Several "runs" were made over a complete 12-hour tidal cycle (i.e., high

* Sea-echo data collected nearly simultaneously is required to construct maps with total current vectors.

tide to high tide), with at least two runs over 24 hours. On June 27, 28, 29, 30, and July 1 drifters were tracked within the coverage area of the radar; the radar systems were operated concurrently with these drifter-tracking operations for comparisons.

"Simultaneous" radar site operation in a few cases refers to concurrent operation of each radar, on different frequencies. Because of concerns about possible mutual interference, however, most of our "simultaneous" operations were actually sequential in nature, with one site operating for 8 1/2 minutes (512 seconds) during which the other site was silent. Thus the data that were later combined from both sites were at most recorded ten minutes apart; we consider this sufficiently close to be "simultaneous" in light of the 12-hour tidal cycle.

A typical 512-second recording session at each site actually consists of four 128-second coherent runs. This means that the digitally filtered time series of HF sea echo from each of the four receiving antennas and for each of sixteen range (time-delay) gates are sampled every quarter second (for both in-phase and quadrature receiver channels). Thus one 128-second period for each site actually results in 4 x 16 x 4 x 2 x 128 words, each 10-bits in length; this is a total of 65,536 words per 128-second run (or 655,360 bits of data). Five blocks of four such 128-second runs are stored on a single data tape (13 million words or 130 million bits of data), spanning a measurement period of approximately one hour and forty minutes. Over a 12-hour tidal cycle, more than seven tapes per site are recorded for a total of 187 million words. Without question, one such twelve-hour run provides a greater volume of raw data on currents than has been gathered by all nations, over all oceans, in the history of mankind. The point is — having returned from Alaska with a total of $\sim$ 150 such data tapes — we cannot possibly present all of this information sensibly. Thus considerable thought is being given as to how to effectively utilize and interpret this massive amount of data.

The raw time-series data stored on tape are archived in Boulder for later use; these same data were also processed further in the field on our PDP 11/34 minicomputers during hours when the radar is not operating. This post-processing consists of (i) Fourier transforming each of the sixteen 128-second runs for each of the four antennas; (ii) extracting the angle of arrival of the signal from the Fourier transform output (at each frequency) using the four antenna signals; (iii) averaging the current radial velocity component (directly proportional to the Doppler frequency at the Fourier transform output) vs angle of arrival for the four 128-second runs constituting the 8 1/2 minute data block. In this process, angles associated with weak signals are excluded, and angles associated with stronger signals are weighted more heavily in the averaging process. Thus the tape-recorded output of this next processing phase for each 8 1/2-minute block at each radar site is an array of radial current velocities vs range and azimuth angle.

The final phase of processing is the construction of a current vector map. This is done by taking the radial current data from both sites vs polar coordinates (range and azimuth) and combining them trigonometrically at a preset rectangular grid of points spaced 3 x 3 km geographically. Gaps will occasionally occur in the maps where no vectors appear; this happens because the signals from one or both of the two sites fell below a threshold deemed acceptable for quality averaging. Hence these basic current-vector maps often look somewhat sporadic in coverage and random in terms of the current field. Smoothing, interpolation, and spatial averaging techniques can then be used to refine the maps further.

The ultimate combination of averaging, thresholding, weighting (by signal-to-noise ratio), interpolating, and integrating the equation of continuity has by no means yet been optimized. We are still in a learning mode, experimenting with the various processing parameters. The criteria we are using at present to decide when a given processing scheme is superior to previous ones are (i) use of simulated random sea echo in which we know exactly the input current field, and (ii) comparisons with drifter-deduced surface currents. Thus the maps to be shown subsequently should be considered an interim product, by no means representative of our final, more optimal results.

III. SAMPLE PRELIMINARY CURRENT MAPS

Two current maps are selected for display here as Figs. 3 and 4. They were made from data taken July 1. This particular day was chosen because of simultaneous drifter-deduced currents; of all of our ship tracking of drifters, July 1 represented the one day during which the greatest amount of drifter data was obtained over the widest possible area. We recorded, processed, and mapped currents out to only 42 km on July 1 because ship operations were confined to this coverage area.

The first — Fig. 3 — represents the surface currents (as obtained from the computer pen-plotter) at 1120 hours. At this point in the tidal cycle (some 2 1/2 hours before high tide), the current influx into Cook Inlet was near — but had not yet reached — maximum Northward flow. Maximum flow occurred close to 1230 hours, as seen in a subsequent table of drifter velocities. The familiar flow into the Kachemak Bay toward the south is evident, as is the curving Northward flow around the Anchor Point head.

The second — Fig. 4 — was obtained at 1920 hours, coinciding within minutes of low tide. The outflow from the inlet is clearly in evidence, with maximum surface current velocities near 5 knots. The southward outflow is nearly maximum at this time. There is some indication of a "null zone" in the southernmost portion of the radar coverage area. We have seen this phenomenon in other radar-current maps also, and it has been suggested as real by the Alaska Fish and Game Service based upon some of their investigations. We intend to examine this region more extensively using sets of our radar data covering this area out to a greater range.

Each of these computer-generated current maps required seventeen minutes of radar-observations to produce (8 1/2 minutes per site). The maps were generated entirely within the computer software, with no human editing done to remove bad points. Four consecutive 128-second runs for each site were averaged, with the resulting radial current vector thresholded and weighted by the signal-to-noise ratio; this eliminates data points associated with weak signals. Both the positive and negative Doppler sidebands were employed, and total semi-averaged current vectors were calculated for each grid point. Finally, data at the grid points were recalculated, averaging the four Doppler sideband combinations together with signal-to-noise ratio weighting and a weighted spatial interpolation. The maps are the result. Again, this processing is by no means yet optimized. Vectors near the baseline joining the sites are especially "noisy" in these maps. Software is nearly completed which which improves the accuracy in these regions — as well as extending accurate coverage further out to the north and south. In addition, the removal of an unsymmetrical bias shift in the Doppler sidebands — presently under investigation -- appears to improve the accuracy further. As these improvements are made, the resulting current maps available in the near future will be even more meaningful and complete representations of the near-surface circulation than the preliminary but useful maps shown here.

IV. COMPARISON WITH DRIFTERS

The only presently meaningful way to make comparisons with radar-deduced currents during operations is to simultaneously track drifter buoys within the radar coverage area. This was done during the week of June 26. However, the boat that was available through June 29 was so slow (i.e., the "Puffin" from Alaska Fish and Game Service) that it precluded obtaining more than four or five points per day, and these were too close to the baseline between the radar sites to give meaningful comparisons over most of the radar coverage area. Consequently, we rented a faster charter fishing boat on June 30 and July 1. The data from July 1 are presented here for comparison because (i) the time over which drifter data were obtained was longer, from 1130 to 2100 hours on station; (ii) the spatial coverage was much greater than on June 30; (iii) one of the radar sites was inoperable for three hours on June 30 in the middle of the drifter measurements because of gasoline generator problems.

The comparison between radar-deduced currents and drifter-deduced currents is given in Table I. The current vectors for each case are broken into North and West components. Typically; the drifter - drogued with baffle plates 0.5 m deep - was tracked over a 15 minute period, noting its position at the beginning and end of that period.

The mean position of each drifter measurement is shown as an x-y position. The coordinate origin of this system is the center of the line joining the two sites (36 km long), with x pointing along the line toward the North site and y pointing perpendicularly outward from the line in a (generally) Westward direction. With this coordinate system and scale, the position of the various drifter measurements can be estimated quickly if desired.

Table I — spanning nearly 3/4 of a tidal cycle in time — shows the north/south reversal in the current, detected and tracked both by the drifter and by the radar. The radar signal processing used to estimate the surface currents is described at the end of the preceding section. These current-extraction algorithms are presently in a state of optimization, and we expect closer agreement soon based upon improvements. There are a number of physical reasons why radar-deduced surface currents (essentially Eulerian spatial averages over 3 x 3 km areas) can be expected to differ from drifter-deduced surface currents (which are Lagrangian in nature). However, our measurements from Florida show that — due to surface current turbulence — individual drifter estimates of currents within the same 3 x 3 km patch seen by the radar can vary as much as 10-15 cm/s.

A scatter plot of the data represented by Table I is shown in Fig. 5, along with the regression fit to the data. The values of the coefficients "a" and "b" indicate that the regression fit is very close to the desired 45° line. Also, the regression quality coefficient, $r^2 = 0.92$, is quite close to the unity value for a perfect fit.

Table II gives a summary of the means and standard deviations between the radar and drifter currents shown in Table I. The standard deviations of $\sim$ 30 cm/s compare with our Florida drifter analyses, which yielded $\sim$ 27 cm/s. This is nearly one-half knot in both cases. Because of standard deviations between individual drifter measurements within a given radar cell of $\sim$ 10-15 cm/s, we hesitate to say we compared our radar data with "ground truth." At worst, we can say that — even with our preliminary radar signal processing — the rms radar error does not exceed one-half knot. At best, the radar accuracy may be as good as — or better than — 15-20 cm/s rms when drifter variability is taken into account.

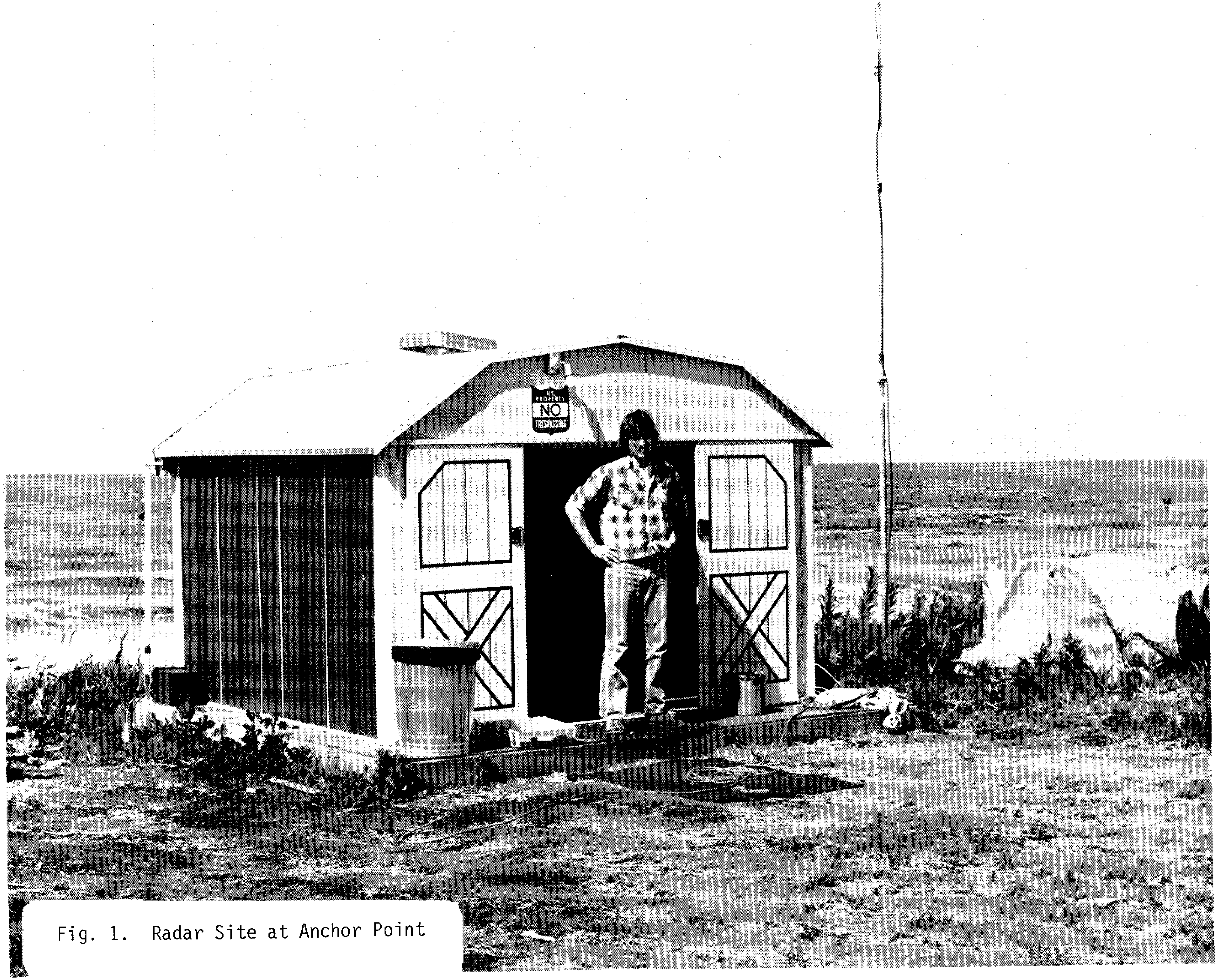


Fig. 1. Radar Site at Anchor Point

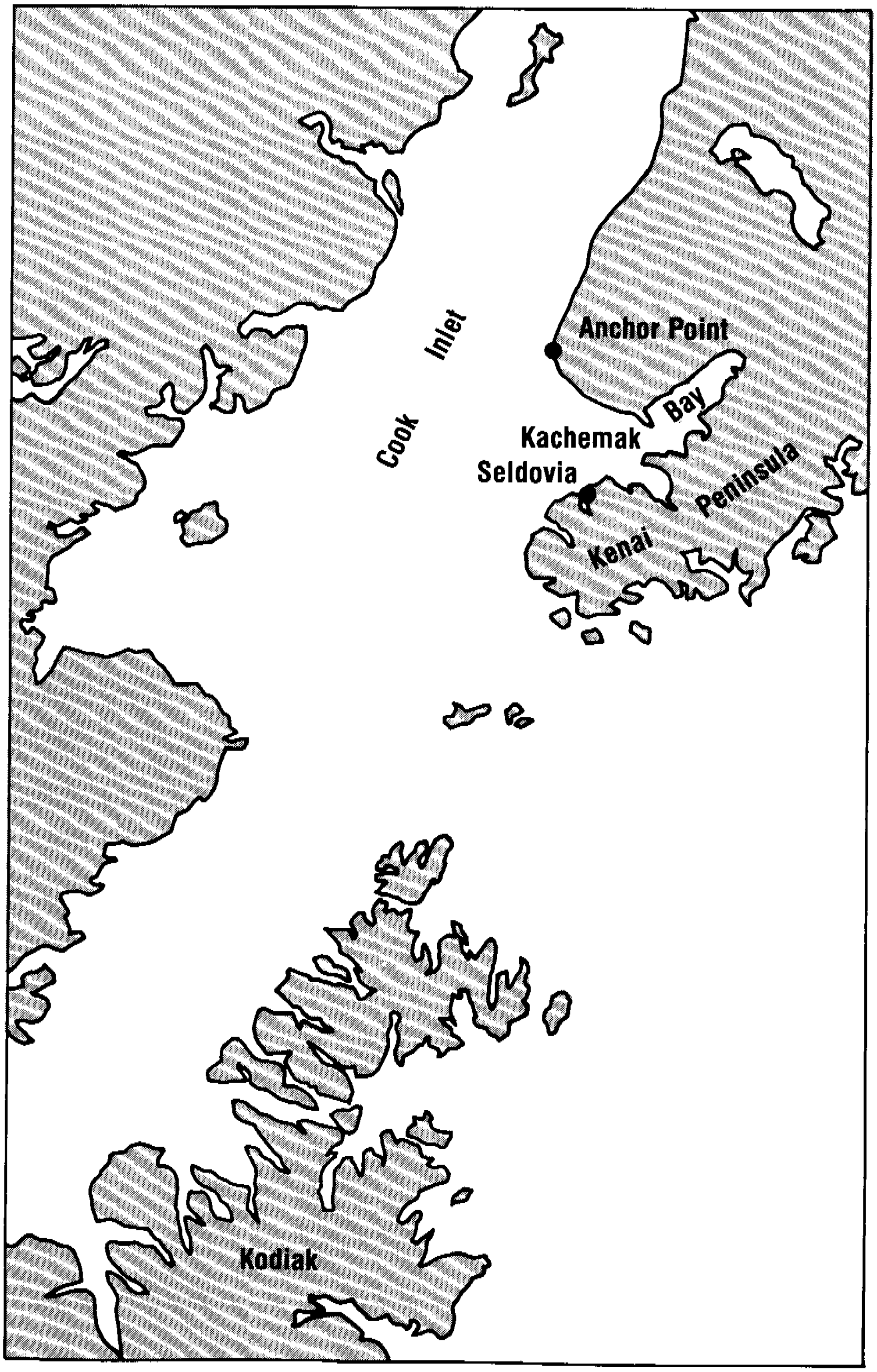


Fig. 2. Area of Radar Operations;
Dots Denote Radar Sites

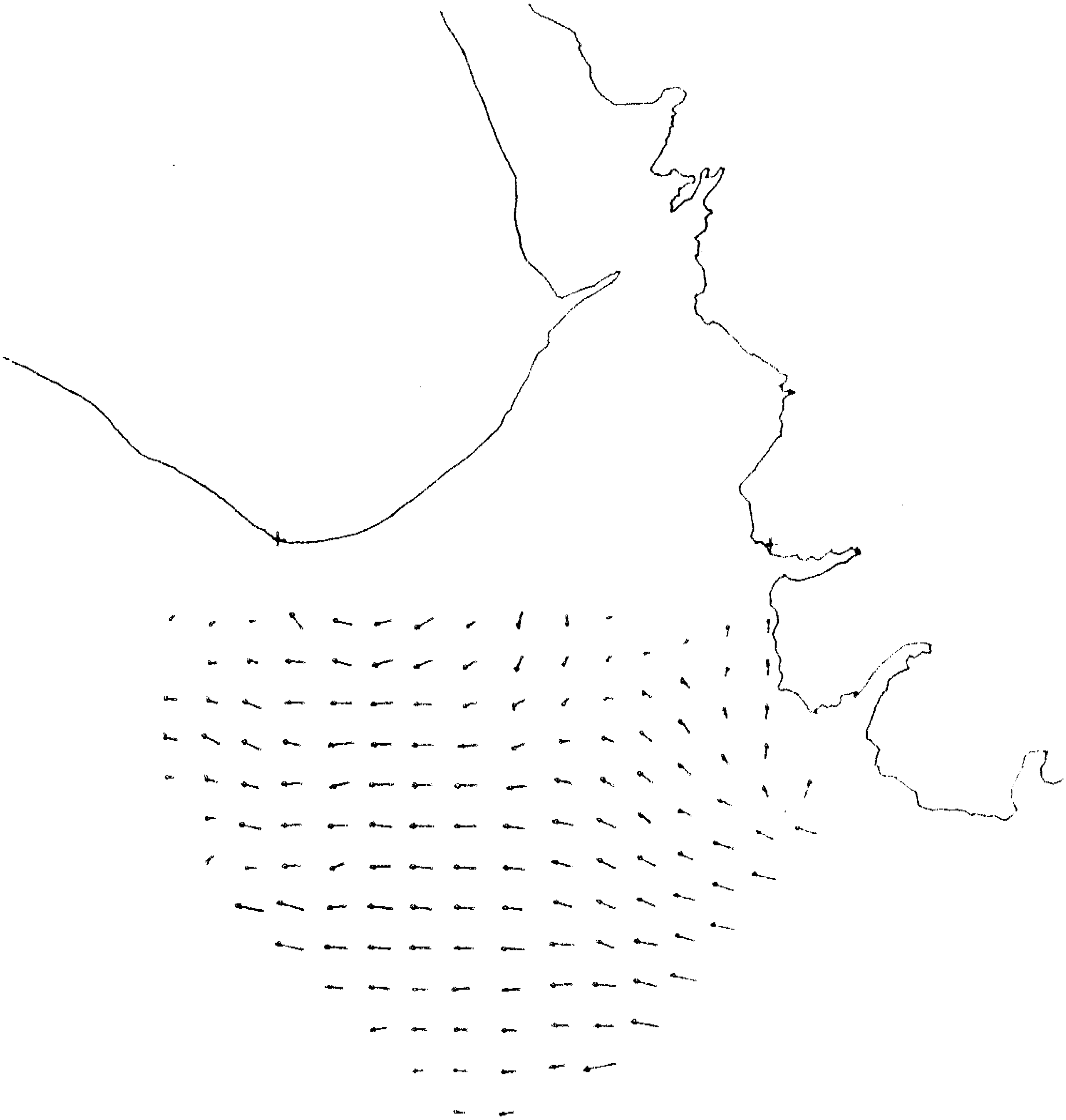


Fig. 3. Surface Current Patterns on July 1, 1977 at 1120 Hours

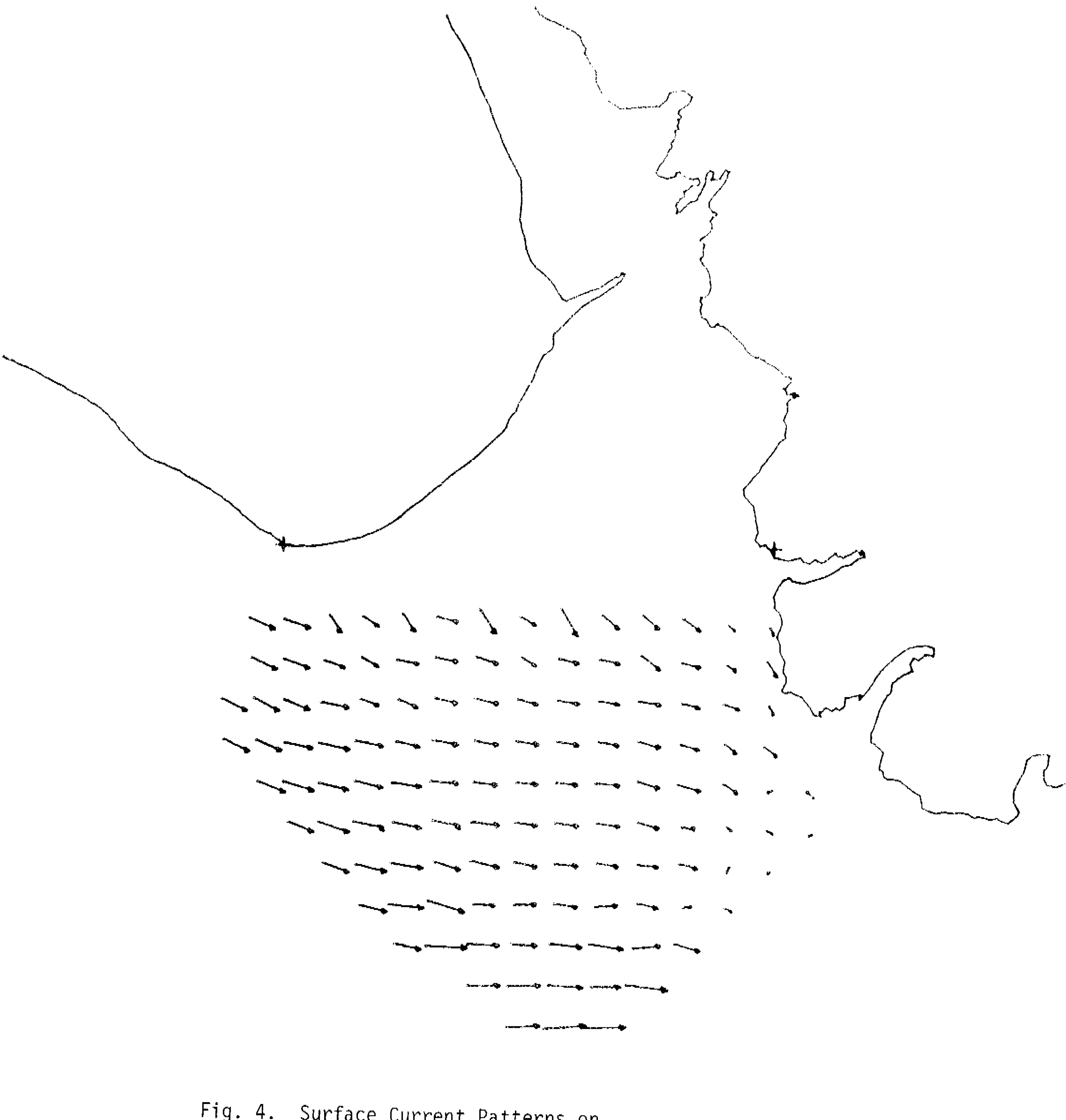


Fig. 4. Surface Current Patterns on July 1, 1977 at 1920 Hours

Table I.

RADAR vs DRIFTER SURFACE–CURRENT COMPARISONS
JULY 1, 1977 --- COOK INLET --- ALASKA

Time & Position		Drifter Current Components	Radar Current Components
1137 hours	x = 12.3 km y = 4.6 km	V_N = 160 cm/s V_W = 63 cm/s	V_N = 121 cm/s V_W = 73 cm/s
1200 hours	x = 17.2 km y = 7.3 km	V_N = 231 cm/s V_W = 25 cm/s	V_N = 256 cm/s V_W = 48 cm/s
1306 hours	x = 20.1 km y = 14.6 km	V_N = 190 cm/s V_W = −24 cm/s	V_N = 261 cm/s V_W = 29 cm/s
1413 hours*	x = 17.5 km y = 19.7 km	V_N = 175 cm/s V_W = −26 cm/s	V_N = 170 cm/s V_W = −19 cm/s
1446 hours	x = 12.3 km y = 18.6 km	V_N = 135 cm/s V_W = −23 cm/s	V_N = 158 cm/s V_W = −12 cm/s
1525 hours	x = 4.4 km y = 20.6 km	V_N = 71 cm/s V_W = −21 cm/s	V_N = 91 cm/s V_W = −9 cm/s
1733 hours	x = −14.8 km y = 10.3 km	V_N = −54 cm/s V_W = 41 cm/s	V_N = −33 cm/s V_W = −1 cm/s
1824 hours	x = −6.1 km y = 8.4 km	V_N = −75 cm/s V_W = 20 cm/s	V_N = −85 cm/s V_W = −25 cm/s
1922 hours**	x = −0.4 km y = 9.0 km	V_N = −82 cm/s V_W = −19 cm/s	V_N = −96 cm/s V_W = −12 cm/s
2000 hours	x = 4.7 km y = 8.3 km	V_N = −109 cm/s V_W = −45 cm/s	V_N = −108 cm/s V_W = −3 cm/s

*High Tide **Low Tide

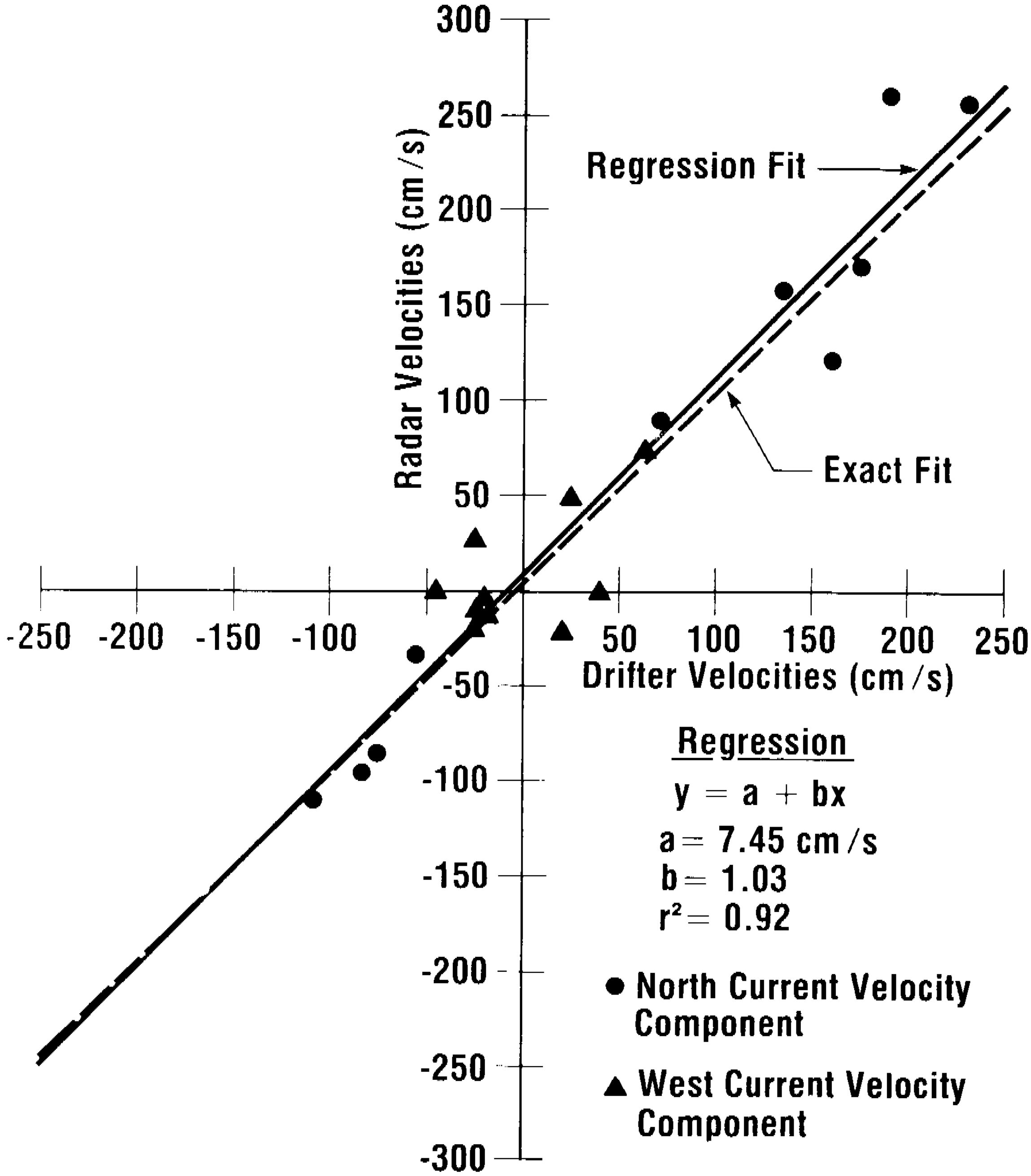


Fig. 5. Correlogram of Radar vs
Drifter Surface Current Velocities

Table II.

ALASKAN TESTS --- JULY 1, 1977

PRELIMINARY DRIFTER-RADAR COMPARISON SUMMARY

$V_d \equiv$ Drifter Velocity

$V_r \equiv$ Radar Velocity

$\Delta \equiv V_d - V_r$

- $\overline{\Delta} = -8.6$ cm/s
- $\sqrt{\overline{\Delta^2}} = 30.2$ cm/s
- $\sqrt{\overline{(\Delta - \overline{\Delta})^2}} = 29.7$ cm/s

QUARTERLY REPORT

Contract No:

03-5-022-67, T.O. #3

Research Unit No.:

91

Reporting Period:

1 July - 30 September 1977

Number of Pages:

1

Current Measurements in Possible Dispersal Regions of the Beaufort Sea

Knut Aagaard

Department of Oceanography
University of Washington
Seattle, Washington 98195

3 October 1977

I. Objectives

To provide long-term Eulerian time series of currents at selected locations on the shelf and slope of the Beaufort Sea, so as to describe and understand the circulation and dynamics: and in conjunction with the STD program, to examine the possible spreading into the Canadian Basin of waters modivied on the Beaufort shelf.

II. Field Activities

None. Retrieval of the two moorings deployed on Cruise W27 (March/April 1977) is planned for late October.

III. Results, and IV. Preliminary Interpretation of Results

Analysis of the earlier current records is continuing.

V. Problems Encountered

None.

VI. Estimate of Funds Expended by Department of Oceanography, University of Washington to 31 August 1977.

TOTAL ALLOCATION (5/16/75-9/30/77):			$183,042
A. Salaries, faculty and staff		$27,815	
B. Benefits		3,551	
C. Supplies & Expendable Equipment		26,952	
Repair to instrumentation	$1,500		
Arctic shelter	$1,200		
D. Permanent Equipment		65,430	
E. Travel		4,089	
F. Computer		618	
G. Other Direct Costs		20,296	
H. Indirect Costs		12,183	
	TOTAL		160,934
	REMAINING BALANCE		22,108

QUARTERLY REPORT

Contract R7120846
R7120847

Research Unit #138

Reporting Period: 1 July - 30 September 1977

Number of Pages: 18

GULF OF ALASKA STUDY OF MESOSCALE OCEANOGRAPHIC PROCESSES (GAS-MOP)

Dr. S. P. Hayes

Dr. J. D. Schumacher

Pacific Marine Environmental Laboratory
National Oceanic and Atmospheric Administration
3711 15th Avenue N. E.
Seattle, Washington 98105

September 28, 1977

I. TASK OBJECTIVES

- Eulerian measurements of the velocity field at several positions and levels
- Measurements of the along- and cross-shelf sea surface slope
- Process study to understand the interrelations among the velocity field, the bottom pressure gradient, the density field, and the wind field in order to determine the dynamics of the circulation on the continental shelf.

II. FIELD OR LABORATORY ACTIVITIES

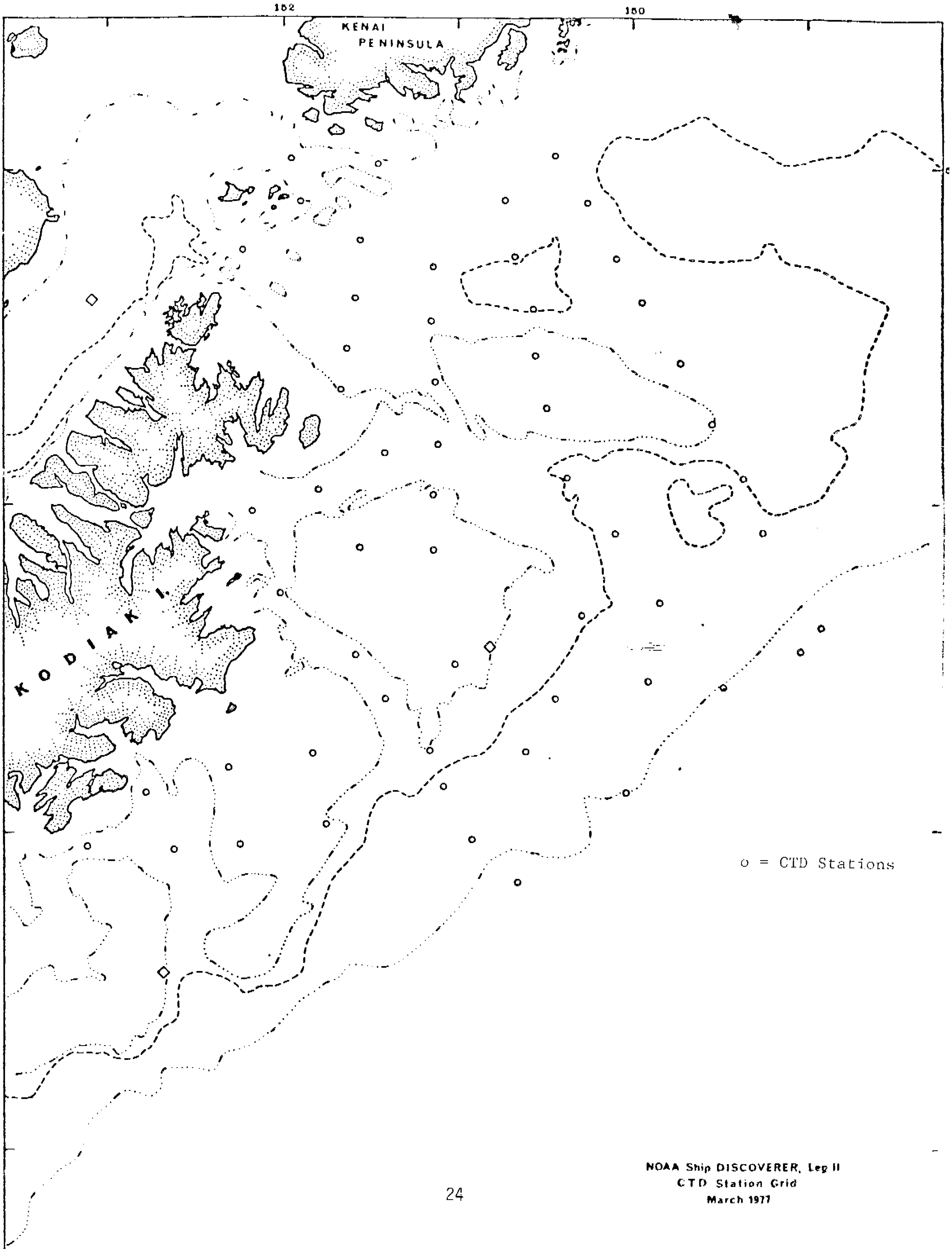
A. Cruises: See attached Cruise Report (1).

III. RESULTS

A scientific paper by Schumacher, Dreves and Sillcox discussing circulation in the Kodiak Island, Shelikof Strait (KISS) region. Attached is the introduction, Figure and Table 2 showing the location of CTD stations discussed in this paper. The final version is to be submitted in the next Quarterly report.

Introduction

Since August 1974 the Pacific Marine Environmental Laboratory (PMEL) has participated in field operations supporting NOAA's Outer Continental Shelf Environmental Assesment Program (OCSEAP) in the Gulf of Alaska. One facet of this program was an exploratory field experiment in the Kodiak Island, Shelikof Strait (KISS) region (Figure 1) which included current meter moorings and conductivity, temperature versus depth (CTD) measurements. In this report we present CTD data for the KISS region collected during two curises in March 1977. Current records for the period October 1976 to March 1977 are presented and discussed. Additionally, satellite imagery is used to aid our understanding of surface temperature features. Our purpose is to describe and interpret the observed hydrographic and velocity field features and to make this information available to other investigators in OCSEAP.



NOAA Ship DISCOVERER, Leg II
CTD Station Grid
March 1977

CRUISE REPORT

RP-4-SU-77B, LEG V, Cruise II

TO : Captain James G. Grunwell
Commanding Officer, NOAA Ship SURVEYOR

FROM: Rick Miller
University of Washington

GENERAL CHRONOLOGY

JD 248 - Depart Kodiak and commence CTD stations south of Kodiak Island. Forty stations were taken.

JD 252 - A break in the weather allowed the recovery of current meter mooring WGC-2F. Instrumentation on the mooring consisted of 2 Aanderaa RCM-4 current meters recording current deviation and velocity, as well as temperature, conductivity and pressure, every 30 minutes. The mooring was recovered by releasing an AMF acoustic release which was attached to a 4,000 lb. concrete anchor.

After recovery of WGC-2F the remaining 30 CTD stations designated on the PMEL Gulf of Alaska CTD grid were completed. Also included in the above were 16 CTD stations that were not on the standard grid (stations 310 - 325).

JD 255 - Depart CTD station 310.2 for Icy Bay area. Arrive at the 1500 M CTD station on line #2 in the Icy Bay area. Complete 12 CTD stations on line #2. Stations were spaced 10 km apart from 1500 M to 250 M and then taken every 5 km to the 50 M contour.

Arrive at the 50 M pressure gauge mooring station SLS 22 on line #1, Icy Bay area. The mooring consisted of a pressure gauge and a Type 322 AMF acoustic release mounted on an aluminum tripod and secured to the railroad wheel anchor via the AMF release. A 28# aluminum sphere was used for floatation. SLS 23 was an identical type of mooring located in 102 M of water and was also retrieved in good condition. Current meter station 62L was then retrieved from 194 M with all four current meters in good condition. The meters were Aanderaa type RCM-4. Pressure gauge station SLS 24, in 250 M of water, responded to interrogation and acknowledged the release command, however it failed to surface. Further interrogation several hours later indicated that the release was in the same position that it had been before firing. It is assumed that the mooring was "fished" and either the float torn loose or the release mechanism was jammed.

JD 256 - The CTD stations along line #1 began at the 1500 M point and continued to the 50 M contour using the same sampling scheme used on line #2. Line #1 was a line projected from SLS 22 thru SLS 24 and extended to 1500 M and consisted of 16 stations.

Because of the smoothness of the operation to this point, Ship SURVEYOR was ahead of schedule and an extra line of CTD stations was completed extending into Icy Bay. A total of 7 stations was taken.

The final scheduled work of the cruise was a CTD line along 141°W beginning at 1500 M and running north to the 50 M contour. Stations were taken at 10 km intervals.

JD 257 - A series of CTD stations taken in Yakutat Bay was the second line allowed by the extra time gained by efficient operations throughout the cruise.

DISTRIBUTION AND ABUNDANCE OF MARINE BIRDS (Patrick J. Gould, USF&WS)

Ninety-three standard ten-minute marine bird transects were completed in the KISS grid of the Northwest Gulf of Alaska.

Seventy-one standard ten-minute marine bird transects were completed in the Northeast Gulf of Alaska. Thirty-four species of marine birds were recorded. Tables 1 and 2 show the relative abundance (%) and maximum observed densities for each observed species in the Northwest Gulf of Alaska and Northeast Gulf of Alaska respectively.

PERSONNEL

Rick Miller	University of Washington
Roy Oberstreet	OCSEAP Project Office
Patrick J. Gould	U.S. Fish and Wildlife Service

ACKNOWLEDGEMENTS

SURVEYOR conducted all operations smoothly and efficiently, with the result that the required operations were completed ahead of schedule. This permitted some extra CTD work to be done in Icy Bay and Yakutat Bay. The efforts of LCDR W. T. Turnbull are recognized and appreciated in coordinating all operations. Special appreciation is extended to Assistant Boatswain King Claggett and his Deck Department for their recovery work on the moorings, and to Chief Survey Technician Luceno and the Survey Department for the CTD work. I want to thank everyone aboard for their contributions to making this a successful cruise.

TABLE I

WESTERN GULF OF ALASKA STATION GRID

STATION	LAT. (N)	LONG. (W)	DEPTH (METERS)
193	59°09.8'	150°58.8'	24
194	59°06.0'	150°58.8'	165
195	59°02.0'	150°56.3'	155
196	58°57.8'	150°54.7'	146
197	58°51.5'	150°52.9'	146
198	58°44.8'	150°50.4'	170
199	58°38.5'	150°48.0'	199
200	58°38.9'	150°45.8'	
201	58°25.5'	150°23.7'	64
202	58°19.5'	150°03.0'	64
203	58°13.7'	149°41.6'	59
204	58°07/5'	149°21.9'	137
205	58°01.8'	149°00.9'	128
206	57°55.2'	148°40.2'	120
207	58°36.5'	151°45.0'	135
208	58°24.0'	151°28.2'	155
209	58°10.8'	151°11.2'	128
210	58°12.0'	151°00.4'	123
211	58°05.4'	150°58.5'	110
212	57°59.0'	150°44.4'	119
213	57°53.1'	150°29.2'	97
214	57°46.9'	150°14.8'	123
215	57°40.0'	149°58.3'	229
216	57°30.6'	149°48.1'	990
217	57°18.5'	149°32.8'	2000

TABLE I (Western Gulf of Alaska Station Grid) - Cont'd

STATION	LAT. (N)	LONG. (W)	DEPTH (METERS)
218	58°04.0'	151°45.9'	165
219	57°56.2'	151°33.2'	71
220	57°49.0'	151°21.2'	60
221	57°44.8'	151°09.0'	66
222	57°38.8'	150°52.8'	86
223	57°33.6'	150°38.5'	102
224	57°28.4'	150°26.0'	238
225	57°25.0'	150°20.0'	460
226	57°22.3'	150°12.1'	730
227	57°08.6'	149°55.8'	1830
228	56°30.0'	149°33.5'	4750
229	57°30.0'	151°55.7'	82
230	57°17.0'	151°42.0'	55'
231	57°06.0'	151°34.3'	119
232	56°58.2'	151°25.1'	825
233	56°48.3'	151°15.2'	1060
234	56°41.0'	151°07.7'	1830
235	56°22.0'	150°55.8'	5230
236	57°18.4'	152°28.5'	91
237	57°10.4'	152°17.8'	79
238	57°02.8'	152°07.4'	66
239	56°54.6'	151°57.5'	80
240	56°45.1'	151°50.2'	90
241	56°36.0'	151°43.5'	1100
242	56°26.8'	151°36.8'	3260

TABLE I (Western Gulf of Alaska Station Grid) - Cont'd

STATION	LAT. (N)	LONG. (W)	DEPTH (METERS)
243	57°03.8'	152°50.8'	91
244	56°48.3'	152°29.6'	168
245	56°41.4'	152°06.8'	31
246	58°32.0'	152°29.1'	227
247	56°25.2'	152°23.3'	256
248	56°22.1'	152°19.9'	460
249	56°18.7'	152°15.9'	1920
250	56°42.1'	153°28.7'	110
251	56°40.1'	153°15.9'	143
252	56°30.8'	153°10.9'	75
253	56°24.6'	153°03.5'	26
254	56°19.9'	153°00.5'	91
255	56°17.0'	152°58.7'	460
256	56°11.6'	152°53.7'	1740
257	55°33.9'	152°02.0'	5120
258	56°24.1'	154°16.1'	44
259	56°14.7'	154°06.5'	146
260	56°07.3'	153°55.8'	183
261	55°58.3'	153°44.8'	82
262	55°54.5'	153°50.8'	183
263	55°50.1'	153°35.9'	1060
264	55°42.6'	153°24.8'	4020
265	55°39.5'	155°10.0'	274
266	55°33.8'	155°03.9'	730
267	55°27.8'	155°01.5'	910
268	55°22.2'	154°55.0'	1830

TABLE I (Western Gulf of Alaska Station Grid) - Cont'd

STATION	LAT. (N)	LONG. (W)	DEPTH (METERS)
269	55°37.5'	155°51.3'	128
270	55°38.8'	156°19.9'	247
271	55°29.9'	156°21.4'	219
272	55°20.2'	156°17.0'	183
273	55°17.9'	156°02.1'	685
274	55°14.3'	155°51.2'	820
275	55°05.5'	155°44.9'	1510
276	54°58.6'	155°35.0'	1830
277	55°01.6'	156°57.6'	550
278	54°56.2'	156°46.0'	1100
279	54°49.4'	156°37.9'	1740
280	55°45.8'	158°43.8'	75
281	55°43.7'	158°44.0'	79
282	55°41.7'	158°42.3'	84
283	55°38.9'	158°39.9'	88
284	55°36.4'	158°38.1'	137
285	55°34.0'	158°36.8'	110
286	55°31.5'	158°39.8'	146
287	55°29.0'	158°31.8'	146
288	55°26.5'	158°30.0'	146
289	55°24.4'	158°28.0'	154
290	55°21.5'	158°26.7'	99
291	55°19.1'	158°24.8'	152
292	55°17.0'	158°22.8'	150
293	55°14.3'	158°20.5'	148
294	55°11.8'	158°18.4'	146
295	55°09.5'	158°16.1'	146

TABLE I (Western Gulf of Alaska Station Grid) - Cont'd

STATION	LAT. (N)	LONG. (W)	DEPTH (METERS)
296	55°07.0'	158°14.0'	152
297	55°04.5'	158°11.9'	150
298	55°02.3'	158°09.8'	146
299	55°00'.2'	158°07.8'	141
300	54°57.5'	158°04.8'	128
301	54°54.9'	158°02.5'	100
302	54°25.5'	158°00.5'	91
303	54°50.1'	157°58.0'	110
304	54°47.7'	157°56.0'	134
305	54°45.2'	157°53.2'	183
306	54°42.5'	157°50.2'	915
307	54°36.7'	157°44.0'	1100
308	54°31.2'	157°38.6'	1830
309	58°44.4'	152°22.2'	119
310	58°15.0'	147°56.4'	1928
311	58°21.9'	148°17.8'	1460
312	58°28.5'	148°37.8'	183-
313	58°31.8'	148°47.5'	118
314	58°35.1'	148°57.6'	110
315	58°38.4'	149°07.5'	132
316	58°41.7'	149°17.2'	156
317	58°45.2'	149°27.9'	192
318	58°48.5'	149°36.7'	210
319	58°51.4'	149°45.8'	234
320	58°54.2'	149°54.8'	229
321	59°00.0'	149°56.8'	210

TABLE I (Western Bulf of Alaska Station Grid) - Cont'd

STATION	LAT. (N)	LONG. (W)	DEPTH (METERS)
322	59°05.0'	149°59.0'	183
323	59°10.8'	150°01.5'	137
324	59°15.9'	150°03.5'	194
325	59°21.3'	150°06.0'	156

Table II

MOORING INFORMATION SUMMARY

MOORING	ACTION	TIME	DAY	LAT.	LONG.	DEPTH	CURRENT METER	PRESSURE GAUGE
WGC-2F	Recovered	0257Z	252	57°34.3'N	150°49.6'W	90.5 M	2	0
SLS 22	Recovered	1728Z	255	-59°47.4'N	141°39.5'W	52.0 M	0	1
SLS 23	Recovered	1918Z	255	59°40.6'N	141°41.2'W	102.0 M	0	1
62L	Recovered	2218Z	255	59°38'N	142°06'W	194.0 M	4	0
SLS 24	Not Recovered			59°21.9'N	142°09.7W	250.0 M	0	1

CTD STATIONS NEGOA

Line #2 - JD 255

STATION	LAT.	LONG.	DEPTH (METERS)
81	59°22.3'N	142°58.3'W	1829
82	59°26.7'N	142°57.2'W	1097
83	59°31.3'N	142°48.7'W	780
84	59°36.3'N	142°44.4'W	560
85	59°40.5'N	142°39.9'W	350
86	59°45.1'N	142°35.0'W	208
87	59°47.3'N	142°32.3'W	163
88	59°49.3'N	142°29.7'W	139
89	59°51.4'N	142°27.6'W	27
90	59°53.8'N	142°25.2'W	91
91	59°55.9'N	142°23.2'W	79
92	59°57.9'N	142°20.1'W	57

Line #1 - JD 256

STATION	LAT.	LONG.	DEPTH (METERS)
93	59°12.4;N	142°21.8'W	1680
94	59°16.0'N	142°17.3'W	1189
95	59°20.1'N	142°12.1'W	457
96	59°22.2'N	142°09.1'W	241
97	59°24.4'N	142°06.6'W	203
98	59°26.6'N	142°04.1'W	190
99	59°28.6'N	142°01.8'W	190
100	59°30.6;N	141°59.7'W	179
101	59°32.6'N	141°57.2'W	166
102	59°34.7'N	141°55.0'W	158
103	59°37.0'N	141°51.8'W	147
104	59°38.7'N	142°06.9'W	189

CTD STATIONS NEGOA - Continued

STATION	LAT.	LONG.	DEPTH (METERS)
105	59°38.9'N	141°49.4'W	130
106	59°40.9'N	141°47.4'W	107
107	59°43.1'N	141°44.7'W	87
108	59°45.4'N	141°42.0'W	68
Icy Bay Stations			
IC-1	59°47.9'N	141°39.0'W	44
IC-2	59°51.9'N	141°36.2'W	31
IC-3	59°55.8'N	141°32.9'W	68
IC-4	59°58.0'N	141°24.5'W	64
IC-5	59°59.1'N	141°22.6'W	73
IC-6	60°00.8'N	141°20.2'W	16
IC-7A	60°02.6'N	141°20.4'W	115
141° CTD Line			
116	58°44.3'N	140°59.9'W	1500
117	58°49.5'N	140°59.7'W	
118	58°54.3'N	141°00.2'W	450
119	59°00.2'N	141°00.5'W	190
120	59°06.4'N	141°00.4'W	183
121	59°11.2'N	141°00.3'W	177
122	59°16.9'N	141°00.3'W	161
123	59°21.9'N	140°59.8'W	154
124	59°27.6'N	141°00.0'W	300
125	59°33.1'N	141°00.0'W	225
126	59°37.4'N	141°00.1'W	95
127	59°40.5'N	141°00.2'W	49

CTD STATIONS NEGOA - Continued

STATION	LAT.	LONG.	DEPTH (METERS)
YT-7	59°56.3'N	139°35.1'W	247
YT-6	59°52.9'N	139°41.5'W	250
YT-5	59°47.5'N	139°42.4'W	82
YT-4	59°45.7'N	139°50.0'W	64
YT-3	59°42.7'N	139°57.1'W	206
YT-2	59°39.0'N	140°04.7'W	142
YT-1	59°34.9'N	140°10.4'W	38

TABLE III

RELATIVE ABUNDANCE OF MARINE BIRD SPECIES OBSERVED IN KISS GRID, SEPTEMBER 5 - 10, 1977

SPECIES	%	HIGHEST RECORDED DENSITY
Black footed Albatross	+	17 birds in one sighting
Layson Albatross	+	2 birds in one sighting
Northern Fulmar	2	$38/km^2$
Sooty Shearwater	63	$2154/km^2$
Short-tailed Shearwater	4	$25/km^2$
New Zealand Shearwater	+	$2/km^2$
Scaled Petrel	+	$1/km^2$
Fork-tailed Storm Petral	8	$141/km^2$
Leach's Storm Petrel	+	$2/km^2$
Pelagic Cormorant	+	$1/km^2$
Glaucous-winged Gull	+	$4/km^2$
Herring Gull	+	$1/km^2$
Black legged Kittiwake	4	$49/km^2$
Red Phalarope	+	$1/km^2$
Northern Phalarope	1	$21/km^2$
Pomarine Jaeger	+	$3/km^2$
Parasitic Jaeger	+	$2/km^2$
Long-tailed Jaeger	+	$1/km^2$
Golden Plover	+	$2/km^2$
Common Murre	6	$127/km^2$
Cassin's Auklet	+	$3/km^2$
Parakeet Auklet	5	$44/km^2$
Horned Puffin	+	$8/km^2$
Tufted Puffin	6	$18/km^2$

Note; + = less than 0.5%   Total of 93 10-minute transects

TABLE IV

RELATIVE ABUNDANCE OF MARINE BIRD SPECIES OBSERVED

IN THE NEGOA, SEPTEMBER 11 - 15, 1977

SPECIES	% OF TOTAL	HIGHEST RECORDED DENSITY
Black-footed Albatross	+	18 birds in one sighting
Laysan Albatross	+	6 birds in one sighting
Northern Fulmar	3	$3/km^2$
Sooty Shearwater	3	$5/km^2$
Short-tailed Shearwater	1	$2/km^2$
New Zealand Shearwater	+	$1/km^2$
Fork-tailed Storm Petrel	4	$2/km^2$
Double-crested Cormorant	16	$35/km^2$
Pelagic Cormorant	1	$4/km^2$
Glaucous-winged Gull	6	$5/km^2$
Herring Gull	1	$2/km^2$
Mew Gull	+	$1/km^2$
Black-legged kittiwake	12	$8/km^2$
White-winged Scoter	+	$2/km^2$
Red Phalarope	+	$1/km^2$
Northern Phalarope	5	$12/km^2$
Pomanine Jaeger	5	$2/km^2$
Parasitic Jaeger	1	$1/km^2$
Skua	+	$1/km^2$
Golden Plover	+	$1/km^2$
Common Murre	+	$1/km^2$
Marbled Murrelet	1	$2/km^2$
Parakeet Auklet	16	$14/km^2$
Rhinoceros Auklet	9	$8/km^2$
Tufted Puffin	6	$3/km^2$

TABLE IV- Continued

SPECIES	% OF TOTAL	HIGHEST RECORDED DENSITY
Water Pippit	+	$1/km^2$
Orange Crowned Warbler	+	$1/km^2$
Savannah Sparrow	+	$1/km^2$
Fox Sparrow	+	$1/km^2$

Note: + = less than 0.5%

QUARTERLY REPORT

RESEARCH UNIT #: 140
REPORTING PERIOD: July 1, 1977 to September 1, 1977
NUMBER OF PAGES: 3

Numerical Studies of Alaskan OCS
(July-Sept. 1976 and Oct.-Dec. 1976)

Jerry Galt
PMEL/NOAA

QUARTERLY REPORT

Research Unit: 140
Reporting Period Ending: 9/30/77
P.I.: Jerry Galt

Introduction

The modelling effort as described in the work statement is advancing as four developmental pieces. During the reporting period progress has been made on all four tasks. These parts and their proponents are as follows:

1. Diagnostic Model - Galt, Watabayashi
2. Environmental Disc - Galt, Pease
3. Pollutant Trajectory Model - Galt, Karpen
4. Meteorological Model - Overland, Galt

Present Accomplishments

1. Diagnostic Model - Basic changes in the diagnostic model were made to accomodate more stations and alleviate boundary value problems. The model was reorganized into a collection of overlays which approximately doubled the station capability and lessened the core space requirements of the program. The coordinate routine was changed into a Mercator transformation so that plots can be correctly scaled to fit standard Mercator charts. The matrix assembly routine was altered to impose a no-net-flow condition across solid boundaries. The matrix solving routine was replaced by an algorithm which takes advantage of the sparseness of the matrix and so saves

space. A boundary value routine was added which will solve a first order vorticity equation along depth contours for the case with no bottom friction. Documentation for these improvements is now in the final stage of preparation.

2. Environmental Disc - Development of an Environmental Disc for the NEGOA region was begun. This library will be the prototype environmental library for use with the full oil trajectory model. The disc file arrangement and directory and access systems layout were planned.

3. Pollutant Trajectory Model - The components of the general oil spill trajectory model were designed, and most of the software for the designs was completed. Simple tests of the basics of the graphics system and model components were made. Routines to handle time series data were written. The central routines necessary for solving the distribution of variables equation were written and initial testing was begun.

4. Meteorological Model - A variant of LaVoie's model was used as the prototype for application along the Alaskan Coastline. Major changes were made in LaVoie's original formulation. The most notable change was the choice of a more basic finite difference lattice which eliminated numerical noise in the solution and rid the problem of over specification of boundary conditions. Also a provision was made for the marine boundary layer to actually intersect the topography of the high coastal mountain peaks along the south coast of Alaska. Because the primitive equation

system is rich in solutions and four open boundaries must be specified for a meteorological small region, the application of a LaVoie-type model to this new area was a non-trivial exercise. Recent progress was centered on a one dimensional version of the model for generalized flow conditions. It was decided that the lateral boundary conditions in the general model could be specified from calculations of the one dimensional model for the same topography. Evaluation of surface winds and surface wind stress derived from large scale objective sea level pressure analyses was undertaken. One study compared monthly wind stress fields computed from monthly averaged pressure with those computed from twice daily surface maps to determine if constant correction factors could be applied to monthly data to estimate the effect of daily variability. It was found that stress ratios were not stable in the region of his atmospheric variability. This implies that monthly mean stress fields cannot be adequately generated from monthly mean pressures.

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Bristol Bay Oceanographic Processes
(B-BOP)

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25 September 1977

Task Title: BRISTOL BAY OCEANOGRAPHIC PROCESSES (B-BOP)

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Reporting Period 1 July 1977 - 30 September 1977

I. Task Objectives:

1) Determine spatial and temporal variability in the velocity-field and obtain indications of spatial coherence at various length scales across Bristol Bay.
2) Determination of sea level perturbation time and length scales.
3) Examination of meteorological factors related to observed pulses in mean flow.
4) Characterization of temporal and spatial variability of hydrographic properties.

II. Field and Laboratory Activities:

A. Cruises: See attached cruise report for RP-4-SU-77B, Leg III. Cruise report for RP-4-DI-77C, 6-29 September will be included in the next Quarterly Report.

III. Results:

CTD data from cruise RP-4-SU-77B, LEG III of the OCSEAP Bering Sea project are being processed. The abstract, "Observations of a boundary front during the early summer: Bristol Bay, Alaska" (Attachment B) has been submitted for presentation at the Fall 1977 AGU meeting. As noted in the SURVEYOR cruise report (Attachment A) 46 XBT drops were taken in July to further investigate the extent and behavior of the boundary front.

As noted in the last Quarterly Report (April-June 1977), a paper dealing with current meter observations is being prepared. It became clear that data yielding vertical profiles of velocity, time-series of velocity at selected depths near the pycnocline and time-series CTD casts were required to elucidate mixing processes and velocity field characteristics. Thus, we designed the "Pycnocline Mixing Experiment" (see Attachment C). which was conducted from the SURVEYOR. These data are being processed.

The following narrative and figures (Attachment D) have been generated in preparing the "Tidal Observations in Bristol Bay, Alaska" paper by C. Pearson.

B-BOP Hydrographic Data Summary

Dates	Stations	Cruise	Region	Remarks*
20 July - 8 August 1977	139	SURVEYOR RP-4-SU-77B Leg III	Southeast perimeter and Pribilof Islands	

* 105 CTD downcasts
34 upcasts
46 XBT drops

extensive coverage in region where Nimbus drifters were located, Pycnocline Mixing Exp.

Attachment A

University of Washington
Department of Oceanography
Seattle, Washington 98195

Preliminary Report

University of Washington participation in Cruise RP-4-SU-77B Leg III of NOAA Ship SURVEYOR

Bristol Bay Oceanographic Processes

20 July - 8 August 1977

by

Thomas H. Kinder

NOAA Contract 03-5-022-67 TA-4

Approved by ______________________
L. K. Coachman, Professor
Principal Investigator

____
Francis A. Richards, Professor
and Associate Chairman for Research

REF: M77-89

Bristol Bay Oceanographic Processes

1. *Introduction*

This cruise was part of a cooperative study between the University of Washington and the Pacific Marine Environmental Laboratory (PMEL), Environmental Research Laboratory, National Oceanic and Atmospheric Administration (NOAA). This study, Bristol Bay Oceanographic Processes, is one component of the Outer Continental Shelf Environmental Assessment Program (OCSEAP), funded by the Bureau of Land Management and conducted by NOAA. The general goal of our study is to elucidate the circulation and water masses of the southeastern Bering Sea near Bristol Bay, in order to contribute to the understanding of the potential impact of petroleum development.

2. *Objectives*

The specific objectives of this cruise were:

A) To make closely spaced XBT drops across the front which has been found near the 50 m isobath around Bristol Bay;

B) To conduct a time-series station in the strongly stratified water column near the Alaska Peninsula to elucidate the anomalous tidal behavior and to examine possible mixing processes across the pycnocline there;

C) To take CTD stations to provide hydrographic data near the tracks of satellite-tracked drifters; and

D) To take CTD stations in the vicinity of the Pribilof Islands in order to examine the hydrographic structure and to support bird observations.

3. *Narrative*

Mike McCaslin and I arrived in Kodiak on Sunday, 17 July, to prepare for the scheduled 1700, 19 July departure of the NOAA ship SURVEYOR. Because of the late arrival of four cases of expendable bathythermographs (XBT's) and a shallow water XBT modification kit which had been air freighted from Seattle, I delayed the sailing until 1030, 20 July.

On 21 July the ship did a conductivity-temperature-depth (CTD) cast with a concurrent XBT drop. Both the CTD and XBT systems worked properly. On the following day, 22 July, the ship entered Unimak Pass at 0700 and began the first CTD station, 46, at 1100 (see figures for locations). The ship proceeded parallel to the Alaska Peninsula until station 91 at 0005, 23 July, when it turned toward the coast. After a CTD at station 90.1 near the coast, the ship steamed toward station 91 again, dropping 15 XBT's at 1 nm intervals. Surprisingly, even the shallowest station at 22 m depth showed some thermal stratification. After the last XBT drop, we took a CTD cast at station 90.2.

Reaching the vicinity of station 91 again at 0700, SURVEYOR began a careful bathymetric survey that showed a depth variation of less than 1 fathom within 1 nm of the station. At 0915 the ship anchored in about 73 m of water. The weather was ideal: sea state 0, light airs, and cloudless skies. During the next 32 hours the worst weather was 16 knots of wind and wave heights of 5 feet, but the weather was the best encountered during the cruise.

This station was designed to gather time-series data to explore the anomalous tidal behavior that had appeared in records from current meters that had been moored nearby, and to test some ideas concerning mixing across the pycnocline. The data collected included normal vertical CTD profiles, CTD time-series (ten minutes length) at constant depth within the thermocline, velocity profiles taken with 2 vertically separated Aanderaa RCM-4 current meters suspended from the ship, and current time-series in the thermocline which also used the Aanderaa current meters. We gathered the following data:

32 CTD profiles
10 CTD time-series at the center of the thermocline
6 CTD time-series at the edge of the thermocline
11 velocity profiles
9 velocity time-series within the thermocline.

The ship weighed anchor at 1700, 24 July, and proceeded to station 103.1. I had hoped to do an XBT section across the front near station 103, but the stratification was still very strong when 103.2 was reached at 0050, 25 July. We therefore proceeded to 104; I wished to do an XBT section across the front somewhere between station 104 and 84. At 0350, when 104 appeared strongly stratified (3°C temperature difference) we continued inshore to station 119 at 0645. Station 119 still had a 2°C temperature difference. Because of the confusing bathymetry inshore of station 119, running farther inshore to find vertically homogeneous water in shallower depths (depth at station 119 was 37 m) seemed futile. Instead, we ran south from 119 to 84, dropping 32 XBT's at intervals of 2 nm to record the change in stratification across this part of the shelf. Upon reaching station 94 at 1240, 25 July, the ship headed south to begin the Nimbus satellite grid, taking CTD stations across the shelf along the way.

During the cruise we received updated drifter positions from PMEL. The inferred tracks of these drifters fell into three categories: 1) tracks westward, parallel to the shelf break; 2) cyclonic gyre, over the deep water in the southeastern Bering Sea; and 3) onto the shelf near the Pribilof Islands. The first category was too far west to chase, while the third could be addressed during bird observations near the Pribilof Islands on 1-5 August. In order to explore the drifters which appeared to outlie a cyclonic gyre, we did stations over the deepest part of the B-BOP grid, beginning with station 37.1 at 0430, 26 July and ending with station 33 at 1450, 31 August. In addition to their value in understanding the drifters' motion, these stations have not been previously occupied.

After bird watchers came aboard, we did several sets of CTD stations at night during 31 July to 5 August. The starting point for these grids depended upon the finish of each day's bird observations, typically at 2130. The beginning point depended upon the start of the next day's observations, which usually began at 0700. Even though our choice of stations was restricted by the bird observation program, by remaining on the SURVEYOR during the bird observations we gained about 45 hours of ship time for the physical oceanography program, which resulted in about 40 additional stations. We also planned stations to investigate correlations between bird densities and water properties, as suggested by George Hunt, the principal investigator for the bird program. During the bird observations, the ship took surface salinities and temperatures every 30 minutes.

Beginning at 2140, 31 July we occupied 6 stations south and west of St. Paul. On the night of 1-2 August, we took 10 stations southeast of St. George, including B-BOP stations 43 and 44 and a closely spaced grid over a shoal where intense bird activity is found. During 2-3 August, we took 9 stations south and west of St. George, including B-BOP stations 24 and 34. Six stations between the two islands were taken on 3-4 August, and 9 stations north and west of St. Paul completed the program on 4-5 August.

Upcasts (i.e., recording data while the CTD is coming up) were taken on 34 casts, mostly near the Pribilofs. These data were taken to help examine the time-lag properties of the instrument.

At 0700, 5 August the ship steamed from northwest of St. Paul Island for Kodiak via Unimak Pass. The bird observers departed the ship on 4-5 August to St. George or St. Paul, while Mike McCaslin and I left the ship at Kodiak on 8 August.

4. *Methods*

CTD casts were taken with a Plessey Environmental Profiling System, Model 9040. The sensor, model 9040-2, serial 5914, had a range of -2 to 35°C, 10 to 60 m/mho, and 0-1500 meters. Data were recorded on magnetic tape and returned to PMEL for processing.

We started recording data with a 0.1 s interval, in accordance with the ship's operation manual and our past experience. It soon became apparent, however, that doing 1500 m CTD casts at this rate produced huge quantities of tape. After station 2.1, we therefore increased the scan interval to 0.2 s.

Calibration temperature and salinity samples were obtained by Nansen bottle at the greatest depth at about one-half the stations. Salinity samples were analyzed using a Beckman RS7C portable induction salinometer serial 24670, calibrated by NOIC in January 1977.

Two Aanderaa RCM-4 current meters were used for the velocity measurements, separated vertically by 2.5 m, and with a 60 lb weight on the bottom meter to reduce the wire angle. The upper instrument was modified to accept an electrical cable which was attached to a printer on the ship. The upper instrument (ser. 1926) read temperature, time (time code generator), pressure, direction, and speed. The lower meter (ser. 2158) read temperature, conductivity, pressure, direction, and speed. Both instruments sampled at 1 minute intervals and recorded data internally on magnetic tape.

5. *Personnel*

Physical Oceanography (20 July - 8 August)

Dr. T. H. Kinder	Chief Scientist	Univ. of Washington
Mike McCaslin	Scientist	Univ. of Washington

Bird Observations (1-5 August)

Dr. G. L. Hunt	Principal Investigator	U.C. Irvine
M. Naughton	Laboratory Assistant	"
W. Rodstrour	Laboratory Assistant	"
S. Shor	Laboratory Assistant	"
M. Roelke	Observer	Marine Mammal Div., Nat. Marine Fisheries

6. *Statistics*

CTD stations	105
CTD upcasts	34
XBT drops	46
Surface salinity samples	119
Calibration salinity samples	89

(see narrative for station 91 statistics)

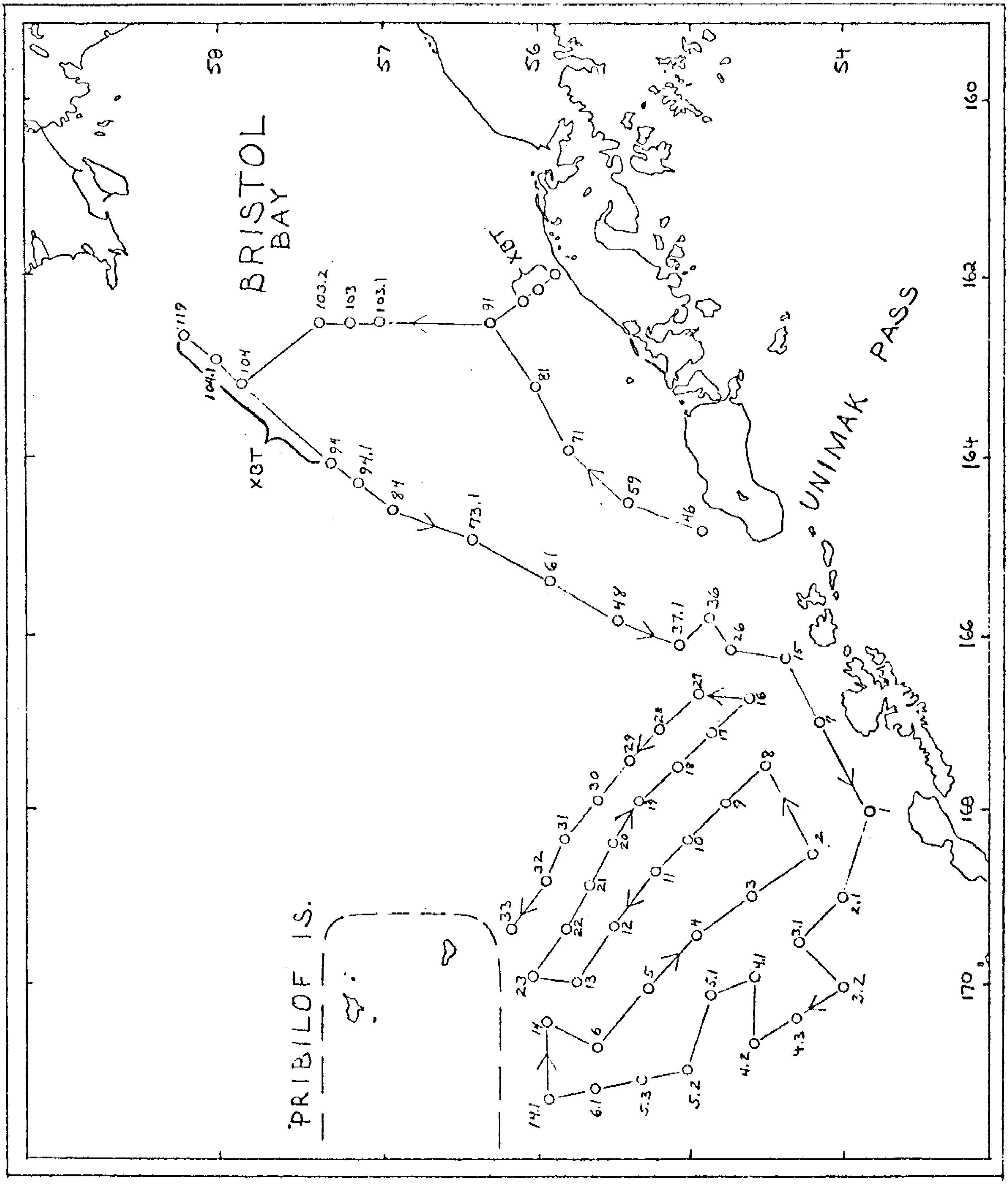
<u>List of CTD Stations</u>

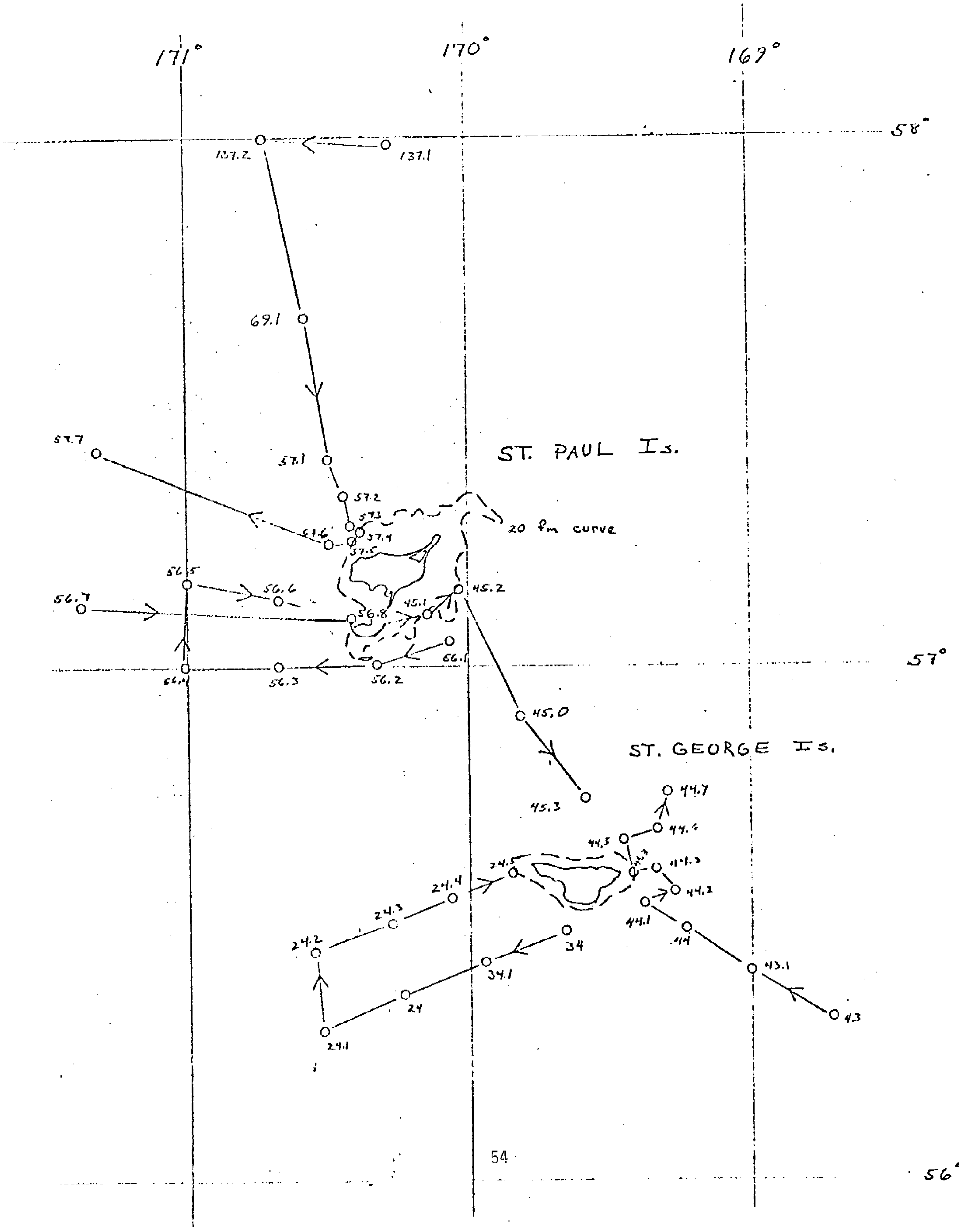
	B-BOP Grid	Time (GMT)	Latitude (N)	Longitude (W)	Depth (m)
1	46	2020 22 Jul	54-55.8	164-51.2	79
2	59	2335 "	55-23.2	164-30.1	101
3	71	0308 23 Jul	55-44.9	163-55.8	93
4	81	0613 "	56-02.0	163-04.6	88
5	91	0905 "	56-17.7	162-30.1	77
6	90	1119 "	56-00.3	162-09.1	66
7	90.1	1259 "	55-52.0	161-58.0	22
8	90.2	1444 "	56-05.6	162-15.8	74
9	* 91	1845 "	56-16.0	162-32.0	73
10	103.1	0639 25 Jul	57-00.4	162-32.4	60
11	103	0811 "	57-13.0	162-30.9	60
12	103.2	0957 "	57-28.6	162-32.1	49
13	104	1304 "	57-54.0	163-12.7	45
14	104.1	1431 "	58-01.9	162-56.3	40
15	119	1554 "	58-11.0	162-38.4	36
16	94	2151 "	57-17.7	164-04.3	60
17	94.1	2330 "	57-07.1	164-18.7	68
18	84	0119 26 Jul	56-55.3	164-36.5	71
19	73.1	0418 "	56-24.9	164-56.1	82
20	61	0731 "	55-55.7	165-23.9	98
21	48	1057 "	55-23.6	165-42.9	119
22	37.1	1341 "	55-00.6	165-54.3	132
23	36	1458 "	54-51.3	165-44.2	140
24	26	1655 "	54-42.9	166-09.5	253
25	15	1926 "	54-23.2	166-18.4	706
26	7	2338 "	54-08.8	167-01.0	1510
27	1	0532 27 Jul	53-48.0	167-59.4	1372
28	2.1	1030 "	53-59.0	168-59.5	1800
29	3.1	1436 "	54-17.5	169-58.5	1500

	B-BOP Grid	Time (GMT)	Latitude (N)	Longitude (W)	Depth (m)
30	3.2	1807 27 Jul	54-00.3	169-59.8	1856
31	4.3	2120 "	54-17.7	170-18.9	1829
32	4.2	0048 28 Jul	54-34.4	170-39.7	2045
33	4.1	0417 "	54-35.1	169-56.3	1838
34	5.1	0703 "	54-52.9	170-08.5	2200
35	5.2	1035 "	54-59.8	170-56.8	3100
36	5.3	1332 "	55-19.4	171-02.7	3100
37	6.1	1608 "	55-36.3	171-09.1	3000
38	14.1	1914 "	55-56.4	171-18.9	2908
39	14	2255 "	55-59.2	170-24.6	1700
40	6	0217 29 Jul	55-34.8	170-39.3	3150
41	5	0557 "	55-14.6	170-01.0	2740
42	4	0933 "	54-54.7	169-24.8	2700
43	3	1254 "	54-33.6	168-58.1	1463
44	2	1602 "	54-10.9	168-30.1	2414
45	8	2023 "	54-29.1	167-32.1	713
46	9	2241 "	54-43.6	167-55.5	1485
47	10	0528 30 Jul	54-57.3	168-18.2	1600
48	11	0815 "	55-11.3	168-40.8	2000
49	12	1143 "	55-25.6	169-16.2	2400
50	13	1511 "	55-43.4	169-56.7	2213
51	23	1747 "	56-01.9	169-53.9	142
52	22	1957 "	55-50.2	169-21.4	1700
53	21	2244 "	55-39.1	168-50.1	375
54	20	0046 31 Jul	55-31.9	168-24.3	256
55	19	0304 "	55-18.2	167-55.8	307
56	18	0446 "	55-06.5	167-35.1	263
57	17	0705 "	54-50.4	167-08.4	334
58	16	0912 "	54-36.5	166-42.9	393
59	27	1135 "	54-56.7	166-37.1	155
60	28	1342 "	55-11.2	167-02.3	141
61	29	1535 "	55-23.7	167-25.1	141
62	30	1803 "	55-37.5	167-54.4	132
63	31	1958 "	55-48.8	168-18.5	137
64	32	2143 "	55-57.9	168-48.9	622
65	33	2353 "	56-10.0	169-17.9	783
66	56.1	0652 1 Aug	57-02.8	170-03.8	60
67	56.2	0802 "	57-00.1	170-19.8	62
68	56.3	0915 "	56-59.8	170-40.4	86
69	56.4	1030 "	56-59.9	171-00.7	97
70	56.5	1144 "	57-09.6	170-59.9	88
71	56.6	1312 "	57-07.5	170-40.1	76
72	43	0636 2 Aug	56-19.3	168-43.8	135
73	43.1	0752 "	56-24.6	169-00.4	115
74	44	0859 "	56-29.3	169-13.5	92
75	44.1	0956 "	56-32.0	169-22.4	77
76	44.2	1117 "	56-33.6	169-16.2	73
77	44.3	1218 "	56-33.6	169-19.4	51
78	44.4	1253 "	56-35.8	169-25.1	42

	B-BOP Grid	Time (GMT)		Latitude (N)	Longitude (W)	Depth (m)
79	44.5	1342	2 Aug	56-39.9	169-20.5	71
80	44.6	1426	"	56-40.9	169-20.5	68
81	44.7	1516	"	56-45.4	169-19.7	76
82	34	0659	3 Aug	56-29.1	169-39.6	84
83	34.1	0815	"	56-25.6	169-57.3	95
84	24	0922	"	56-21.7	170-14.0	106
85	24.1	1035	"	56-17.6	170-31.3	115
86	24.2	1152	"	56-27.0	170-31.3	119
87	24.3	1314	"	56-30.3	170-16.8	106
88	24.4	1423	"	56-33.1	170-03.3	97
89	24.5	1523	"	56-35.6	169-51.1	82
90	56.7	0641	4 Aug	57-06.9	171-22.6	100
91	56.8	0938	"	57-05.4	170-25.4	45
92	45.1	1057	"	57-05.5	170-08.9	36
93	45.2	1152	"	57-08.4	170-02.5	36
94	45	1328	"	56-53.9	169-48.1	64
95	45.3	1447	"	56-44.7	169-35.8	71
96	137.1	0325	5 Aug	57-59.1	170-15.0	70
97	137.2	0510	"	57-59.9	170-43.8	80
98	69.1	0718	"	57-39.6	170-34.8	78
99	57.1	0907	"	57-24.0	170-28.9	65
100	57.2	1002	"	57-19.8	170-25.4	67
101	57.3	1100	"	57-16.3	170-23.6	53
102	57.4	1141	"	57-15.3	170-22.5	37
103	57.5	1221	"	57-14.9	170-24.4	53
104	57.6	1304	"	57-14.0	170-29.0	53
105	57.7	1539	"	57-24.7	171-18.9	92

* The second occupation of B-BOP Grid 91 lasted from 1845 23 Jul to 0229 25 Jul and included 11 vertical CTD profiles.


BRISTOL BAY
PRIBILOF IS.
UNIMAK PASS
XBT
XBT
59
57
56
54
160
162
164
166
168
170


171°
170°
169°
58°
57°
56°
137.2
137.1
69.1
57.7
57.1
57.2
57.3
57.4
57.5
57.6
ST. PAUL Is.
20 fm curve
56.5
56.6
56.7
56.8
45.1
45.2
56.1
56.2
56.3
45.0
ST. GEORGE Is.
45.3
44.7
44.6
44.5
44.3
44.2
44.1
44
43.1
43
24.5
24.4
24.3
24.2
24.1
24
34
34.1

Attachment B

OBSERVATIONS OF A BOUNDARY FRONT DURING THE EARLY SUMMER: BRISTOL BAY, ALASKA

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T. Kinder, (Department of Oceanography, Univ. of Washington, WB-10, Seattle, WA 98195)
D. Pashinski
R. Charnell (both at: Pacific Marine Environmental Laboratory/ERL/NOAA, 3711 15 Ave. NE, Seattle, WA 98105)

Conductivity, temperature, and depth data collected during June 1976 and expendable bathythermograph (XBT) data collected during May 1977 are presented. These data show the existence of a front paralleling the 50 m isobath in Bristol Bay. The front forms a boundary between coastal waters which are well mixed and shelf waters which are stratified, while mean heat and salt content is approximately equal on either side. The well mixed water has intermediate temperature and salinity values while the stratified water has a warmer, less saline upper layer and a colder, more saline lower layer. Both of these layers are well mixed. We examine the balance between tidal mixing energy and buoyancy flux using a stratification parameter. The results indicate that about 2% of the tidal dissipation can completely mix a 50 m deep water column using the estimated buoyancy flux (from insolation, melting ice, and freshwater runoff). The data suggest that the front results from this energy balance. The variation of these two factors across the shelf determines the location of the front.

1. 023972SCHUMACHER
2. 1977 Fall Meeting
3. Oceanography
4. None
5. No
6. Yes, preferred
7. 10% in: The Hydrographic Structure over the continental Shelf near Bristol Bay, Alaska, June 1976 by Thomas H. Kinder, Univ. of Washington Technical Report (Ref: M77-3)
8. Same as 1
9. 01-7-035-11911

PYCNOCLINE MIXING EXPERIMENT

Introduction

We want to test some ideas about mixing across the pycnocline in the strongly stratified water over the Bering Sea shelf. To do this, we need a time-series of current meter and CTD measurements at one location, over at least one diurnal tidal cycle (> 25 hours). These measurements will consist of both standard techniques to obtain vertical profiles, and measurements made with the sensors held at a fixed depth. Additionally, because we are worried about the possibility of subtle effects of the local bathymetry, we will need more soundings than are normally taken.

General Procedure

The site for a 30-hour time-series station will be surveyed to determine if there is any unusual bottom topography. If the bottom is smooth, the ship will then anchor in about 75 m of water. The scope of chain paid out should not affect our experiment: we do not think that either the radius of the circle about the anchor, or a slight dragging of the anchor are critical to us. We want to remain close to the chosen site ($\lesssim$ 500 m) throughout the 30 hours. We can only take these measurements in good weather, so that we will not ask the ship to anchor in rough weather.

Each hour, we desire a CTD cast, including a time-series in the middle of the thermocline. Every three hours we will take a vertical profile of velocity using our Aanderaa deck read out system. Also every three hours (but not coincident with the current profile measurements) we will take a time-series of velocity in the middle of the pycnocline. Twice during the experiment we will take time-series measurements at the upper and lower boundary of the pycnocline. We anticipate that the hourly procedures will require 30 to 50 minutes to complete.

CHECKLIST (cont'd)

Time	Sequence	Events
_____(+14)	15	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. velocity profile (10,20,25,30,50,70)
_____(+15)	16	1. 2 minute sounding 2. CTD profile (w/10 min. soak)
_____(+16)	17	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. thermocline velocity (> 10 min.)
_____(+17)	18	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. velocity profile (10,20,25,30,50,70)
_____(+18)	19	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. CTD thermocline extremes (10 min. each)
_____(+19)	20	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. thermocline velocity (> 10 min.)
_____(+20)	21	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. velocity profile (10,20,25,30,50,70)
_____(+21)	22	1. 2 minute sounding 2. CTD profile (w/10 min. soak)
_____(+22)	23	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. thermocline velocity (> 10 min.)
_____(+23)	24	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. velocity profile (10,20,25,30,50,70)
_____(+24)	25	1. 2 minute sounding 2. CTD profile (w/10 min. soak)
_____(+25)	26	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. thermocline velocity (> 10 min.)
_____(+26)	27	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. velocity profile (10,20,25,30,50,70)
_____(+27)	28	1. 2 minute sounding 2. CTD profile (w/10 min. soak)
_____(+28)	29	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. thermocline velocity (> 10 min.)

CHECKLIST (cont'd)

Time	Sequence	Events
______(+29)	30	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. velocity profile (10,20,25,30,50,70)
______(+30)	31	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. CTD thermocline extremes (10 min. each) 4. velocity profile (5,10,15,20,25,30,35, 40,45,50,55,60,65,70) 5. CTD profile (no soak)

then progresses north and northeast into Bristol Bay, with the cotidal lines aligned east-west in Kuskokwim Bay and north-south in Bristol Bay to the east of Cape Newenham. The large range at the head of Bristol Bay is noted and that there is undoubtably a considerable tide in Kuskokwim Bay. Another cotide chart is given in Office of Climatology and Oceanographic Analysis Division (1961). It also shows the M_2 tide wave entering through the Aleutians and moving northeasterly into Bristol Bay. Cotide lines east of Cape Newenham shown radiating out of the Cape, indicating a virtual amphidrome there. Ranges increase toward the head of the bay.

OBSERVATIONS OF TIDES IN BRISTOL BAY

Introduction

Since 1975 PMEL has maintained current meter and pressure gage moorings in Bristol Bay, Alaska as part of NOAA's Outer Continental Shelf Environmental Assessment Program (OCSEAP). These data are being used to help define processes of transport and dispersion of water-borne contaminants resulting from potential development of petroleum resources on the continental shelves. As part of this effort, the data have been analysed for tidal components and have been used, along with historical tide data, to define the characteristics of the tide in Bristol Bay.

Bristol Bay is located on the southwestern coast of Alaska, in the bight formed by the Alaskan Peninsula and the mainland (Fig. 1). For this study its seaward boundaries are defined by the continental shelf break between Unimak Pass and the Pribilof Islands, and a line from the Pribilofs to Nunivak Island. This comprises an area of about 2 x 10^5 sq km, or approximately 10% of the total area of the Bering Sea. Bristol Bay is characterized by a broad flat continental shelf, with depths generally greater on the south side along the Alaskan Peninsula. A large portion of the world's tidal dissipation occurs in the Bering Sea. Miller (1966) estimates about 10%, caused by friction of the tidal currents over the large continental shelf area. Up to now, little has been known of the characteristics of the tide in Bering Sea and Bristol Bay. Defant (1961) summarizes the description given by Harris (1904) Pt. IV, p. 394, and remarks on the remarkably small S_2 amplitude found throughout the Bering Sea. Harris in his Fig. 34 gives a semidiurnal cotidal chart for the Bering Sea based on theory and a few observations. He shows the tide wave entering the deepest of the Bering Sea through the wider passages in the Aleutians to the west of Unimak Island (169^{o}W). It

Cotidal Charts

Based on the observed data and historic harmonic constants, coamplitude and cophase charts have been constructed for the major diurnal and semi-diurnal constituents, M2 and K1. Historic data were obtained from the IHB tables (International Hydrographic Bureau, 1939) and unpublished data from the National Ocean Survey (NOAA, Dept. of Commerce). For several of the NOS stations harmonic constants were not available, but only high and low water analysis. According to Schureman (1940) an estimate of the M2 amplitude may be found by multiplying the mean range by 0.47, and the Greenwich phase from the relationship

$$M2^{o} = \tfrac{1}{2}(HWI+LWI)x28.984^{o} + 90^{o}$$

where HWI and LWI are the corrected high and low water lunitidal intervals respectively. Stations with only high and low water analysis are denoted on the location chart (fig. 2) by an asterisk.

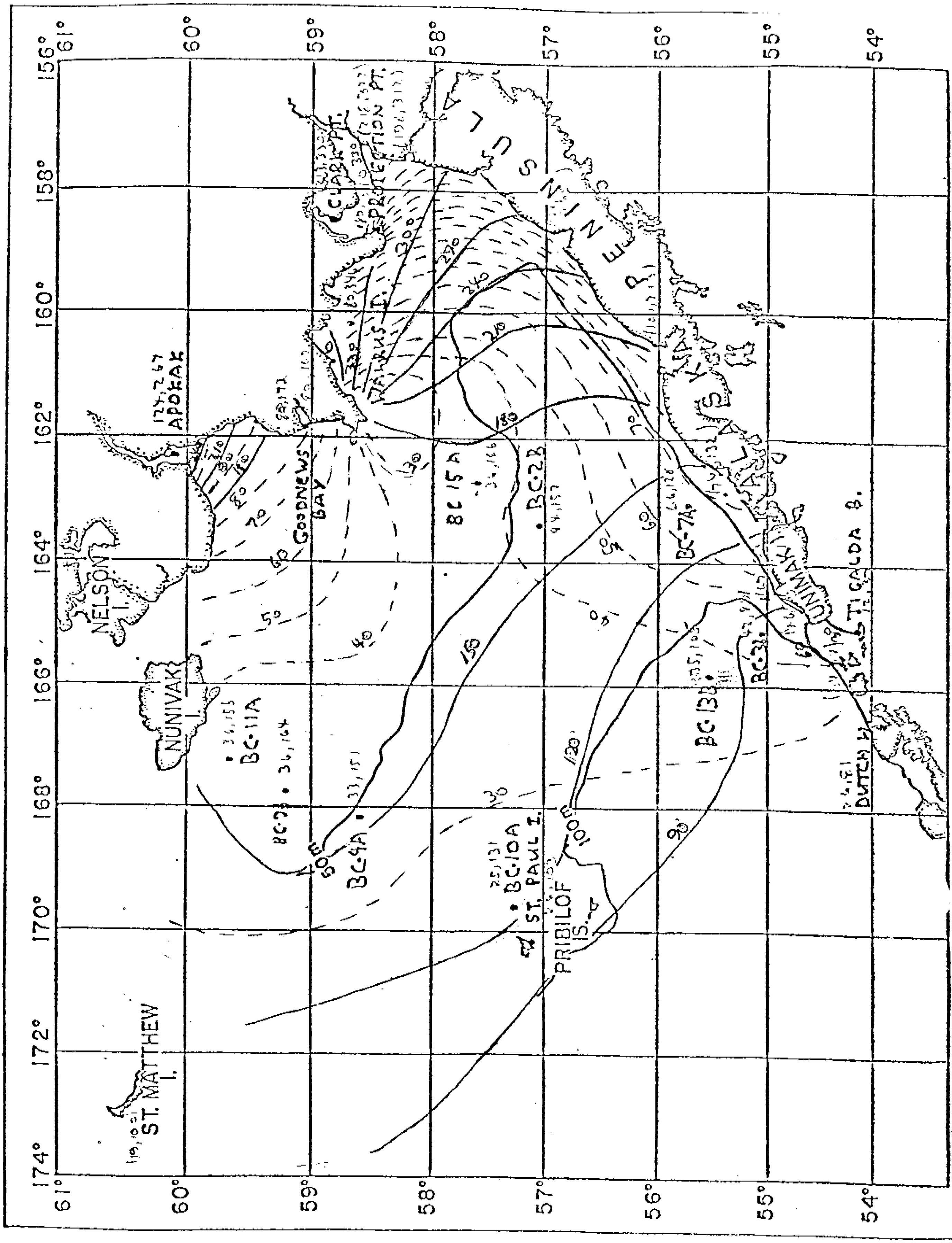
The K1 cotide chart (fig. 6) shows an amphidrome located between Nunivak Island and the Pribilofs. This location is approximately 1/4 wavelength from the head of Bristol Bay. Rotation around the amphidrome is contrasolem, consistent with a Kelvin wave. Amplitudes increase near the Alaskan Peninsula and in the inner parts of Bristol Bay and Kuskokwim Bay. Phases are relatively constant seaward of the 100 meter contour between the Pribilofs and Unimak Island. The direction of progression of the wave is from the deep part of Bering Sea northeastward onto the Bristol Bay shelf. Diurnal admittances at 9B (Table 7) show a decrease in amplitude toward the lower frequencies. This indicates that the amphidrome moves closer to 9B with decreasing frequency, due to longer wavelength.

The M2 cotidal chart (fig. 5) shows the tide wave entering Bristol Bay from the southwest, as shown in the earlier published charts. It appears that an amphidrome is located near Cape Newenhan, which is ¼ of an M2 wavelength from the head of the bay. Amplitudes are large along the Alaskan Peninsula and toward the head of Bristol Bay and Kuskokwim Bay. Amplitudes decrease between station 2B and Cape Newenhan, as seen at station 15A (Table 11). At 2B the wave is prediminately progressive, as indicated by the 14^{0} phase difference between the tide and flood current. At 4A there is a 35^{0} difference, indicating some co-oscillation with Kuskokwim Bay. This is also evidenced by the nearly equal phases between 9B and Goodnews Bay. A smaller N2:M2 ratio at Goodnews Bay than at 15A suggests that the semidiurnal amphidrome moves west with increasing wavelength.

A large amount of tidal dissipation occurs east of 162^{0}W longitude, an area representing about 2.5% of the Bering Sea. An estimate of tidal energy flux across a sectional area A_E is obtained from Miller's (1966) formula;

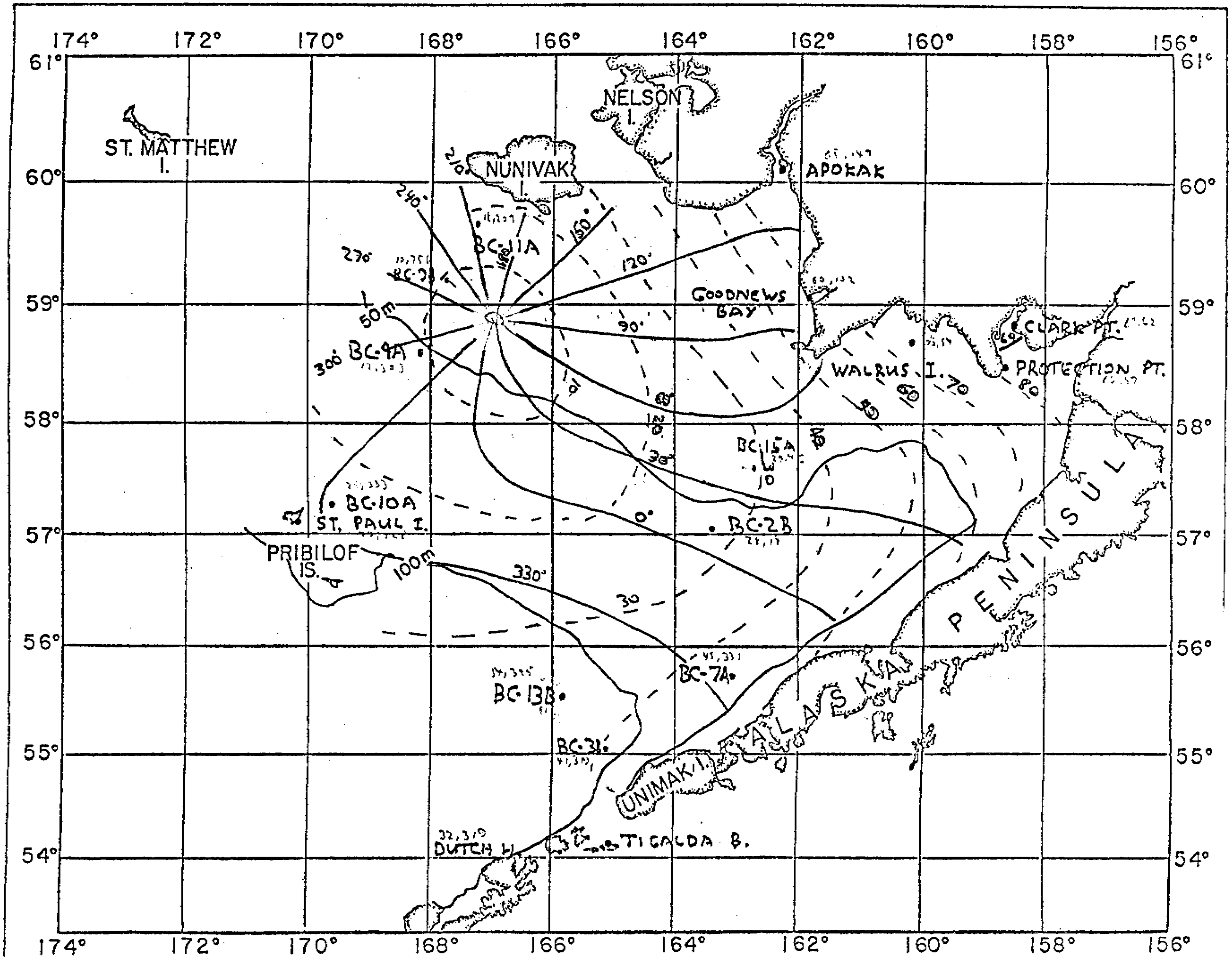
$$F_E = A_E(\tfrac{1}{2} g a u_0 \cos\phi)$$

where a and u_0 are amplitudes of tidal height and current respectively, and ϕ is the phase difference between flood current and tidal height. Using an estimate of mean amplitude for the M2 tide across 162^{0}W longitude, the value obtained is 1.2×10^{17} ergs/sec. This is about 80% of that across a line between Unimak and Nunimak Islands or about 5% of the total for the Bering Sea as estimated by Miller.


BRISTOL BAY
LOCATION OF TIDE & PRESSURE GAGE STATIONS
ST. MATTHEW I.
NUNIVAK I.
NELSON I.
APOKAK
GOODNEWS BAY
CLARK PT.
PROTECTION PT.
WALRUS I.
PRIBILOF IS.
ST. PAUL I.
UNIMAK I.
TIGALDA B.
DUTCH H.
ALASKA PENINSULA
BC-11A
BC-9A
BC-4A
BC-10A
BC-15A
BC-2B
BC-7A
BC-13B
BC-3
60 m
100 m
150
120
90
30
40
50
60
70
80
180
210
240
270
300
330
156°
158°
160°
162°
164°
166°
168°
170°
172°
174°
54°
55°
56°
57°
58°
59°
60°
61°

- - - - Coamplitude

BRISTOL BAY   LOCATION OF TIDE & PRESSURE GAGE STATIONS



Specific Procedures

1. Bathymetric survey: We would like a short bathymetric survey around the selected station. We suggest a circle of 1 nm radius, with two sounding lines through the center, but any similar pattern is satisfactory.

We would like an annotated sounding trace and ship's track (relative to the anchoring point) so that we can reconstruct the local bathymetry.

2. Hourly CTD profile: First, take a standard CTD cast at 30 m/minute, with a temperature and salinity calibration sample at the bottom. Take care not to run the data logger until just before lowering the CTD. After obtaining the calibration sample, raise the CTD to the depth indicated by the scientist (this will correspond to the middle of the thermocline, as indicated by the analog trace). Record for 10 minutes at this depth, then secure the cast. Normal station data will be logged for each cast, and a 2 minute, annotated, echo sounder trace taken. We would like the echo sounder trace after this experiment.

3. CTD thermocline experiment (at least three times during the station). After completing the 10 minute time series in the middle of the thermocline, lower the CTD to the bottom of the thermocline, as directed by the scientist, and record for ten minutes, then raise the CTD to the top of the thermocline and record for 10 minutes, then secure the cast.

4. Velocity profile: Every three hours, lower the current meters to the following depths, obtaining at least 3 (1 minute each) readings at each depth: 10, 20, 25, 30, 50, 60, and 70 m.

5. Thermocline velocity: Every three hours, lower the current meter to the middle of the thermocline and record as long as possible (> 10 minutes).

CHECK LIST

Time	Sequence	Events
_____(0)	1	1. 2 minute sounding 2. CTD profile (w/10 min. soak)
_____(+1)	2	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. thermocline velocity (> 10 min.)
_____(+2)	3	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. velocity profile (10,20,25,30,50,70)
_____(+3)	4	1. 2 minute sounding 2. CTD profile (w/10 min. soak)
_____(+4)	5	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. thermocline velocity (> 10 min.)
_____(+5)	6	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. velocity profile (10,20,25,30,50,70)
_____(+6)	7	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. CTD thermocline extremes (10 min. each)
_____(+7)	8	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. thermocline velocity (> 10 min.)
_____(+8)	9	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. velocity profile (10,20,25,30,50,70)
_____(+9)	10	1. 2 minute sounding 2. CTD profile (w/10 min. soak)
_____(+10)	11	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. thermocline velocity (> 10 min.)
_____(+11)	12	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. velocity profile (10,20,25,30,50,70)
_____(+12)	13	1. 2 minute sounding 2. CTD profile (w/10 min. soak)
_____(+13)	14	1. 2 minute sounding 2. CTD profile (w/10 min. soak) 3. thermocline velocity (>10 min.)

QUARTERLY REPORT

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NORTON - CHUKCHI OCEANOGRAPHIC PROCESSES
(N-COP)

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30 September 1977

Task Title: NORTON - CHUKCHI OCEANOGRAPHIC PROCESSES (N-COP)

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Report Period 1 July - 30 September 1977

I. Task Objectives:

1) Verify fluctuations in the predominantly northward transport through the system.
2) Delineate the bifurcation of northward flow which occurs west of Pt. Hope.
3) Define time and space scales of eddies ubiquitous in the system and provide data toward a dynamical description.
4) Define the circulation in Norton and Kotzebue Sounds.

II. Field and Laboratory Activities:

A. Cruises: RP-4-SU-77B, Leg IV: 11 August - 2 September (see attached report).
B. Laboratory Activities: None proposed or carried out.

III. Results, and IV. Preliminary Interpretation of Results:

The technical report, "The physical oceanography of Kotzebue Sound Alaska, during late summer, 1976" by T. H. Kinder, J. D. Schumacher, R. B. Tripp and D. J. Pashinski is in the final stage of peer review. A final draft will be sent to the project office and upon completion (early November) and will appear in the next Qaurterly Report.

On 8-12 July, scientists from the research unit participated in a cruise to Norton Sound aboard the R/V Sea Sounder from U.S.G.S. Menlo Park (D. Cacchione, Chief Scientist). During this cruise 25 CTD casts were made in Norton Sound, and three current moorings were deployed. Two of these moorings (NC-20 and NC-21) were subsequently recovered in

September (see attached cruise report). Preliminary examination of the CTD data have substantiated the findings from a September 1976 cruise to the region (cf. the 1976 Annual Report). The system was in general strongly two-layered in temperature and salinity. High salinity (~34.5 $^{o}/oo$), low temperature (~0.2°C) bottom water in the eastern Sound was a remnant of the previous winter's vertical convective layer. A summary of these data will be presented in a poster session at the 7-9 November Geological Society of America annual meeting in Seattle (Drake, D. E., D. A. Cacchione and R. D. Muench. Suspended and bottom sediment movement in Norton Sound, Alaska: abstract only).

V. Problems Encountered:

See Cruise Report.

CRUISE REPORT
RP-4-SU-77B Leg IV
11 August - 2 September, 1977

To: James G, Grunwell, Captain NOAA
Commanding Officer, NOAA Ship SURVEYOR

From: David J. Pashinski
NOAA/ERL Pacific Marine Environmental Lab.

DESCRIPTION

RP-4-SU-77B Leg IV completes the initial observational phase of OCSEAP research unit 541, Norton Sound Chukchi Sea Oceanographic Processes, begun in August of 1976. This is a joint program between the University of Washington and NOAA/PMEL addressing the objectives of the OCSEAP specific to the continental shelf between St. Lawrence Island and Cape Lisburne. The specific objectives of this research unit are to: 1) verify the fluctuations in northward transport of water,2) describe the temporal and spatial characteristics of the bifurcation of northward flow in the vicinity of Point Hope, 3) examine the temporal and spatial variability of the smaller scale motions characteristic of the area, and 4) define the circulation of Norton Sound and Kotzebue Sound.

These program objectives were addressed via current observations distributed along the fluid boundaries of the system and systematic hydrographic observations through CTD soundings. The physical passage from the Pacific Ocean to the Arctic Ocean, the Bering Strait, was also instrumented as it is central to the discussion of processes in the program area. Details of the circulation within Norton and Kotzebue Sounds have been investigated through closely spaced CTD soundings and current observations.

To meet the program objectives Leg IV has been planned about a primary task of recovering the long term current observation moorings deployed at the beginning of the program and the three short term moorings deployed earlier this summer. As these current meters will have been in the water approaching twelve months by the time of this leg, their recovery is the primary objective. It has been anticipated that there will be some equipment loss or data loss due to the longevity of the observational program.

CTD observations in the course of RP-4-SU-77B Leg IV are intended to improve our understanding of the distribution of properties in particular within Norton and Kotzebue Sounds. CTD observations, however, are considered second in priority to the recovery of current stations and are aquired when convienient in the course of recovery scheduling. Observations in the past year have revealed surprisingly large horizontal and vertical gradients of temperature and salinity withinKotzebue and Norton Sounds. The horizontal variability was expected but in a more diffused sense. Tidal mixing was expected to maintain a well mixed vertical structure with horizontal gradients reflecting the mixing of fresh water input from the major rivers in each sound. In reality, however, tidal mixing, though present, is not sufficient to overcome the increased stability resulting from the fresh water input nor provide an effective flushing mechanism for either sound. Apparently with the onset of ice formation the water becomes uniformly mixed through convection with an increase in salinity through brine rejection. As the spring thaw begins the fresh water overrides the cold,salty water effectively isolating it from summer warming and mixing.

CTD observations on this cruise have verified the existence of relic winter water in both sounds and supports the concept of winter flushing in that the relic winter water is of substantialy different salinity than yast year. Also the influence of the discharges of the Noatuk river and the Yukon river have been noted in the records.

A denser sampling of CTD observations was undertaken along the Cape Lisburne section to provide a better resolution of the bifurcation of flow from the Bering Strait into the Arctic Ocean.

To further aid in resolving questions as to the source and age of the properties exhibited in the CTD observations, samples were collected and frozen for nutrient analysis at the University of Washington. The content of phosphate, nitrate, nitrite, and silicate will be determined. Samples were collected from the surface and the calibration sample for all casts in Kotzebue Sound and the Cape Lisburne section.

As a part of a world-wide sampling program twelve liters, twelve samples of one liter each, were collected for tritium analysis. Tritium is an isotope of hydrogen which is a by product of atmospheric nuclear explosions. Thus the input of tritium is precisely known in oceanic time scales and the progression of tritium throughout the ocean is being monitored world wide. As tritium has a long life it is valuble as a tracer of deep ocean circulation and exchange through the thermocline. This program is being carried out with a number of univeristies and government organizations with the analysis being carried out at the University of Miami in Florida under the guidence fo Dr. Claus Roothe.

PERSONNEL

David J. Pashinski	NOAA/PMEL
Richard B. Tripp	University of Washington
Steve Harding	University of Washington

CHRONOLOGY

<u>15 August</u> Work began with the recovery of NC-16.17 and the attempt at NC-,8. The recovery operations went smoothly with diver inspection of NC-16. NC-18,with a 395 release, did not respond, it is presumed that ambient noise depleted the pinger supply battery. A release command was issued, however, the unit was not seen. The weather was excellent. XBTs were taken between stations.

<u>16 August</u> NC-19 was interrogated, no response was heard. Difficulties were suspected with the receiving equipment. Again the weather was excellent with reasonable visibility so a release command was issued and a search commenced with no positive results. The problems with NC-19 are considered to be similar to NC-18. CTDs were collected across the west St. Lawrence passage.

<u>17 August</u> Operations began on the Bering Strait moorings NC-11,12,13, and 10. The Helle pinger was rigged for service to back up the basic deck receiving gear. No response was obtained from NC-11 or 12. NC-13, however, was detected with the Helle equipment confirming receiver failure in the main deck gear. Helicopter operations commenced to Tin City for land line communications with Seattle for back up equipment. NC-13 was released but never left the bottom. NC-10 was located using the Helle equipment, released and recovered. CTE operations were run across the Bering Strait. Tritium samples were obtained from the strait at one station.

<u>18 August</u> A second attempt was made for NC-11. The mooring was detected and released. The unit did not leave the bottom. Positive word was received concerning the back up equipment and transit to Kotzebue began immeadiately. CTD, XBT, and nutrient observations commenced on arrival in Kotzebue Sound.

<u>19 August</u> CTD, XBT, and nutrient observations continued throughout the day. Helicopter operations commenced in the morning to pick up the replacement receiving gear.

<u>20 August</u> Moorings NC-8 and 9 were recovered using the replacement deck gear. Diver inspection of NC-9, the first of the rope moorings, allowed photography of the equipment while suspended at the surface. CTD, XBT and nutrient observations continued to complete the Kotzebue Sound grid.

<u>21 August</u> With arrival in the Point Hope area anchorage was located and a shore site established for a much need rest-bit from the pressures of operations. Transit to the Cape Lisburne was completed and CTD observations were begun at a higher density station interval.

<u>22 August</u> NC-7 was recovered, with indications of possible problems in the release units. NC-6 was approached and interrogated, with no response was obtained on the second interrogation. The unit was released and recovered. NC-5 was interrogated but not released due to deteriorating visibility. CTD observations continued with tritium and nutrient samples.

OPERATIONAL COMMENTS

With respect to current meter mooring recoveries the recovery operations themselves proceeded exceptionaly smoothly. Only one instance occurred where an improper connection was selected for separation. Observers noted the fact and alerted the deck force before any loss could occur. This supports the continued requirement for observers present who are not directly involved in the operations taking place. Diving operations associated with the mooring inspection and the recovery attempt on NC-22 proceeded smoothly due to the professionalism exhibited by the divers and the support personnel. The major difficulties associated with the current meter operations can be attributed to problems with the equipment on the moorings themselves. The results from these operations will lead to a re-evaluation of specific mooring components. In particular an investigation must be undertaken to locate a battery to power the equipment for long periods at temperatures near and below zero degrees centigrade. The credit for the high degree of success in the mooring recoveries belongs to the excellence of navigation maintained by the NOAA vessels. Were there any discrepency in either the deployment positions or the reoccupation of those stations the loss of moorings would have been much higher.

CTD operations likewise showed a high level of professionalism by the ships complement. Two points were noted in the operations, solutions to which should be considered. These points are primarily associated with operations in shallow waters, first is the depth to which the CTD lowered for surface equilabration, and second the proximity to the bottom that can safely be attained. In general these two points amount to five meters of the water column, in many of our operations that could amount to as much as 30% of the water column not being sampled. There are two potential solutions to these problems to my knowledge, and other solutions are likely availible. The two solutions I reference are in the form of accessories to the Plessy system; first the version of the rossette sampler for use with the 1.7 liter Niskin bottles, second a bottom sensing device as used on the GATE 9040's. The first is a compact unit which would allow the fish to be brought to the surface before the descent is started and the second is a switch which lights an indicator on the deck unit when a weighted line reaches the bottom. I offer these two suggestions for consideration and do not wish to limit consideration to these suggestions. The ability of the ship to read the CTD data tapes provided much desired confirmation of CTD operation and was of great value to the scientific party.

As a supplementary note the prescence of the helicopter capability was greatly appreciated in the early course of the cruise. The availibility of its service immeasurably reduced the difficulty of solution to problems that developed in electronics in the early portion of the cruise. It allowed land line communication when radio communications were effectively impossible, and also allowed operations to continue while replacement equipment was being picked up.

ACKNOWLEDGEMENTS

At the close of this cruise one fact is clearly evident, the vessel functions as an efficient integrated system. Excellence in all departments has combined to form a truely unified operation. Seldom does one have the opportunity to participate in a cruise where all the functions mesh finely. This efficiency transformed a potentially difficult cruise into a pleasure.

APPENDIX A
MOORING SUMMARY

SITE	LATITUDE	LONGITUDE	DAY	TIME	RECOVER	X	Y	Z	COMMENTS
NC-1	68-15.3	172-40.9	236	0536z	Y	16983.90	29325.00	47698.27	Fog
NC-2	68-29.5	171-55.6	236	0252	Y	17035.81	29255.93		Fog
NC-3	68-44.1	171-06.2	235	2345	Y	17088.56	29193.61		Fog
NC-4	69-00.6	169-59.4	235	1953	Y	17156.51	29128.37	47364.80	Fog-Reply died after release
NC-5	69-00.7	169-09.4	235	0501	N	17217.32	29092.78	47285.54	Fog-Replied once-Not released
	69-00.7	169-09.8	235	1645	N	17216.80	29093.03	47286.59	No reply-Released-Not recovered
NC-6	68-57.4	168-18.0	235	0202	Y	17282.43	29061.79		Current meter & Tide gage
NC-7	68-55.1	167-20.2	234	2315	Y	17351.92	29833.52		
NC-8	66-54.8	164-00.8	232	1915	Y	17762.85	29040.50	46854.00	Viney floats damaged
NC-9	66-46.6	164-07.9	232	1655	Y	17775.28	29045.33	46883.51	by ice
NC-10	65-46.3	168-25.8	230	0046	Y	17553.59	29156.07	47558.62	Current meter & Tide gage
NC-11	65-41.05	168-37.5	237	0950	N	17546.05	29197.64	47596.00	Confirmed on the bottom
NC-12	65-41.3	168-25.7	237	0804	N	17563.34	29168.07		Floatation collaps is
NC-13	65-41.2	168-16.4	237	1110	N	17577.47	29145.90	47547.91	the most likely cause.
NC-14	64-21.9	165-20.2	237	2124	Y	17976.19	29657.00	47244.02	
NC-15	64-06.5	165-16.8	237	2321	N	18012.72	29824.11	47259.48	No response-Search repeated
NC-16	62-37.0	166-53.2	227	1705	Y	18090.67	30924.07	47776.95	
NC-17	62-48.0	167-25.7	227	1941	Y	18012.52	30815.20	47852.75	
NC-18	63-09.5	168-20.5	228	0045	N	17873.90	30619.26		No response
NC-19	64-04.3	172-08.5	228	1848	N	17317.92	30417.81	48335.04	No response-released-search
NC-20	63-59.6	165-29.7	238	0243	Y	18011.82	29897.84		Short term mooring
NC-21	63-08.2	163-15.6	238	2307	Y	18141.70	29888.70	46876.20	Short term mooring
NC-22	63-40.8	163-01.1	239	2000	N	18213.86	30156.00	46851.98	Short term moorting-released On the bottom 100 meters @ 100°. T Visibility near zero, currents can be strong

CTD SUMMARY

CONSC. #	STA. #	LATITUDE	LONGITUDE	DAY	TIME(Z)	WATER DEPTH	CAST DEPTH	SAM.
West St. Lawrence								
1	2	64-04.6	172-15.6	228	2240	50 M	40 M	
2	3	64-01.3	172-10.3		2345	55	41	
3	4	63-56.7	172-04.8	229	0114	55	45	T
4	5	63-52.5	171-55.5		0215	40	24	
5	6	63-48.9	171-48.6		0304	29	21	
Bering Strait								
6	50	65-38.6	168-12.0	230	0347	40	33	
7	51	65-38.0	168-21.5		0507	45	38	
8	52	65-37.4	168-31.3		0548	43	42	T
9	53	65-37.9	168-40.5		0653	50	44	
10	54	65-38.1	168-48.7		0738	49	44	
11	55	65-38.0	168-57.0		0827	49	44	
12	56	65-26.2	169-05.0		1013	58	51	
13	57	65-26.0	169-12.1		1055	50	46	
14	58	65-26.8	169-23.0		1143	50	45	
15	59	65-28.5	169-29.9		1225	50	45	
16	60	65-31.0	169-38.0		1318	49	46	
17	61	65-32.5	169-46.0		1356	49	45	
Kotzebue Sound								
18	66	67-10.9	164-53.0	231	0615	27	18	
19	70	67-05.3	164-24.6		0740	23	18	
20	76	66-55.2	163-56.3		0918	20	16	
21	79	66-46.2	163-46.2		1104	17	14	
22	82	66-38.2	163-00.9		1236	15	13	
23	85	66-28.4	162-45.1		1409	15	12	
24	88	66-18.9	162-31.5		1528	15	10	
25	90	66-10.3	162-10.5		1710	13	10	
26	91	66-10.8	162-43.2		1859	15	15	N
27	88	66-19.1	162-31.5		2016	15	15	N
28	89	66-23.0	162-10.5		2135	15	13	N
29	84	66-34.1	162-25.0		2315	15	14	N
30	85	66-28.4	162-43.1	232	0027	15	14	N
31	87	66-19.9	163-00.0		0216	15	12	N
32	92	66-12.1	163-18.1		0333	15	11	N
33	86	66-22.6	163-21.1		0447	15	13	N
34	81	66-32.4	163-14.6		0604	21	18	N
35	82	66-37.8	163-00.0		0706	15	14	N

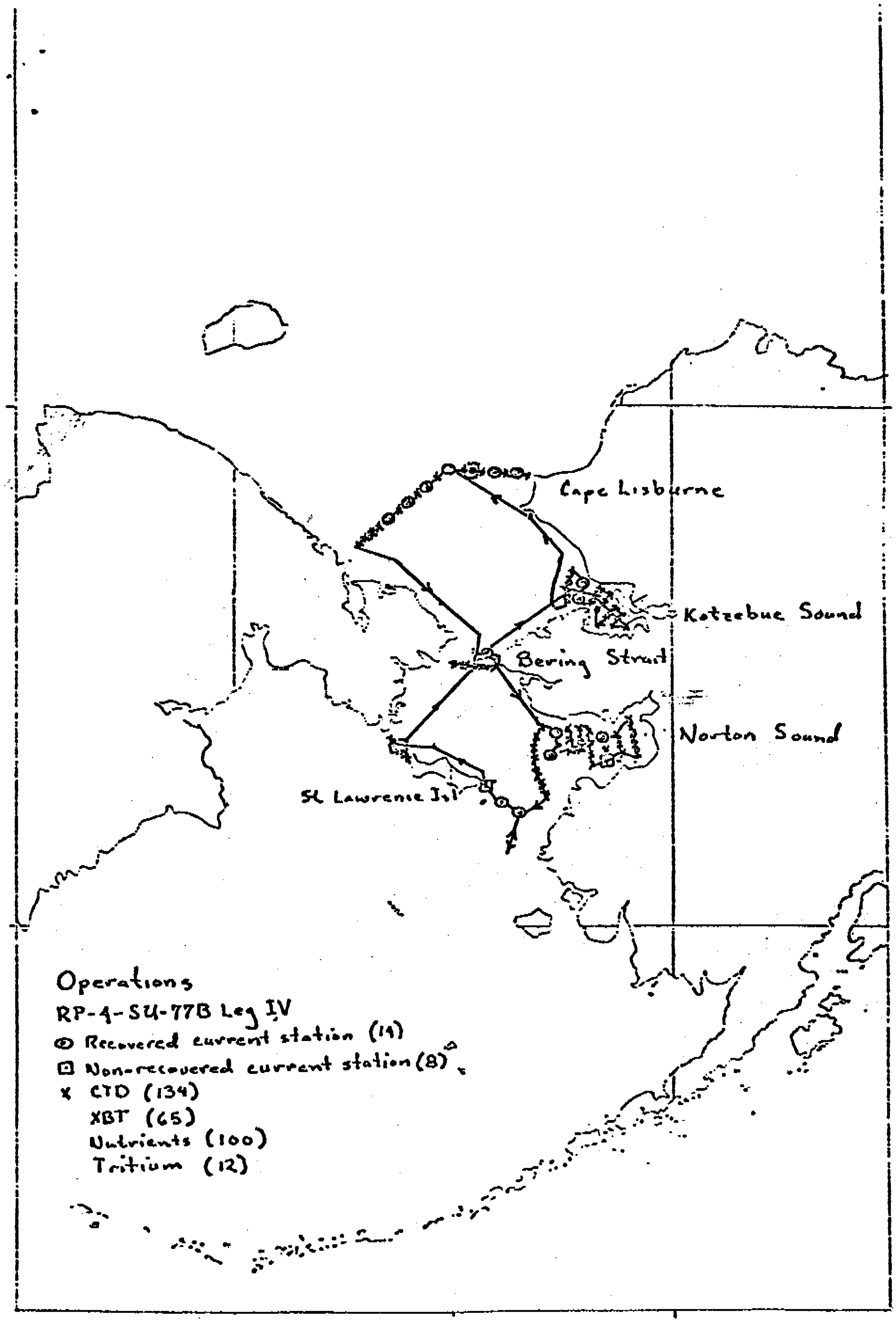
36	83	66-43.6	162-53.2		0757	15	14	N
37	78	66-56.1	163-14.9		0937	13	13	N
38	79	66-46.5	163-26.3		1102	20	16	N
39	80	66-39.0	163-35.0		1211	26	26	N
40	74	66-40.8	164-07.0		1338	21	20	N
41	75.1	66-48.0	164-00.0		1443	24	18	N
42	76	66-55.9	163-56.3		2037	24	20	N
43	77	67-01.0	163-48.0		2134	18	16	N
44	69	67-10.0	164-07.0		2250	22	21	N
45	70	67-05.0	164-21.6		2349	28	28	N
46	71	66-58.8	164-35.3	233	0052	28	22	N
47	72	66-49.1	164-43.2		0157	24	19	N
48	73	66-41.1	164-40.1		0300	20	16	N
49	63	66-42.1	165-10.4		0425	24	16	N
50	64	66-52.4	165-14.2		0539	26	25	N
51	65	67-02.0	165-15.7		0651	30	29	N
52	66	67-11.2	164-52.7		0817	31	31	N
53	67	67-17.8	164-30.7		0935	26	25	N
54	68	67-22.8	164-12.3		1040	23	22	N
[illegible]	9							
Cape Lisburne								
55	97	68-55.0	169-14.0	234	0929	55	53	N
56	96.1	68-55.4	168-54.5		1032	54	51	N
57	96	68-55.0	168-33.0		1137	54	51	N
58	95.1	68-54.0	168-13.5		1231	51	49	N
59	95	68-53.6	167-53.2		1341	50	46	N
60	94.1	68-52.9	167-33.0		1437	47	44	N
61	94	68-51.6	167-14.2		1534	49	41	N
62	93	68-51.0	166-38.4		1658	44	40	T,N
63	97.1	68-55.4	169-35.0	235	0631	55	49	N
64	98	68-56.4	169-56.4		0732	55	51	N
65	98.1	68-52.3	170-04.0		0825	55	50	N
66	99	68-46.4	170-22.0		0932	55	51	N
67	99.1	68-43.0	170-46.6		1046	56	50	N
68	100	68-38.0	171-13.0		1203	56	51	N
69	100.1	68-36.8	171-30.9	236	0141	55	48	N
70	101	68-29.5	171-55.0		0333	54	51	N
71	102	68-15.6	172-42.0		0620	50	44	N
72	101.1	68-22.5	172-17.9		0734	51	46	N
73	102.1	68-05.2	172-51.4		0938	48	44	N
74	103	67-54.5	173-02.2		1057	48	46	N
75	103.1	67-47.0	173-16.1		1202	49	46	N
76	104	67-40.8	173-30.2		1305	48	43	N
77	104.1	67-34.1	173-37.0		1402	44	40	N
78	105	67-27.9	173-44.3		1500	35	31	N
79		67-16.3	170-19.0		2235	47	44	T,N

Norton Sound

80	25.1	63-59.6	165-28.9	238	0327	20	19
81	25.2	64-00.9	165-10.7		0433	18	16
82	30.1	64-02.1	164-46.7		0552	20	18
83	30.1	64-02.0	164-46.4		0603	20	18
84	29.1	64-04.0	164-27.4		0717	22	17
85	35	64-06.0	164-03.2		0845	22	20
86	35.1	64-07.9	163-39.1		1000	23	21
87	39.1	64-09.8	163-14.2		1118	24	20
88	41	64-16.8	162-44.0		1245	25	20
89	41.1	64-07.9	162-38.9		1353	21	17
90	42	63-59.3	162-33.1		1450	18	15
91	42.1	63-51.7	162-29.7		1551	18	15
92	43	63-44.4	162-26.6		1642	17	15
93	37.1	63-40.3	163-01.8		2002	16	14
94	38.1	63-54.7	163-08.2		2147	19	17
95	21	64-08.9	163-17.5		2348	26	24
96	41	64-15.8	162-44.0	239	0131	24	22
97	46	64-25.8	162-03.0		0327	17	13
98	46.1	64-15.1	161-56.0		0436	18	14
99	45	64-04.8	161-51.0		0546	19	17
100	45.1	63-58.5	161-43.2		0640	19	16
101	48.1	63-52.2	161-35.8		0733	18	14
102	49.1	63-45.9	161-29.0		0835	15	12
103	49	63-40.5	161-23.0		0931	15	12
104	44.1	63-41.4	161-45.2		1054	16	11
105	44.2	63-42.3	162-05.6		1201	16	14
106	43	63-43.6	162-26.1		1306	14	12
107	43.1	63-42.9	162-45.0		1407	16	12
108	36	63-40.8	163-49.6	240	0400	14	11
109	36.1	63-53.7	163-55.0		0548	18	15
110	35	64-06.1	164-04.1		0751	21	19
111	35.1	64-11.8	164-07.2		0848	19	17
112	34	64-18.2	164-10.0		1150	15	14
113	34.1	64-22.0	164-20.1		1247	16	11
114	33	64-26.1	164-26.1		1338	25	21
115	33.1	64-23.6	164-43.2		1438	29	26
116	32	64-20.9	164-55.8		1536	33	29
117	31	64-15.2	164-49.1		1625	15	11
118	30	64-07.8	164-49.7		1723	18	15
119	29	63-57.9	164-46.6		1834	18	17
120	25	63-54.0	165-20.1		2012	19	16
121	25	63-54.0	165-20.5		2025	19	17
122	25.1	64-02.5	165-22.1		2130	19	16
123	24	64-10.8	165-23.4	241	0015	20	19
124	23	64-20.0	165-29.4		0124	23	19
125	22	64-26.1	165-30.5		0217		24

126	21	64-29.0	165-59.6	0608	21	18
127	20	64-22.1	166-07.2	0710	27	24
128	19	64-14.0	166-14.2	0822	25	22
129	18	64-03.8	166-06.9	0936	23	21
130	18.1	63-53.5	166-00.4	1050	25	23
131	17	63-44.0	165-54.2	1159	26	24
132	17.1	63-35.3	165-42.7	1312	24	23
133	17.2	63-26.5	165-30.0	1427	23	22
134	27.1	63-17.8	165-17.8	1543	17	15

N--nutrient samples
T--tritium samples



Cape Lisburne
Kotzebue Sound
Bering Strait
Norton Sound
St. Lawrence Isl
Operations
RP-4-SU-77B Leg IV
⊙ Recovered current station (14)
⊡ Non-recovered current station (8)
x CTD (134)
XBT (65)
Nutrients (100)
Tritium (12)

ABSTRACT

SUSPENDED AND BOTTOM SEDIMENT MOVEMENT IN NORTON SOUND, ALASKA

DRAKE, D. E., and CACCHIONE, D. A., U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025; MUENCH, R. D., Pacific Marine Environmental Laboratory, National Oceanographic and Atmospheric Administration, Seattle, WA 98111

The pathways of suspended and bottom sediment dispersal in Norton Sound, Alaska are compared to the dominant circulation patterns during two field experiments in 1976 and 1977. During relatively quiescent periods the mean circulation in the northern Bering Sea advects the major fraction of Yukon River suspended matter across the mouth of Norton Sound toward the Bering Strait. A smaller fraction of suspended materials is transported into the Sound, predominantly along the southern and eastern margin by a counterclockwise gyre in the western portion of the Sound. Bottom sediment samples show that a relatively minor accumulation of Yukon silts and clays are found in the more protected areas. The bypassing of suspended materials that normally occurs during these quiescent periods is not enough to account for the reported accumulation of Yukon silts in the Chukchi Sea.

Wave-induced, wind-generated, and hydraulic bottom currents resuspend bottom sediments and support a relatively dense near-bottom suspended load. Measurements taken with instrumented bottom tripods (GEOPROBES) show that sediments are effectively transported during stormy periods. Bottom currents in excess of 15 cm/s within one meter of the sea floor cause entrainment of the relatively cohesionless silts and fine sands in this region. Analysis of data to be collected by two GEOPROBES during July-October 1977 will hopefully define the relationship between bottom current shear and sediment entrainment in different sedimentary environments within the Sound.

QUARTERLY REPORT

Contract No:

03-5-022-67, T.O. #1

Research Unit No.:

151

Reporting Period:

1 July - 30 September 1977

Number of Pages:

1

STD Measurements in Possible Dispersal Regions of the Beaufort Sea

Knut Aagaard

Department of Oceanography
University of Washington
Seattle, Washington 98195

3 October 1977

I. Objectives

To examine by means of STD measurements the possible sinking and spreading into the Canadian Basin of waters modified on the Beaufort shelf. Such sinking and spreading constitute an unexplored but possibly very important dispersal mechanism.

II. Field Activities

None.

III. Results, and IV Preliminary Interpretation of Results

Analysis of the CTD data is continuing.

VI. Problems Encountered

None.

VI. Estimate of Funds Expended to 31 August 1977

TOTAL ALLOCATION (5/16/75-9/30/77):			$142,627
A.	Salaries, faculty and staff	$18,618	
B.	Benefits	2,161	
C.	Expendable Supplies & Equipment	4,542	
D.	Permanent Equipment	23,209	
E.	Travel	4,720	
F.	Computer	2,924	
G.	Other Direct Costs	27,556	
H.	Indirect Costs	9,062	
	TOTAL		92,792
	REMAINING BALANCE		49,835

Quarterly Report

Research Unit # 208
Reporting Period 7/1/77-9/30-77
Number of pages: 5

Yukon Delta Coastal Processes Study

William R. Dupré
Department of Geology
University of Houston
Houston, Texas 77004

11-22-77

QUARTERLY REPORT

I. Task Objectives

The overall objective of this project is to provide data on geologic processes active within the Yukon-Kuskokwim delta in order to aid in the evaluation of the potential impact of scheduled oil and gas exploration and possible production. In particular, attention has been focused on the following:

1) Study the processes along the Yukon-Kuskokwim delta shoreline (e.g., tides, waves, sea-ice, river input) in order to develop a coastal classification including morphology, coastal stability, and dominant direction of longshore transport of sediments. (Task D-4, B-2).

2) Study the hydrology and sediment input of the Yukon and Kuskokwim Rivers as they largely determine the sediment budget of the northern Bering Sea. (Task B-11, B-2).

3) Determine the type and extent of Quaternary faulting and volcanism in the region. (Task D-6).

4) Reconstruct the late Quaternary chronology of the delta complex in order to determine:

    a) frequency of major shifts in the course of the Yukon River.
    b) effects of river diversion on coastal stability.
    c) relative age of faulting and volcanism.
    d) frequency of major coastal storms as recorded in chenier-like sequences along the coast.

II. Field and Laboratory Activities

A. Field trip schedule: June 30 - August 1, 1977

B. Scientific Party:

1) William R. Dupré - Dept. of Geology, University of Houston

2) Rodney O. Thompson - Dept. of Geology, University of Houston

3) Robert Demicco - Dept. Earth & Planetary Sciences, Johns Hopkins University

C. Methods

1) Field Studies:

a) Interpretation of aerial photos and Landsat imagery, in combination with aerial reconnaisance in fixed wing aircraft and NOAA helicopter to aid in coastal classification study.

b) Set up series of coastal stations including beach profiling, sediment and vegetation sampling.

c) Collection of samples for radiocarbon dating, with emphasis on determining age of modern delta and frequency of major storms.

2) Laboratory Studies:

a) Radiocarbon samples submitted to Steven Robinson, U.S.G.S.

b) Study of Landsat imagery to determine seasonal variations in ice patterns and distribution of sub-ice channels of the delta margin.

c) Short cores are being frozen (using liquid nitrogen), split, and x-rayed for sedimentary structures; textural analyses will follow.

d) Pollen analysis in progress by Tom Ager, U.S.G.S.

D. Sample localities

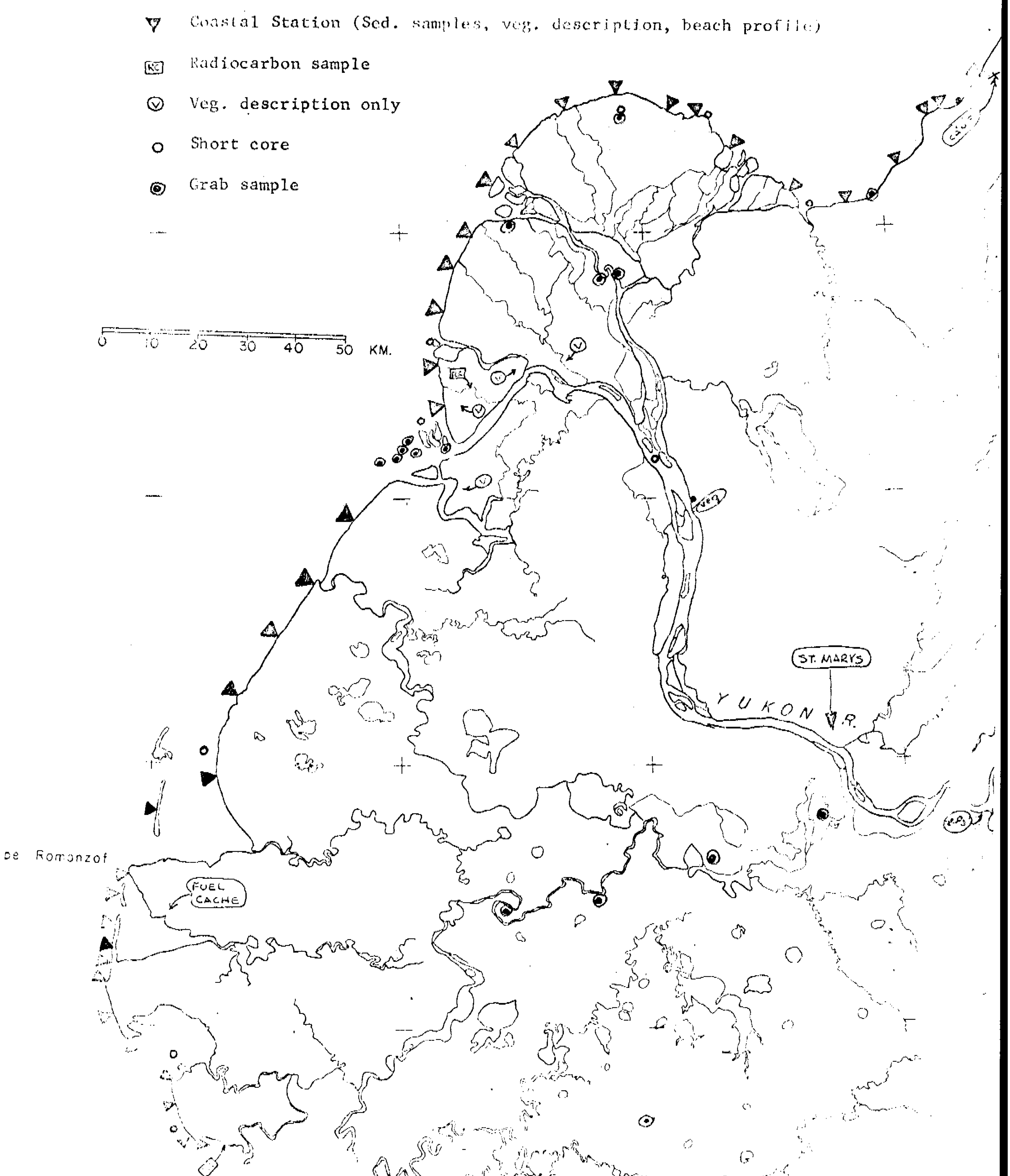
(see Figure 1)

E. Data collected or analyses

1) Number and types of samples/observations

a) Approximately 500 35 mm slides were taken, mainly of the coast to aid in coastal baseline studies.

b) Approximately 40 grab samples were obtained for textural analyses.


Coastal Station (Sed. samples, veg. description, beach profile)
Radiocarbon sample
Veg. description only
Short core
Grab sample
0 10 20 30 40 50 KM.
ST. MARYS
YUKON R.
FUEL CACHE

c) Approximately 50 short cores were obtained for x-ray and textural analyses.

d) Approximately 45 vegetation assemblages were described for different regions of the delta.

e) Approximately 10 samples were collected for possible radiocarbon dating.

f) Forty-one (41) beach profiles were measured.

III. Results and interpretation

Beach profiles have been plotted and compared with last year's profiles where available. Rates of erosion and deposition vary, but in a pattern consistent with previously determined geomorphic criteria. It should be noted that the coastal state between St. Michaels and Cape Romanoff had over 15 meters of erosion occurred between 1976 and 1977. This is in spite of the fact that there were no major storm events during that period.

A depositional model for ice-dominated deltas is being developed which should provide some insights into the role of ice on delta morphology and processes, both sub-arctic deltas and for Arctic deltas as well (e.g. Mackenzie; Colville).

A geologic map is being prepared at a scale of 1:1,000,000 which will emphasize major depostional units as well as the tectonic elements of the region. This will be used to make derivative maps emphasizing potential geologic hazards.

IV. Problems encountered/Recommended solutions

The only serious problem encountered was with the NOAA helicopter, the details of which are included in the Operation Report submitted to the Juneau office. Much of the delay was aggravated by an airline strike, delaying shipment of replacement parts. No major revisions in future operations or schedules seem warranted at this time.

V. Budget: (July 1 - October 1, 1977)*

Estimated total expended	-	$13,777
Estimated total committed	-	3,000
		$16,777

*Note, remaining funds will carry over into FY 78

QUARTERLY REPORT

Research Unit: #217
Reporting Period:
1 July - 30 Sep. 1977
Number of Pages: 3
Figures - 9

Title: Lagrangian Surface Currents

Principal Investigator: D. V. Hansen

Affiliation: Atlantic Oceanographic and
Meteorological Laboratories,
NOAA, Miami, Florida

28 September 1977

I. Abstract:

Data collection by means of drift buoys deployed in the Bering Sea during the preceding reporting period continued very successfully during this reporting period, and are continuing. Important new results include verification of a cyclonic eddy circulation over the Pribilof Canyon. New data obtained from NOPAX investigators, and a simulation model of the North Pacific surface drift confirm earlier results from the northern Gulf of Alaska, and indicate that this region may be an accumulation region for materials entered into the surface waters over a large part of the northeast Pacific Ocean.

II. Objectives:

To obtain and interpret Lagrangian surface current data in the Gulf of Alaska and the Bering Sea.

III. Activities:

1. Of the six Lagrangian drift buoys deployed in the St. George Basin in mid-May 1977, four continue in operation in late September 1977, one is no longer being received, and one is transmitting from a grounded position on St. George Island. Over 700 buoy days of data have been collected from the deployment.

2. No new deployments were planned for this period, and no units are currently in fabrication for future use.

3. All back data have been sent to archive.

4. Separate data tapes and a graphic file of data products have been initiated at AOML for convenience in responding to requests from the project office and to facilitate further analysis and synthesis with other investigators.

IV. Results:

A. St. George Basin: Inasmuch as the buoys deployed in the St. George Basin are still in operation, only preliminary results can be given at this time. These are:

1. Discounting the possibility of interannual variations between 1976 and 1977, currents are considerably stronger in the St. George Basin region than farther back in Bristol Bay.
2. Currents over the continental shelf and the upper slope tend to follow isobaths as expected.
3. Buoys deployed over the lower slope confirm the existence of the cyclonic eddy over the Pribilof Canyon, as hypothesized by Kinder and Coachman (1977), but the eddy revealed in these data appears to be somewhat larger than

that seen in their data from an earlier year.

The new observational results are summarized in the trajectory plots of Figures 1 - 6.

B. Gulf of Alaska: No observations were made in the Gulf of Alaska by this work unit during the reporting period. Some new data were acquired during the period from an unexpected source however. Two drift buoys deployed in the vicinity of 45°N, and 166°W and 162°W as part of a several buoy deployment of NORPAX ultimately entered the Gulf of Alaska, and grounded at Point Riou and on Montague Island (Figures 7 and 8). The behavior of these buoys once in the northern Gulf of Alaska was remarkably similar to that of deployments done for this work unit in 1976. Data for that part of these trajectories of greatest interest to OCSEAP have been obtained from Dr. Dennis Kirwan of Texas A&M University.

V. Preliminary Interpretation of Results:

A. St. George Basin: Even these preliminary results provide clear confirmation of the reality and recurrence of the eddy hypothesized by Kinder and Coachman (1977), and points out the potential for entrapment or concentration of surface pollutants in this region. They also show some potential for beach pollution on the Pribilof Islands if there was ever any doubt of that. The general behavior of these buoys suggests that the Lagrangian dispersion modelling concept that first motivated use of drift buoys in this project will be more appropriate for the Bering Sea than for the Gulf of Alaska.

B. Gulf of Alaska: The movement and grounding of the NORPAX drifters during June-July 1977 tends to confirm the results obtained in this region the previous year. The movement of the NORPAX drifters into this area also provides at least qualitative confirmation of results of a recent model study of Dotson, et al., (1977). Some results from this model study are included here as Figures 9 and 10. The distributions shown are of drift buoy concentrations after 100 and 700 days of simulated advection and dispersion of an initially uniform distribution. The data input to this simulation model consists of surface current estimates derived from the ship drift file produced by the U.S. Navy Oceanographic Office. These data are the most extensive available for surface currents in the oceans, but are subject to systematic errors in regions of persistent wind direction. The feature of this simulation of particular interest to OCSEAP is the buoy concentration maximum, or accumulation region, in the northern Gulf of Alaska. This feature is consistent with our previous drift buoy results from the area and the recent NORPAX results, and suggests that our results apply quite far seaward of where the observations have been made. Materials in the surface waters of the Gulf of Alaska have a strong tendency for entrapment and eventual grounding. Furthermore, the accumulation process appears to extend as far south as Washington or Oregon.

VI. References:

Dotson, Alan, Lorenz Magaard, Gary Niemeyer, and Klaus Wyrtki. A simulation of the movements of fields of drifting buoys in the North Pacific Ocean. Report, Hawaii Institute of Geophysics, HIG-77-3. March, 1977.

Kinder, T. H., and L. K. Coachman (1977). Observations of a bathymetrically trapped current ring. (Unpublished manuscript).

VII. Problems: None.

VIII. Estimate of funds expended: All FY 1977 funds have been expended according to plan.

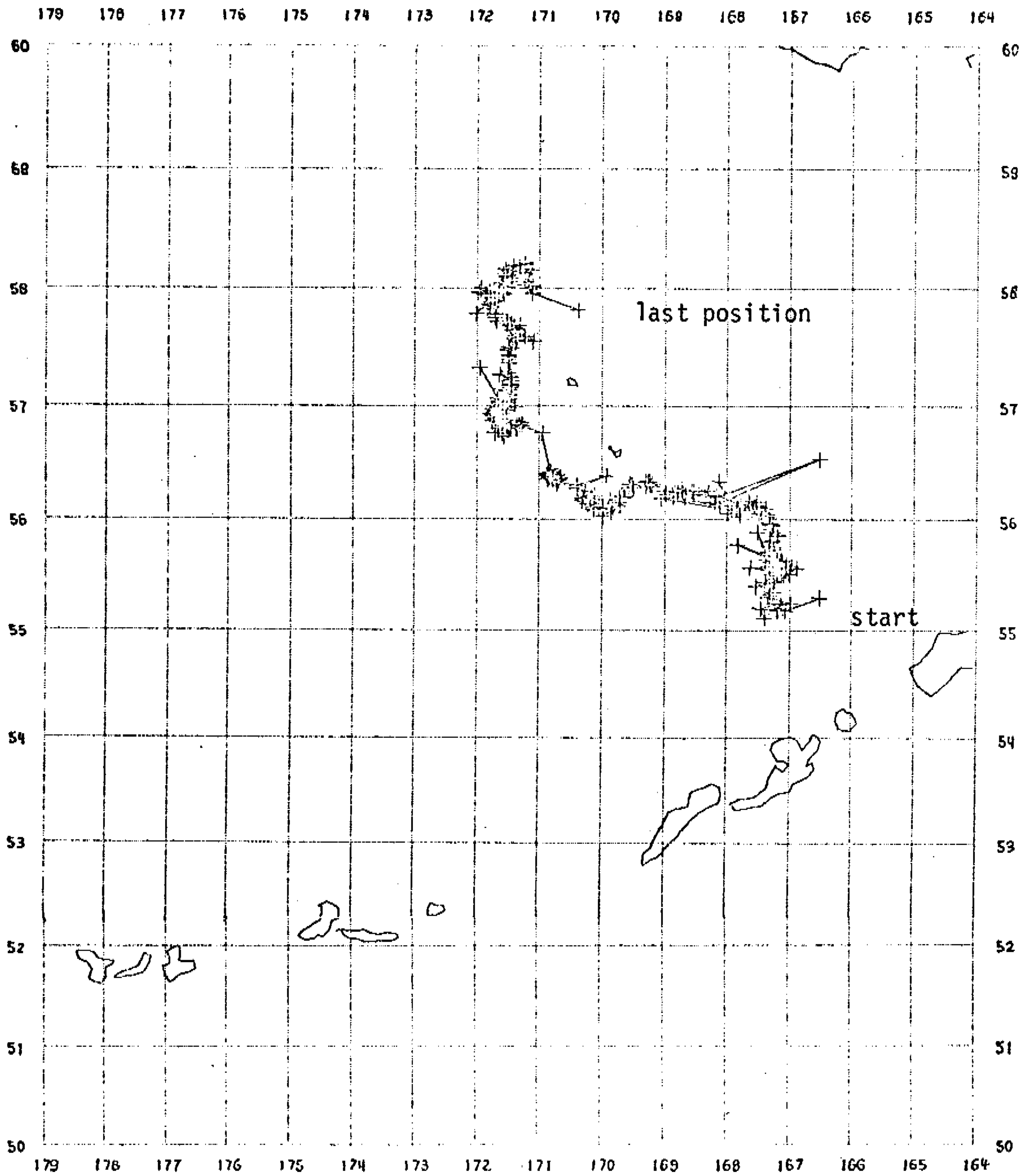


Figure 1. Buoy 0011 deployed day 146 - last position day 254

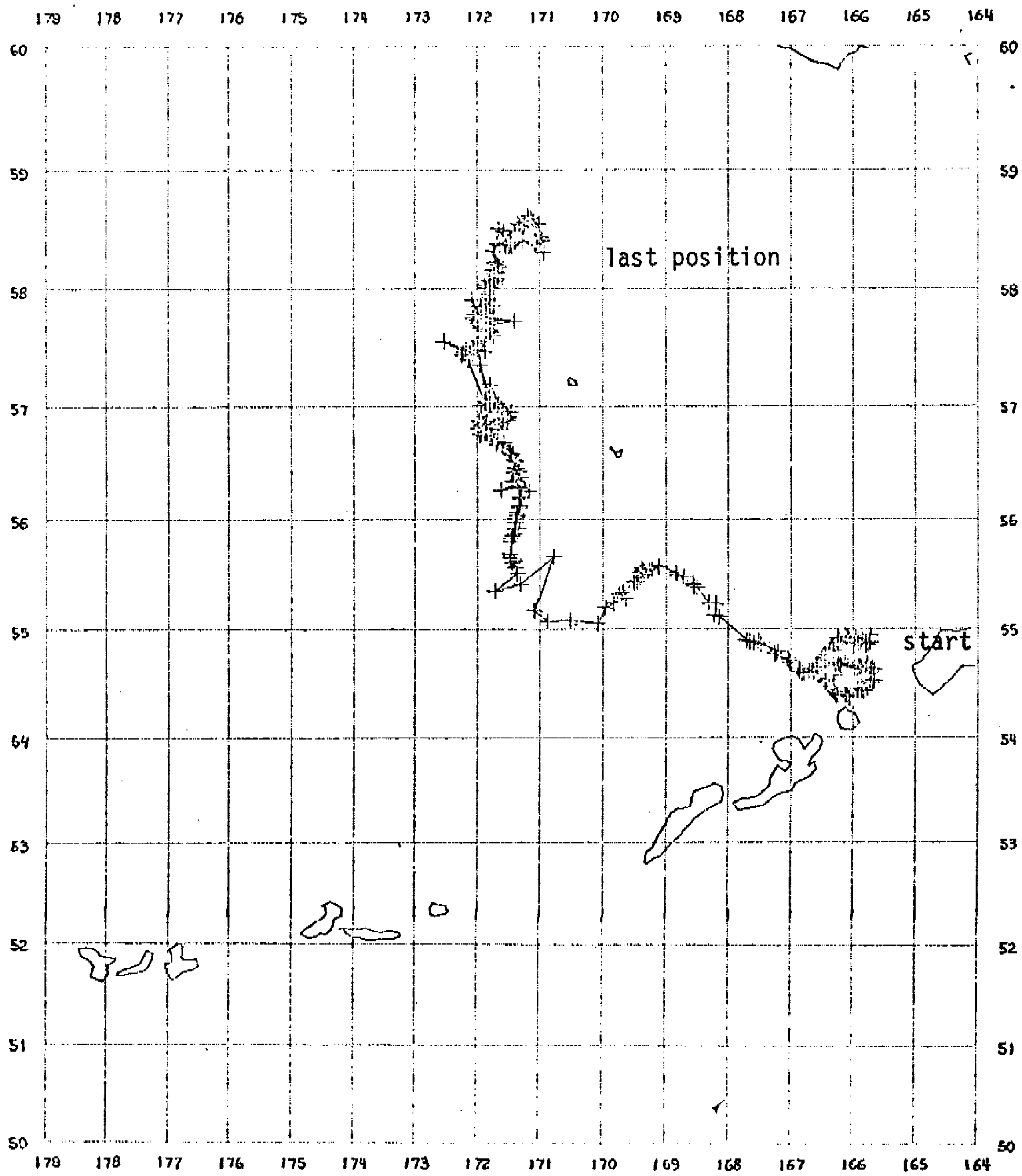


Figure 2. Buoy 0027 deployed day 146 - last position day 254

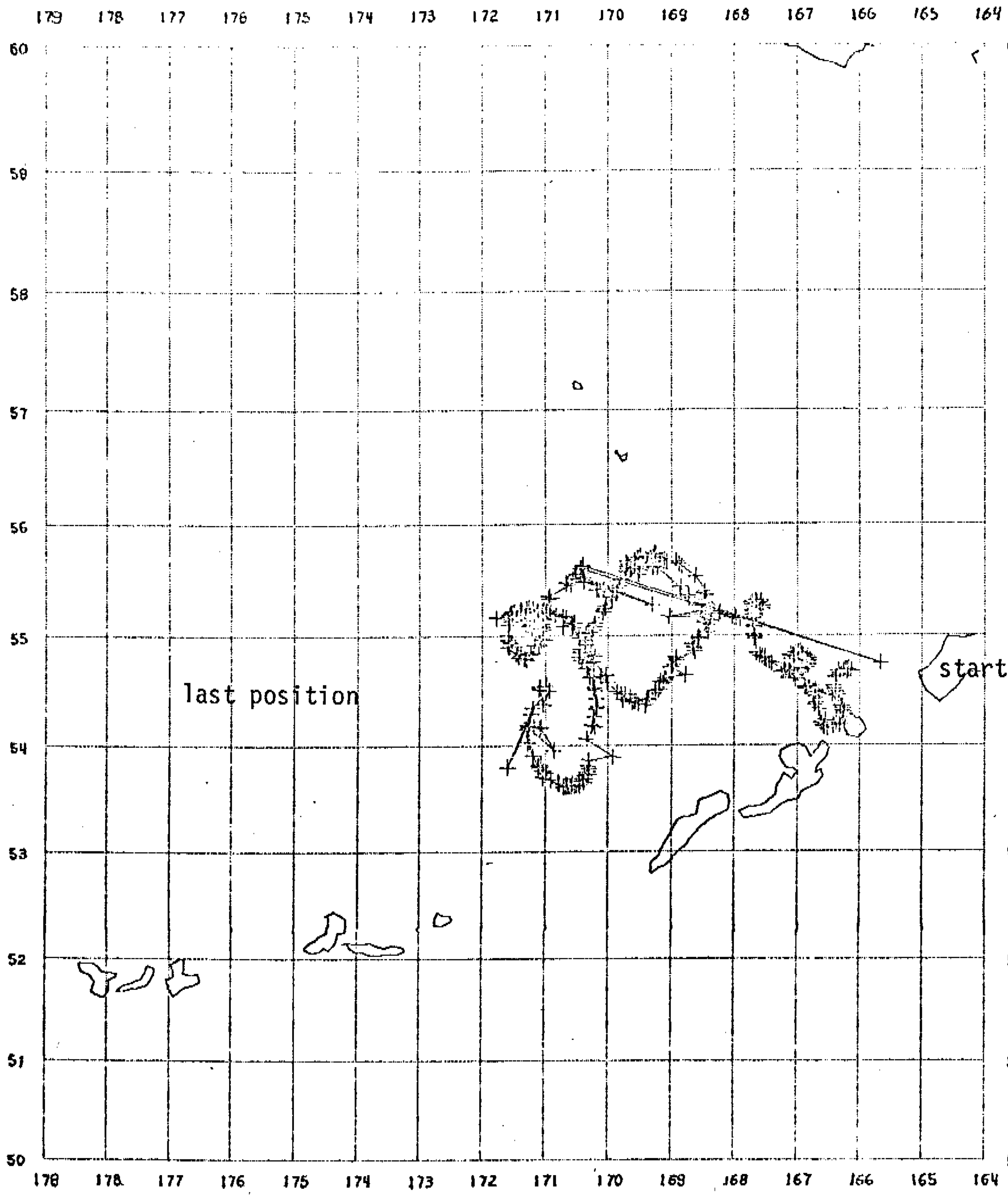


Figure 3. Buoy 0056 deployed day 146 - last position day 254

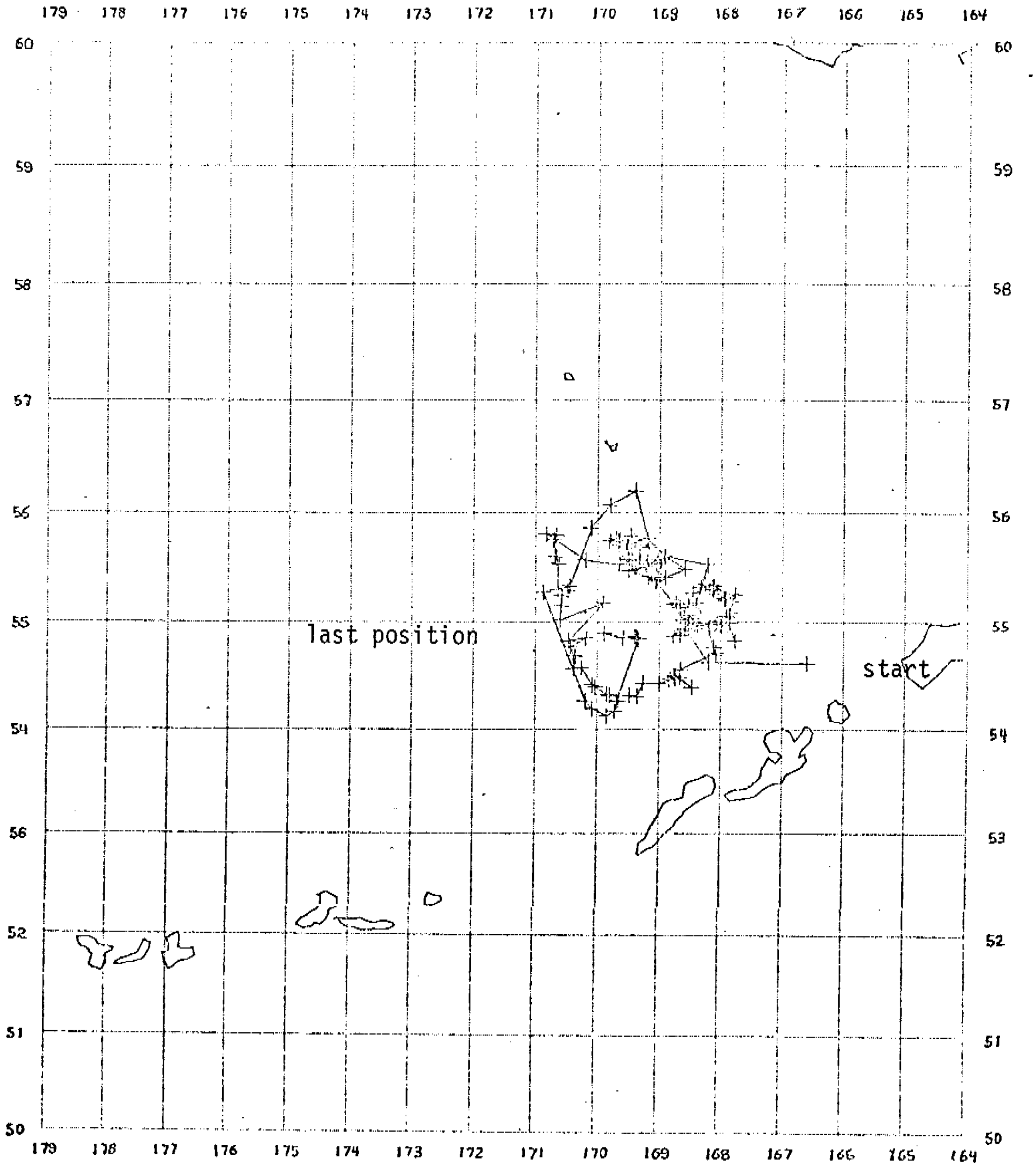


Figure 4. Buoy 0503 deployed day 146 - last position day 250

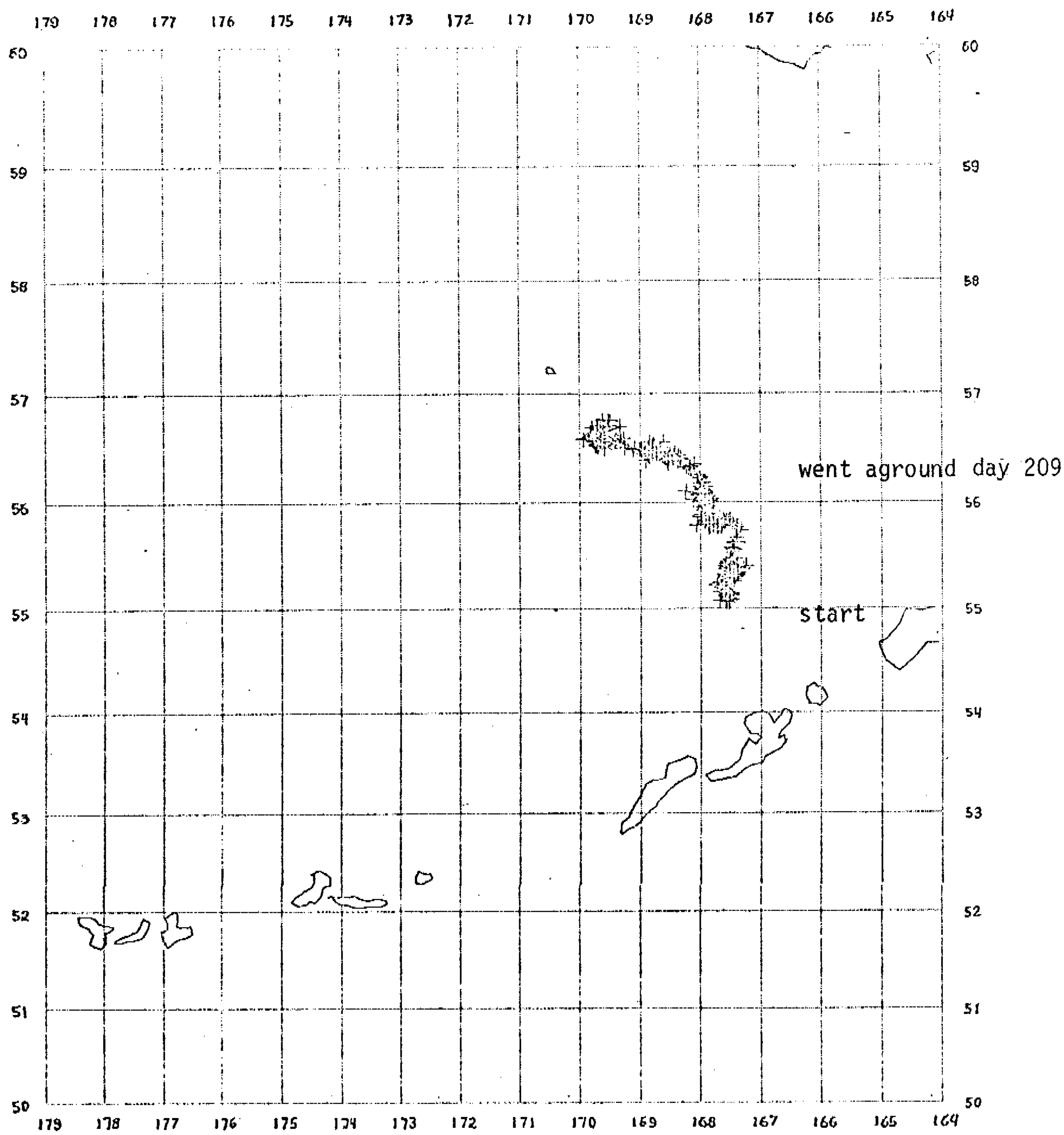


Figure 5. Buoy 0535 deployed day 147 - last position day 254

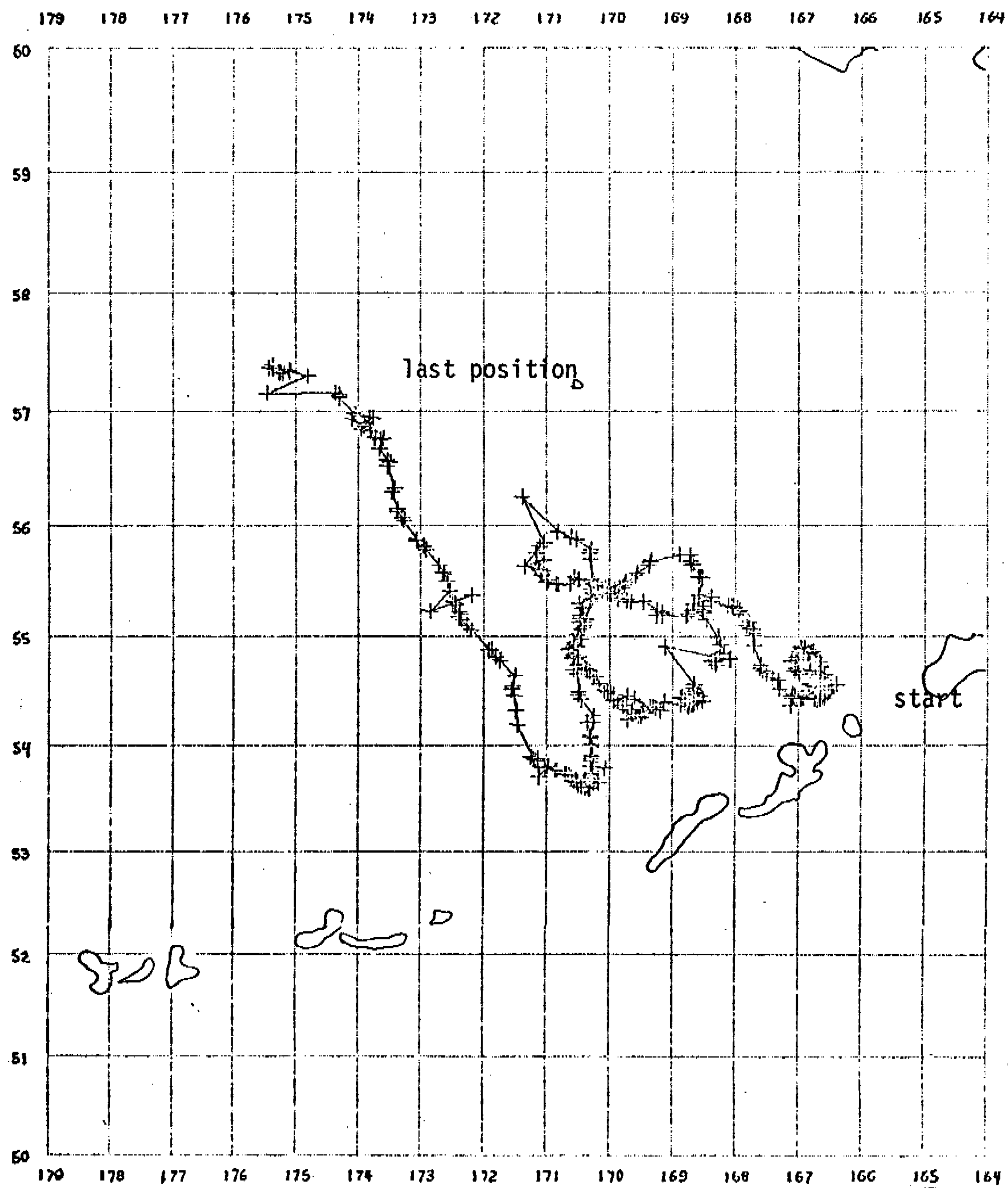


Figure 6. Buoy 0544 deployed day 146 - last position day 254

PERIOD COVERED:
Sept. 1, 1976 to Aug. 31, 1977

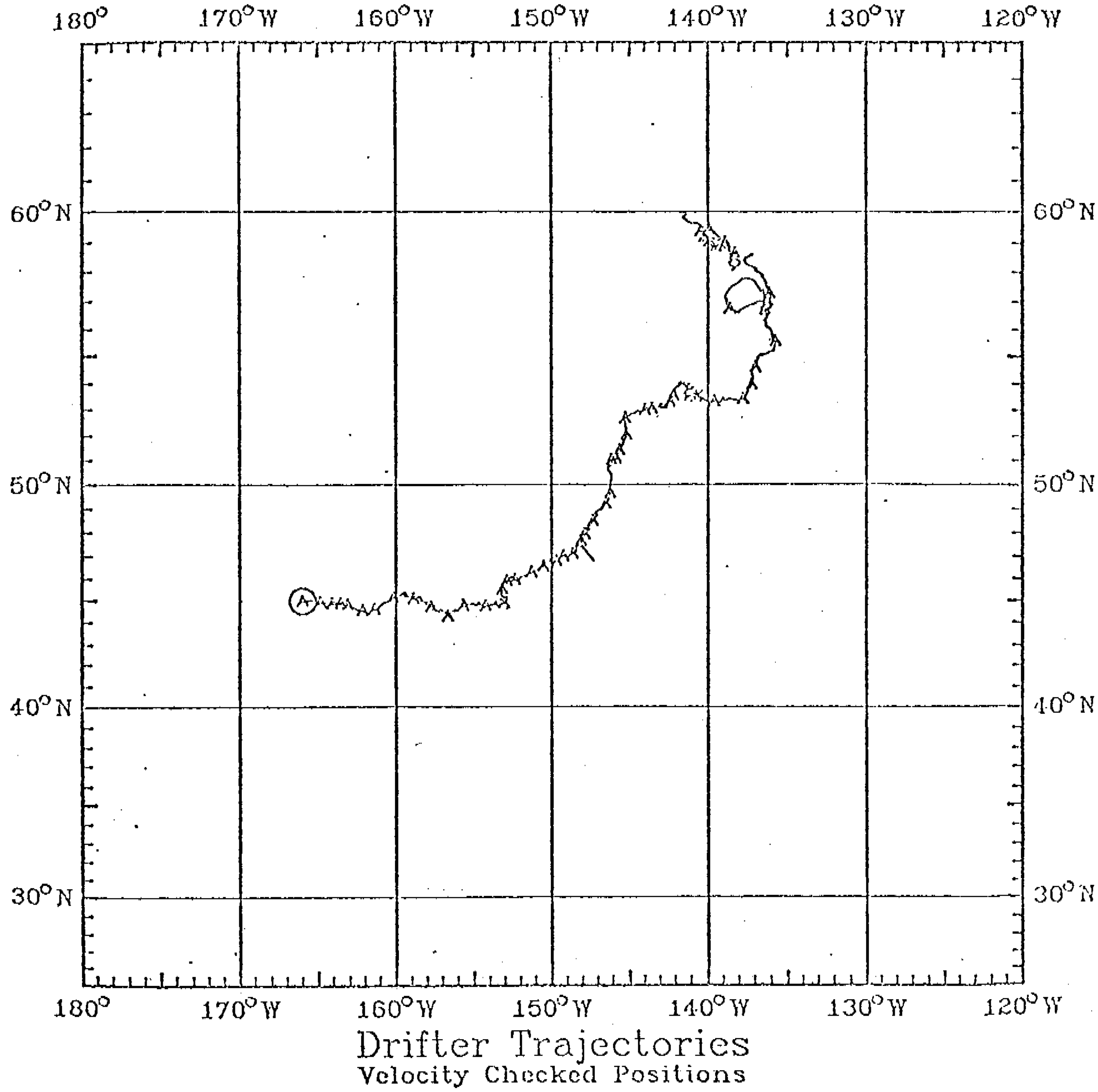


Figure 7. (Courtesy of Dr. D. Kirwan)

PERIOD COVERED:
Sept. 1, 1976 to Augs. 31, 1977

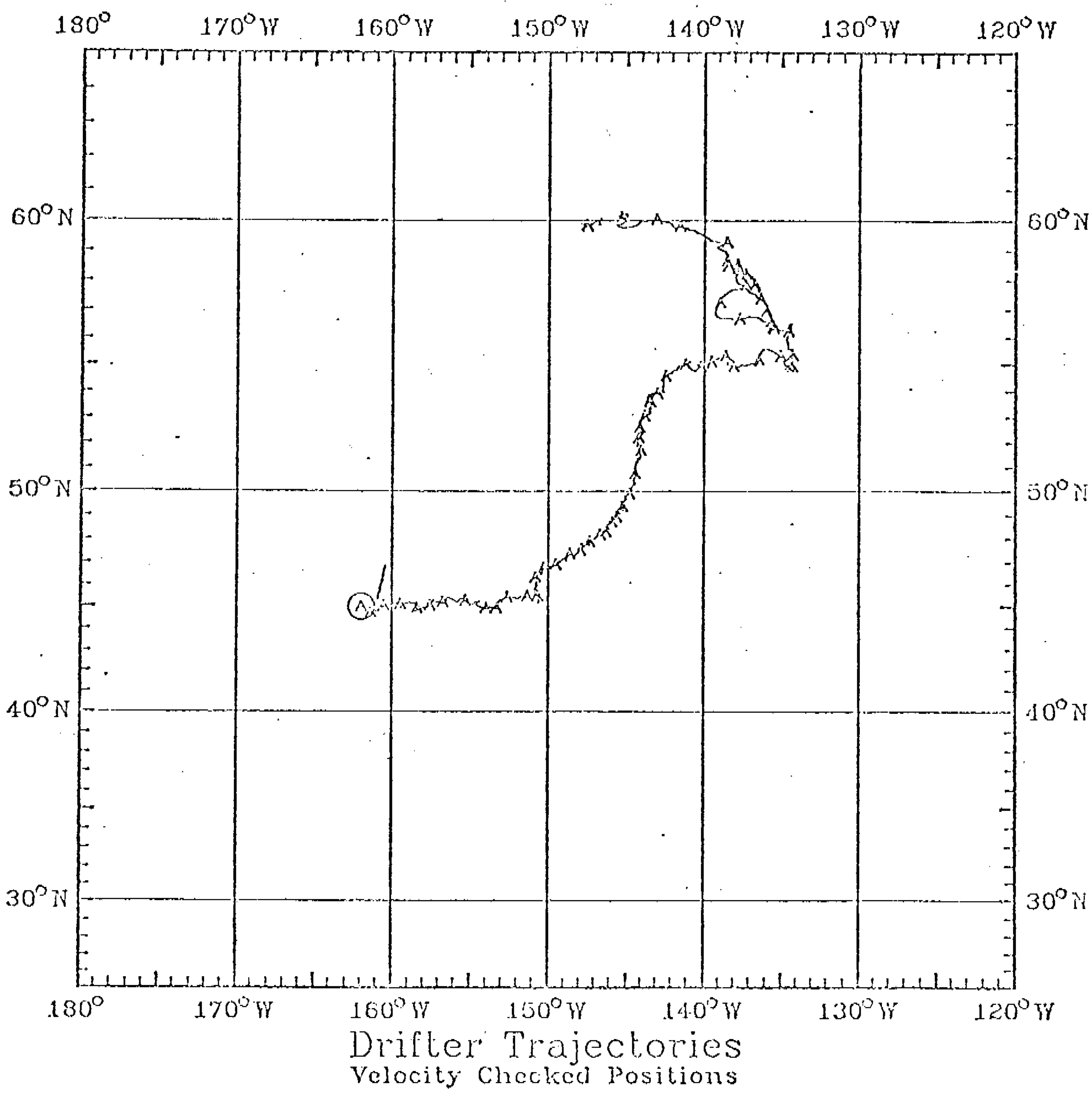


Figure 8. (Courtesy of Dr. D. Kirwan)

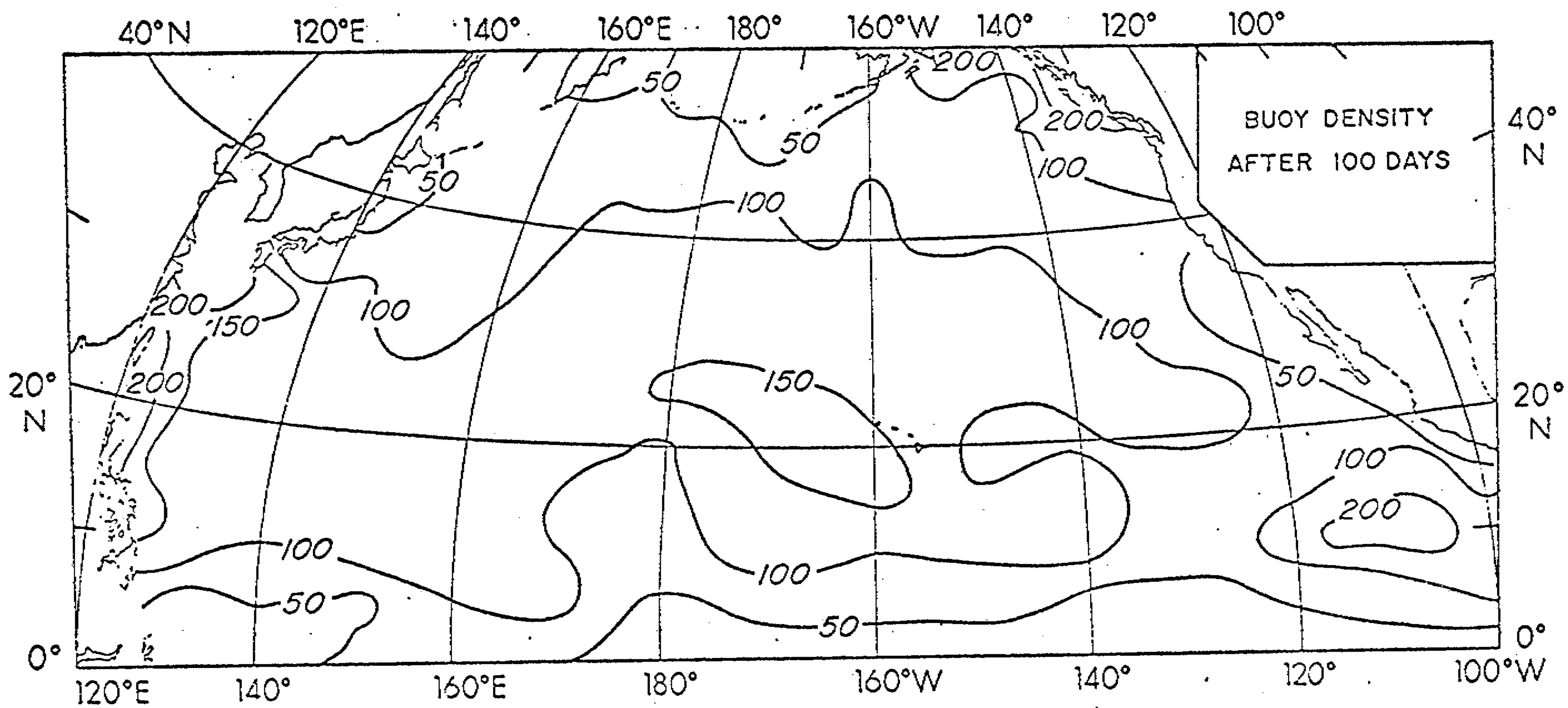


Figure 9. Buoy concentration after 100 days, case E.
(from Dotson, et al., 1977)

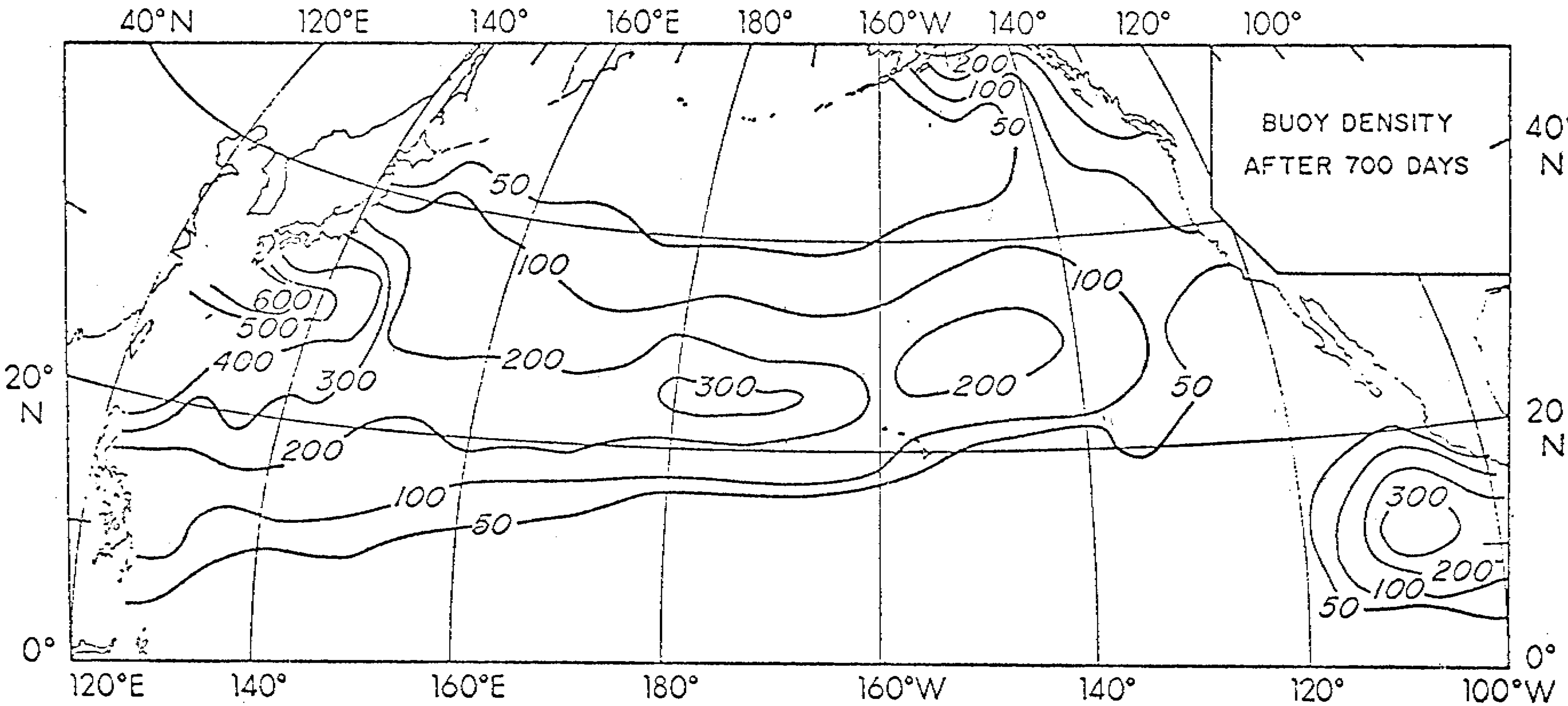


Figure 10. Buoy concentration after 700 days, case E.
(fron Dotson, et al., 1977)

QUARTERLY REPORT

Contract #03-5-022-91

Research Unit #244

Reporting Period: July 1 - Sept. 30, 1977

Number of Pages: 194

STUDY OF CLIMATIC EFFECTS ON ICE EXTENT AND ITS SEASONAL DECAY ALONG THE BEAUFORT SEA AND THE CHUKCHI SEA COASTS

Principal Investigator

R. G. Barry

Professor of Geography

Institute of Arctic and Alpine Research

University of Colorado

Boulder, Colorado 80309

September 30, 1977

A.I. TASK OBJECTIVES.

The objectives during the present quarter have been

a) to complete mapping of ice characteristics for 1973-75 summer seasons,

b) to refine the synoptic climatological analysis.

II. 1. FIELD ACTIVITIES

The 1977 field season activities consisted of aerial reconnaisance and photography of the arctic ice in Kotzebue Sound and the southern Chukchi Sea as well as in the Beaufort Sea between Pt. Barrow and Barter Island. Observations began in early June in Kotzebue Sound in order to observe break-up which usually begins at that time of year in that area. Between 3 and 5 June it was possible to observe break-up in the vicinity of the town of Kotzebue, but much of the Sound remained ice covered. Aerial photography of the Sound and the southern Chukchi Sea were done on 4 June. Photographs and observations were taken from an altitude of 1650 feet along a course due west of Kotzebue to 164° 20'W (66° 50'N) and then southeast to Cape Espenberg and return to Kotzebue. Additional observations were made of southern Kotzebue Sound (Fig. 1).

By mid-June favorable weather permitted aerial observations of the Beaufort Sea ice cover. The observing plans were to fly transects from various points along the coast out over the shorefast ice until reaching the pack ice. The transects flown were nearly the same as those done in June 1976, thus permitting comparisons of the ice cover during two consecutive summers. These comparisons will in turn be very useful when the aerial photographs and observers' notes are compared to ice conditions viewed from Landsat.

Successful (good weather) transects were all flown within a week of one another so that there were few changes in overall Beaufort Sea ice conditions except possibly in the amount of melt water on the ice. Transects are shown on the accompanying maps (Fig. 2) and include the following:

1) Barrow transect: Pt. Barrow to 71°35' 155°30'W
2) Lonely transect: 70°54'N 153°00'W (Lonely a.p.) to 71°29'N 153°00'W
3) Harrison Bay transect: 70°33'N 151°42'W (Atigaru Point) to 71°02' 150°40'W (about 40 km).
4) Oliktok Pt. transect: 70°30'N 149°52'W (O.P.) to 70°57'N 149°52'W (about 50 km).
5) Barter Island transect: 70°05'N 144°W to 70°21'N 144°W (30 km).

In addition ice observations were made when flying between transects.

II.2. OFFICE ACTIVITES

Personnel:

R. G. Barry - P.I.

J. Rogers - Graduate Research Assistant

R. E. Moritz - Graduate Research Assistant (through 15 August)

J. Reynolds - Graduate Research Assistant

B. Warmerdam - Graduate Research Assistant

G. Wohl - Graduate Research Assistant

III. DATA ANALYZED AND RESULTS

A. Aircraft Observations of Ice Conditions (1977).

Since aerial observations of Kotzebue Sound were not made in 1976, it is not possible to compare ice conditions between the two years. However, the observations of ice conditions made during 1977 have helped explain some of the features of Kotzebue Sound breakup observed previously on Landsat images. In particular, Landsat images show that breakup begins in the immediate vicinity of the town of Kotzebue (Landsat E 1314-22043 2 June 1973, E 1674-21573 28 May 1974, and E 2507-21404 12 June 1976). These show a narrow band of open water running NE to SW just west of the village which gradually widens. It is apparent from our observations on 3 July 1977 (see photo 1) that this band of open water is due to relatively warm inflow from the Noatak River and especially a strong current in the area of Kotzebue. Floes of ice, broken off by the currents, were moving very rapidly--perhaps at least as much as 5 km hr^{-1}.

The area of open water continued to increase and varied somewhat with the direction of the wind. It appears that with the opening of this area there is some room for adjacent Kotzebue Sound ice to move if the winds become southerly and westerly and that this area plays an important role in initiating breakup in the remainder of the Sound. Before this area clears, winds have little effect upon breakup processes.

Further aerial observations of Kotzebue Sound revealed it to be flat, relatively featureless (see photo 2), apparently protected from ridging and intrusions of multi year ice floes by its location and geography. The southern Chukchi Sea west of the Sound was also seemingly flat; photo 3 shows that some ridging occurs only along the edges of the large floes. The Sound may have its own near shore fast ice zone (photo 4) which has a character of its own and is separated from the remainder of the ice in the Sound. One Landsat image (1314-22043, 2 June 1973) also suggests this, showing a large lead in the ice in the southern part of the Sound which separates a zone of seemingly shorefast ice from the central ice cover of the Sound.

The Beaufort Sea ice regime was considerably different in 1977 from the conditions in 1976. Some of the major differences were:

1) Considerably more thawing of the ice was underway by mid-June 1977 than in mid-June 1976. It is estimated that the ice decay season was about two weeks ahead of last year. Near large rivers the ice cover had completely melted in some spots. It is noteworthy that Barnett (paper to the Sea Ice Processes Symposium, Sept. 1977) had earlier predicted that 1977 would be about two weeks ahead of that in 1976. He confirmed at the meeting that shipping had begun on 2 August 1977 in the Beaufort Sea whereas in 1976 it did not begin until 15 August.

2) The fast ice zone was flatter and more featureless than in 1976. However, the fast ice zone boundary was characterized by larger areas of ice rubble and more ridging than was noted last year (see photo 5, taken during the Oliktok transect).

3) Specific ice features noted in 1976 were <u>not</u> seen this year, e.g. the pattern of three sets of ridges near Barter Island; the ice islands in Harrison Bay, and multi year floes noted on some photos in 1976.

4) The variation in ice features northward from the coast was similar along all transects, that is there was little regional variation in ice features noted as one moved from shore over the fast ice. Specifically, the ice regime northward from shore generally proceeded as follows:

(i) Near river mouths a very rotted and darkened ice surface was noted or perhaps the area was ice free.

(ii) Smooth shorefast winter ice cover with some snow but generally heavily puddled (see photo 6, taken along the Harrison Bay transect). Some floes of different color (dirtier) frozen into place in this zone, too.

(iii) A band of rough, ridged, hummocked and dirty ice mixed in with but predominating over the flat first year ice (see photos 7 and 8, taken along the Harrison Bay transect).

(iv) Another band (area) where flat winter ice predominates (see photo 9; note that this area precedes lighter colored ridges in the distance).

(v) Rubble fields and ridges marking the end of the shorefast ice zone (see photo 9). In some areas sections of the ridged ice were breaking away from the shorefast zone (see photo 10, taken during the Harrison Bay transect; similar features were recorded on the Barrow transect--photo not included).

This pattern of ice features was noted in some form along each transect and is different from the 1976 ice conditions when features varied considerably from region to region (transect to transect) due to the presence of second and multi year features and varied hummock areas.

B. Ice Maps.

Maps of ice conditions for three sectors along Beaufort Sea coast, and three sectors along the Chukchi Sea coast, have now been completed for the 1973-75 summer seasons. The maps which are now submitted to complete this series are included, together with interpretations, as Figs. 3 - 45 (for the Beaufort (coast). Maps completed earlier for the Chukchi Coast in 1976 are also now included as Figs. 57 - 72.

C. Thawing-degree Day Statistics.

Table 1 gives the ranking of summers in order of increasing number of TDD's at Barrow, Barter Island, and Kotzebue. The number of TDD's is given next to the year of the particular summer; means and standard deviations are shown.

At Point Barrow, where the data go back to 1921, the summers which were colder than normal by greater than one standard deviation are numbers 1 through 8 (1945 to 1975), and those warmer by more than one standard deviation are numbers 42 through 55.

At Barter Island (data back to 1968) the summers colder than one standard deviation are numbers 1 through 5 while only 26 through 28 were warmer by one standard deviation.

At Kotzebue (data back to 1953) the summers which were colder than normal by greater than one standard deviation are 1 through 3 (1975 and 1945 are cold by 2 standard deviations). Summers which were warmer by more than one standard deviation are numbers 29 through 34.

D. Synoptic Climatology of the Chukchi Coast

1. Statistical Considerations

The weather characteristics of the 22 Chukchi types were determined for Kotzebue based on "Local Climatological Data" for January 1955 through August 1976. The weather variables studied were:

1. mean daily temperature departure from normal
2. mean daily dewpoint depression
3. mean daily resultant wind speed
4. mean daily wind direction
5. daily water-equivalent precipitation
6. daily midnight-to-midnight sky cover.

Analysis of variance was applied to the temperature departure, dewpoint depression, and wind speed data grouped by pressure type. The results of the tests are presented in Tables 2-6. Table 2 indicates that for all months a highly significant association exists between pressure pattern types and temperature departure. There is also a significant association between the types and dewpoint depression during all months except March (Table 3) and a highly significant association between the types and wind speed during all months (Table 4).

The Chi-square statistical test was applied to the wind direction, precipitation, and sky cover data grouped by pressure type. Table 5 indicates highly significant association between pressure type and wind direction for all months. Table 6 shows a significant association between types and sky cover during September through January, but the association is not evident during the rest of the year. This is not unexpected, since the summer climate at Kotzebue is a "maritime" phase, with generally high sky cover levels each day. The synoptic pressure pattern types may be of little significance in determining sky cover during February through August; although the test results may be a function of the greater number of types included in the analysis during this period. Table 7, however, indicates that a significant association exists between pressure type and precipitation throughout the year.

These statistical tests indicate that the Chukchi synoptic typing scheme successfully identifies synoptic pressure patterns which are associated with certain distinctive weather characteristics. Therefore, the scheme is a useful tool for climatological research in the Chukchi Sea area.

2. Synoptic Seasonality

As discussed earlier (Quarterly Report, 12/31/76), there appears to be a particular seasonality to the frequency of occurrence of the Chukchi synoptic types. Three "synoptic seasons" were identified: winter (November through May); summer (June through August); and autumn (September-October). Further analysis reveals three categories of types with particular seasonality of occurrence:

1. summer maximum types - types 3,5,7,9,10,12,15,18,19,21
2. winter maximum types - types 1,4,14,16,22
3. no maximum types - types 2,6,8,11,13,17,20.

The graphs of the monthly frequencies of these types appear in Figs. 46 - 48. These figures show that there may also be a "spring" season; during April-May the winter types are becoming less frequent as the summer types (especially 3, 5, and 9) become more frequent, analogous to the reverse transition in autumn.

Summer is a time of more complicated synoptic circulation, as evidenced by Fig.49, which is a graph of the number of types expected to occur at least once in a month in each year (approximately 3% frequency). Twice as many types may be expected to occur each month during the summer as during the winter.

Also of note is the fact that only one winter maximum type is cyclonic in circulation (14, not a major cyclonic type). Winter is generally dominated by anticyclonicity.

3. Weather Characteristics of the Chukchi Pressure Pattern Types

The maps of the 22 types were included in the Quarterly Report (12/31/76) and are presented here in reduced size for ready reference (Figs. 50 -53). Tables 8-13 summarize the weather variable data for each type. Descriptions based on the data are presented below.

a. Important winter types

Type 1: This is the most common of all types, occurring on about 30% of all days of the study period and 40% of the winter days. It consists of high pressure over the Arctic Ocean and decreasing pressure southward. It is characterized by northeasterly observed surface winds, highly variable temperature departures (mean +1.5°C during winter), highly variable sky cover, and general lack of precipitation (78% of winter days <.01" precipitation).

Type 2: Large positive temperature departures are the most important characteristic of this type (mean +8.7°C in January-February). It consists of a low pressure area in the Bering Sea with generally increasing pressure to the northeast. It is associated with very strong easterly observed surface winds (mean approximately 10m/s), high sky cover values, and at least .01" precipitation on about 1/3 of the days it occurs in winter.

Type 3: This type consists of a high pressure cell over the Bering Sea and decreasing pressure northward. During winter, its characteristics are highly variable, the most significant being large positive temperature departures (mean +5.6°C in January-February). Wind speed and direction are highly variable, probably depending upon the strength and actual position of the high pressure cell. At least .01" precipitation occurs on 36% of type 3 winter days.

Type 4: This type consists of high pressure over eastern Siberia with decreasing pressure to the north, east, and south. It is associated with large negative temperature departures (mean $-7.0^{\circ}C$ in February), weaker than normal northerly observed surface winds, variable partly cloudy skies, and significant lack of precipitation (84% of winter days <.01" precipitation).

Type 6: This type consists of a high pressure cell centered on the southern Chukchi Sea near Kotzebue. It is characterized by highly variable weather characterisitics depending upon the origin of this mobile anticyclone. It is associated with easterly observed surface winds and lack of precipitation in winter (83% of days <.01" precipitation).

Type 8: The extended Siberian high pressure cell of type 8 is similar to type 4. Extremely cold weather (mean temperature during winter $-6.9^{\circ}C$, during February $-10.4^{\circ}C$) is produced, accompanied by weak winds of generally northerly direction, light sky cover, lack of precipitation (84% of winter days <.01") and lower than normal humidity.

Type 9: This type has high pressure cells over northern and southern Alaska. Its characteristics are generally similar to the climatic average conditions for Kotzebue.

Type 11: This "marginally cyclonic" type consists of low pressure centered over central interior Alaska. It is characterized by negative temperature departures, winds highly variable in speed and direction, generally high sky cover values, and at least .01" precipitation on 40% of the days it occurs in winter.

Type 12: This is a cyclonic type with low pressure centered over eastern Siberia. This stormy type is characterized by extremely large positive temperature departures (+11.3^{o}C in January), strong southeasterly observed surface winds (mean approximately 10m/s), very heavy cloud cover, and at least .01" of precipitation on 55% of the days.

Type 13: The configuration of this type is high pressure over the Beaufort Sea and low pressure in the Aleutian area. It is characterized by weak northeasterly winds, negative temperature departures (mean -4.6^{o}C November through February), and lack of precipitation (83% of winter days <.01" precipitation).

Type 16: Another expanded Siberian high pressure type which produces extremely cold weather (mean winter temperature departure -7.1^{o}C) with weak winds of variable direction, light sky cover, and significant lack of precipitation (94% of days <.01").

Type 17: The low pressure cell of type 17 over eastern Siberia is similar to type 12. This type is characterized by easterly observed surface winds, large positive temperature departures (mean +5.6C November through March), and at least .01" precipitation on 31% of its winter days.

Type 22: This anticyclonic type consists of high pressure centered over the northern Alaska coast. It is characterized by large negative temperature departures (winter mean -7.4C), weak northeasterly winds, very light sky cover, and extreme lack of precipitation (only one day of this type in the entire study period produced precipitation in winter).

b. Important summer-autumn types

Type 1: Although less common during this period than in winter, type 1 is the most frequent type in all months except July; however, it is less dominant, occurring on average 12% of the summer days. Its summer characteristics are more variable, with westerly or easterly observed surface winds, positive temperature departures (summer mean +2.0°C), and precipitation on about 1/3 of days.

Type 2: This cyclonic type is associated with positive temperature departures (summer mean +2.3°C), westerly or southeasterly observed surface winds, and, on about 1/2 of the days it occurs, at least .01" precipitation.

Type 3: The most common type during July, type 3 produces rather variable weather. It is associated with generally negative temperature departures, variable winds of generally westerly to southerly direction, and at least .01" precipitation on about 1/3 of the summer days and 60% of the autumn days it occurs.

Type 5: The herald of summer, type 5 increases rapidly in frequency April through June. This "marginally cyclonic" type consists of highs over the Bering Sea and northwestern Chukchi Sea and a low over central Alaska. During April-May it is associated with westerly observed surface winds, large negative temperature departures (mean $-4.5^{\circ}C$ in April), apparently partly cloudy skies, and lack of precipitation (<.01" on 85% of the days). During summer it is associated with near-normal temperatures and little precipitation.

Type 7: This cyclonic type consists of a low pressure cell centered over the southern Chukchi Sea west of Kotzebue. It is stormy, producing at least .01" precipitation on over 80% of the days it occurs in late summer and autumn. It is associated with very large falls of precipitation (over 50% of type 7 days >.07" in August), apparently heavy cloudiness, generally southerly observed surface winds, and near-normal temperatures.

Type 8: This anticyclonic type also occurs during summer, bringing strong westerly winds, near-normal to slightly below normal temperatures, and lack of precipitation.

Type 9: The characteristics of type 9 are roughly similar to the climatic average conditions for Kotzebue (as in winter).

Type 10: This type consists of a low in the northeast corner of the synoptic grid and increasing pressure to the southwest. It is characterized by strong west to northwesterly observed surface winds (>7m/s) and rather large negative temperature departures. During late summer and autumn it produces precipitation on about 60% of days.

Type 11: High variable characteristics are associated with this type during summer-autumn, probably depending upon the origin and actual location of the low pressure area. It is associated with highly variable temperature departures (mean near normal), winds of no persistent direction, and at least .01" precipitation on 50% of days.

Type 12: This stormy cyclonic type is associated with strong observed surface winds of southerly direction, near-normal temperatures, apparently heavy cloudiness, and precipitation (73% of type 12 days in late summer and autumn produce at least .01" precipitation).

Type 13: During summer this type is associated with variable northerly to easterly winds, large positive temperature departures (mean $+4.0^{\circ}C$ in July) and dry weather (mean dewpoint depression approximately $5.0^{\circ}C$; precipitation on only 17% of the days it occurs).

Type 15: This type consists of low pressure over interior central Alaska. It is associated with strong westerly observed surface winds (mean 8.2m/s in August), large negative temperature departures (summer mean

-2.4°C) and a general lack of precipitation.

Type 17: During summer, type 17 is associated with winds of variable, but non-northerly direction, positive temperature departures (summer mean +2.0°C), and generally precipitation (at least .01" on 62% of August days).

Type 19: Common only during June and July, the major feature is a strong high over the southern Bering Sea. It is associated with westerly observed surface winds, near-normal temperatures, and lack of precipitation (78% days $<$.01").

Type 21: This type consists of highs over the central Chukchi Sea and western Bering Sea. It is associated with variable northwesterly winds (mean speed approximately 6m/s), negative temperature departures, only partly cloudy skies, and significant lack of precipitation (only 9% of summer days $\geq$.01" precipitation).

4. Summary of Synoptic Climatology at Kotzebue

During winter, type 1 is the dominant type, occurring about 40% of the days. This type represents nearly the average state of the atmospheric circulation for this area at this time - an expanded polar high represented in the Chukchi Sea area and strong Aleutian Low represented by decreasing pressure southward through the Bering Sea. This type is very persistent, occurring in spells with a mean length of about 5 days. It is associated with zonal easterly flow, the classical subpolar easterlies. This situation is disturbed from time to time by invading mobile circulation systems, cyclonic or anticyclonic, with anticyclonic disturbances much more common. After such a system has passed through the area a return to type 1 conditions generally ensues.

The temperature conditions of these invading systems are of considerable importance. Figure 41 depicts the temperature departure characteristics through the year of the major cyclonic (2,7,12,17) and anticyclonic (4,6,8,13,16) types. During winter, cyclonic types are associated with large positive temperature departures from normal and anticyclonic types are associated with large negative temperature departures from normal. Keegan (1958) observed the same phenomenon. There appear to be several reasons for this:

(i) Origin of the systems: most of the cyclonic types are likely to originate over the Pacific Ocean in the area of the Aleutian Low. A southerly, maritime origin is likely to produce air masses which are warmer than average at Kotzebue. Anticyclones, however, generally originate over northerly landmasses such as Siberia, an origin which is likely to produce colder than average conditions at Kotzebue.

(ii) Wind direction: Cyclonic types tend to be associated with southerly geostrophic flow (producing observed surface winds between south and east) causing warm air advection from southerly maritime areas. Anticyclonic types tend to be associated with winds of variable but generally northerly direction, causing cold air advection.

Table 14 illustrates the relationship between observed surface wind directions and temperature departures from normal at Kotzebue Winds from between south and east in winter are all associated with large positive temperature departures. The northerly winds are associated with negative temperature departures.

(iii) Sky Cover: During winter, cyclonic types are associated with high sky cover levels whereas anticyclonic types with little sky cover. The strong relationship between sky cover and mean temperature departure is illustrated by Fig. 55 and Table 15. Heavy cloud cover is associated with large positive temperature departures, light or no cloud cover is associated with large negative temperature departures. This may be due in part to cloud effects on the net radiation budget: heavy cloud cover acts to reduce longwave radiation loss from the surface, whereas clear skies enhance such radiative cooling. Cloud effects on incoming radiation are unimportant during the winter due to the low solar angles.

(iv) Wind speed: Cyclonic types are associated with strong winds while anticyclonic types are associated with weak winds. Besides promoting warm air advection, strong winds contribute to turbulence which tends to break down the Arctic inversion, allowing warmer air aloft to mix with surface air. The weak winds and clear skies of anticyclonic types tend to strengthen the inversion, with cold air remaining at the surface.

For the above reasons, cyclonic types tend to bring "warm" weather to Kotzebue during winter while anticyclonic types bring "cold" weather. Since anticyclones are more common and because of the statistical nature of the data, type 1 then becomes associated with small positive temperatures on average.

Several other types that occur occasionally during winter are of interest. Types 5,10,11, and 15 all contain cyclonic systems in the eastern (marginal) part of the synoptic grid, with anticyclonicity elsewhere. They generally represent situations occurring after passage of cyclones through the Kotzebue area or situations in which cyclones move directly north through continental Alaska, bypassing Kotzebue. These types are associated with north to northwest geostrophic flow (NW to W surface flow) and thus infilling of cool arctic air "behind" the storms. Therefore, though marginally cyclonic, they are associated with negative temperature departures. The characteristics of type 5 are actually more anticyclonic than cylonic.

Type 14, which contains a cyclone in the northern part of the synoptic grid, is rather unusual since it is the only cyclonic type which has a winter maximum of occurrence, and it is rather low on persistence. It tends to be a transtitional type to type 1 or type 4. Because of this, its characteristics are quite variable and inconsistent. Although basically cyclonic, it is not "warm."

Fig. 56a illustrates the temperature departure and precipitation characteristics of the various important winter types.

During summer, the significant difference between the temperature characteristics of the cyclonic and anticyclonic types vanishes (Fig.56b). This seems to occur because there is only a weak north-south temperature gradient and less difference between continental and maritime temperatures during this season, making air mass characteristics of less importance than in winter. Cloud cover and temperature departure are not associated during summer (Table 15), although there seems to be positivetemperature departures associated with clear skies. There remains an association between wind direction and temperature departure, but now the winds of easterly component are associated with large positive temperature departures while winds of westerly component are associated with negative temperature departures. The important temperature gradient appears to be east-west, or in the case of a coastal location such as Kotzebue, maritime vs. continental location. The maritime westerly winds tend to bring cool air advection, while easterly winds cause warm continental outflow. The temperature characteristics of the types are determined by their associated wind directions. The prevailing westerly winds are strong: nearly every type shows at least some westerly flow associated with it. Types 3, 6, and 9 show a seasonal reversal of wind direction, from winter easterlies to summer westerlies, similar to the general climatic average. These are basically anticyclonic types, and it may be that their pressure gradients are weak, such that local features control wind direction. This may be evidence for weak monsoonal flow on this coast (Sater, _et al_., 1971), with flow inland from the sea dominating during the summer and continental outflow evident during winter, unless interupted by strong opposing pressure gradients.

It is interesting to note that the four most significantly warm summer types (types 1,2,13, and 17) have easterly observed surface winds associated with them (although the prevailing westerlies are also evident) while the three most significantly cool types (types 3, 10 and 15) are associated with pronounced westerly observed surface winds.

The summer is a maritime phase of the climate at Kotzebue. The Chukchi Sea is no longer frozen, the wind shifts from prevailing winter easterlies to prevailing westerlies and together with heightened cyclonic activity, produces a humid regime. Winter is basically a continental regime.

While winter was dominated by type 1, summer is a highly variable time in which:

(i) there is no dominant pattern;

(ii) many more types are common: about ½ of the types have a summer maximum of occurrence;

(iii) there is a greater frequency of unclassifiable days, indicating a more complicated circulation system with a greater number of transitions between types and probably weaker pressure gradients; and

(iv) cyclonic circulation systems are more common than anti-cyclonic systems.

Type 3 represents the nearest to average circulation for this area during summer. It is the most common type during July. The expanded high pressure cell over the Pacific Ocean is represented by high pressure over the Bering Sea, with decreasing pressure northward. Many intrusions of circulation systems into this general situation occur. During summer the Arctic front is located on average just a few degrees of latitude north of Kotzebue (Barry, 1967). This is a time of frequent cyclonic activity and maximum precipitation.

The important types occurring in summer can be broken up into four basic categories:

a) zonal: types 1 and 3

b) cyclonic: types 2, 7, 12 and 17

c) anticyclonic: types 4, 6, 8, 9, 13, 19 and 21

d) marginally cyclonic: types 5, 10, 11 and 15.

Fig. 56b summarizes the temperature and precipitation characteristics of these types for summer.

E. Meteorological Factors Relating to Predictability of Summer and Autumn Ice Conditions.

The last Quarterly Report outlined initial work on the possible bases for long-range forecasting of ice conditions in the Beaufort Sea. A paper based on this work has been prepared in conjunction with the Fourth POAC Conference (1977) by J. C. Rogers and this is attached as Appendix 1.

IV. DATA SUBMISSION SCHEDULE

1. A magnetic tape of the synoptic catalog for the Chukchi Sea sector has been forwarded to the Arctic Project Office. The type maps are included in reduced form here (Figs. 50-53), as discussed above.

2. The sector maps of ice characteristics have now been submitted for both coasts for 1973-75 and the Chukchi for 1976. Work is progressing on the 1976 Beaufort imagery and the mapping of sectors should be completed during this quarter.

V. PROBLEMS/RECOMMENDED CHANGES. None

VI. ESTIMATE OF FUNDS EXPENDED. $43,000

REFERENCES

Barry, R.G. 1967 "Seasonal Location of the Arctic Front over North America". Geographical Bulletin, 9: 79-95.

Keegan, T.J. 1958 "Arctic Synoptic Activity in Winter". Journal of Meteorology, 17: 489-506.

Sater, J.E.; Ronharde, A.G.; and Van Allen, L.C. 1971 Arctic Environment and Resources, Washington, D.C., Arctic Institute of North America.

Table 1. Ranking of Summers by TDD Accumulation for Barrow, Barter Island and Kotzebue

Coldest	Barrow	Barter Island	Kotzebue
1	1945 - 225	1955 - 340	1975 - 1521
2	1969 - 227	1965 - 363	1945 - 1524
3	1922 - 276	1959 - 384	1948 - 1614
4	1924 - 287	1969 - 386	1973 - 1748
5	1955 - 303	1964 - 406	1944 - 1751
6	1964 - 311	1974 - 429	1952 - 1787
7	1956 - 321	1970 - 430	1964 - 1790
8	1975 - 346	1960 - 439	1960 - 1810
9	1960 - 351	1975 - 461	1949 - 1860
10	1953 - 366	1952 - 468	1959 - 1845
11	1941 - 367	1967 - 520	1946 - 1865
12	1963 - 371	1948 - 549	1955 - 1871
13	1970 - 375	1949 - 558	1970 - 1876
14	1967 - 379	1956 - 570	1965 - 1880
15	1966 - 389	1966 - 571	1956 - 1897
16	1933 - 408	1963 - 594	1953 - 1897
17	1971 - 426	1953 - 602	1966 - 1903
18	1935 - 431	1961 - 616	1954 - 1909
19	1934 - 439	1971 - 618	1943 - 1917
20	1959 - 441	1972 - 639	1963 - 1932
21	1931 - 449	1962 - 669	1976 - 1942
22	1948 - 450	1973 - 717	1961 - 2009
23	1961 - 456	1954 - 721	1962 - 2017
24	1932 - 458	1950 - 723	1967 - 2025
25	1965 - 462	1968 - 737	1968 - 2032
26	1944 - 466	1951 - 844	1971 - 2062
27	1947 - 467	1957 - 844	1951 - 2068
28	1939 - 495	1958 - 1118	1974 - 2108
29	1943 - 503	Warmest	1947 - 2177
30	1946 - 517		1969 - 2270
31	1952 - 518		1972 - 2275
32	1929 - 557		1950 - 2290
33	1949 - 562		1958 - 2294
34	1937 - 581		1957 - 2306
35	1950 - 594		Warmest
36	1942 - 619		
37	1921 - 622		
38	1957 - 636		
39	1973 - 645		
40	1974 - 655		
41	1940 - 712		
42	1927 - 718		
43	1962 - 721		

Warmer →

Table 1. continued

Coldest	Barrow	Barter Island	Kotzebue
44	1938 - 722		
45	1958 - 737		
46	1928 - 738		
47	1923 - 740		
48	1936 - 748		
49	1968 - 760		
50	1972 - 765		
51	1926 - 785		
52	1930 - 819		
53	1925 - 893		
54	1951 - 865		
55	1954 - 925		
Warmest			
Mean	532	583	1944
S.D.	182	176	204

Results of ANOVA for Temperature Departures

Table 2. With Each Pressure Type at Kotzebue

month	dfd	dfn	s^2	Sp^2	F	F_{99}
1	119	22	738.7	64.9	11.38	2.0
2	107	22	623.7	72.8	8.57	2.0
3	119	23	433.1	55.6	7.79	2.0
4	115	23	222.8	35.6	6.27	2.0
5	119	23	126.4	14.4	8.76	2.0
6	115	23	69.3	10.6	6.57	2.0
7	119	22	92.0	8.1	11.35	2.0
8	119	23	79.5	6.3	12.54	2.0
9	87	23	49.3	6.1	8.03	2.0
10	90	23	76.5	19.4	3.94	2.0
11	109	22	249.2	34.3	7.27	2.0
12	113	21	578.3	67.6	8.55	2.0

Key to Tables 1-3

dfd - degrees of freedom in the denominator
dfn - degrees of freedom in the numerator
s^2 - variance between types
Sp^2 - variance within types
F - $\frac{s^2}{Sp^2}$ (F-ratio)
Fgg - if F exceeds this value, there is a greater than 99% chance that the means of the types come from different populations
( ) - value in parentheses is critical F at 95% significance level

Table 3. Results of ANOVA for Dewpoint Depressions With Each Pressure Type at Kotzebue

month	dfd	dfn	s^2	Sp^2	F	F_{99}	( )
1	58	20	12.4	3.4	3.63	2.2	-
2	52	20	7.9	3.3	2.42	2.25	-
3	49	21	4.7	3.5	1.35	2.25	(1.77)
4	39	21	8.2	2.7	3.04	2.35	-
5	40	21	11.3	4.5	2.48	2.35	-
6	69	23	7.6	4.1	1.86	2.1	(1.70)
7	95	20	15.3	2.6	5.83	2.1	-
8	95	21	7.0	2.9	2.39	2.1	-
9	98	23	5.6	2.7	2.09	2.0	-
10	102	23	4.9	1.9	2.61	2.0	-
11	50	20	5.8	2.1	2.76	2.25	-
12	52	20	12.8	3.9	2.38	2.25	-

Table 4. Results of ANOVA for Resultant Wind Speeds With Each Pressure Type at Kotzebue

month	dfd	dfn	s^2	Sp^2	F	F_{99}
1	95	21	93.9	12.0	7.85	2.05
2	78	20	29.1	10.5	2.77	2.0
3	101	21	30.4	10.6	2.86	2.05
4	111	21	34.9	9.5	3.69	2.0
5	115	21	11.5	5.0	2.31	2.0
6	119	23	17.5	5.2	3.35	2.0
7	124	20	18.5	5.5	3.34	1.95
8	122	21	18.5	6.3	2.95	1.95
9	143	23	14.9	6.1	2.44	1.85
10	148	23	25.8	8.0	3.23	1.85
11	82	20	48.3	10.3	4.71	2.1
12	85	20	62.9	11.2	5.61	2.1

Table 5. Chi Square Results for Wind Direction and Pressure Types at Kotzebue

Month	#Types	Min	Rows	DF	χ^2	χ^2_{99}
1	7	20	6	30	235.2	50.9
2	5	20	6	20	150.6	37.6
3	5	20	6	20	81.5	37.6
4	6	20	6	25	195.9	44.3
5	8	20	6	35	141.7	56.5
6	10	20	6	45	124.6	69.1
7	10	20	6	45	208.1	69.1
8	14	20	6	75	287.2	105.6
9	10	20	6	45	277.8	69.1
10	10	20	6	45	246.5	69.1
11	5	20	6	20	329.6	37.6
12	5	20	6	20	141.7	37.6

Key to Tables 4-6

Season 1 - November through May
Season 2 - June and July
Season 3 - August
Season 4 - September and October
= Table 6

#Types - number of pressure types included in analysis
Min - minimum frequency value necessary for type to be included in analysis for this season (month)
Rows - # of categories of variable analyzed
DF - degrees of freedom
χ^2 - chi-squared statistic
χ^2_{99} - if x^2 exceeds this value, there is a greater than 99% chance that there is an association between synoptic type and the variable tested
( ) - value in parentheses is initial χ^2 at 95% level of significance

Table 6. Chi Square Results for Sky Cover and Pressure Types at Kotzebue

Month	#Types	Min	Rows	DF	χ^2	χ^2_{99}	χ^2_{95}
1	3	20	10	18	42.7	34.8	-
2	3	20	10	18	33.8	34.8	(28.9)
3	3	20	10	18	23.2	34.8	(28.9)
4	5	20	10	36	57.1	57.8	(50.7)
5	5	20	10	36	42.3	57.8	(50.7)
6	9	20	10	72	68.6	102.0	(92.5)
7	7	20	10	54	64.0	80.3	(71.9)
8	8	20	10	63	81.8	91.2	(82.2)
9	6	20	10	45	81.4	69.1	-
10	5	20	10	36	72.5	57.8	-
11	3	20	10	18	35.9	34.8	-
12	3	20	10	18	37.5	34.8	-

Table 7. Chi Square Results for Precipitation and Pressure Types at Kotzebue

Season	#Types	Min	Rows	DF	χ^2	χ^2_{99}	χ^2_{95}
1	21	20	5	80	286.5	111.5	-
2	16	20	5	60	111.2	87.6	-
3	10	20	5	36	54.5	50.8	(50.7)
4	15	20	5	56	187.0	82.7	-

Table 8. Temperature Departures (°C) from the Monthly Mean at Kotzebue, 1955–76, for each Pressure Pattern Type

Chukchi Type		1	2	3	4	5	6	7	8	9	10	11	12
1	M	2.9	-0.2	2.2	0.8	2.0	1.3	2.4	2.3	1.6	-2.3	0.5	2.5
	SD	8.2	9.0	7.4	6.4	4.2	3.7	3.4	2.7	3.1	4.8	6.1	8.7
	n	222	247	263	224	227	83	56	109	143	136	222	215
2	M	8.7	8.6	6.7	2.4	2.1	2.2	2.4	2.1	1.8	0.3	1.1	6.6
	SD	8.2	7.0	7.2	6.2	3.4	3.1	3.3	2.8	2.1	4.7	5.7	10.0
	n	82	46	42	53	82	65	65	61	51	46	69	66
3	M	5.9	5.0	-0.6	0.7	-1.0	-2.0	-0.7	-1.3	-0.6	-0.1	2.5	3.9
	SD	8.7	11.0	8.3	5.7	3.0	2.2	2.5	2.4	1.4	3.7	5.5	9.3
	n	18	11	16	23	22	50	91	51	26	21	22	23
4	M	-6.4	-7.0	-2.8	-3.8	-1.6	-1.9	-3.1	0.3	-0.5	-1.9	-4.2	-5.2
	SD	5.9	6.5	7.5	4.7	3.6	1.4	2.9	2.4	2.6	4.0	6.0	6.9
	n	84	87	68	51	33	12	7	25	72	90	72	105
5	M	1.3	-2.5	0.2	-4.5	-2.2	0.1	2.2	1.1	-1.0	-2.8	-3.1	0.6
	SD	9.3	4.8	8.3	3.5	3.8	4.3	3.9	2.6	2.0	4.1	6.3	4.8
	n	4	9	11	36	39	59	24	22	28	24	12	6
6	M	2.3	-1.2	-4.3	-1.3	-1.5	0.9	1.3	-0.2	-2.1	-3.7	-4.3	-3.1
	SD	10.5	9.1	7.9	6.7	6.3	4.1	2.7	3.4	1.8	2.6	6.0	10.1
	n	27	22	12	15	8	10	17	20	13	9	18	18
7	M	10.1	12.2	6.2	5.8	1.6	-1.3	-0.7	-0.7	1.3	2.9	10.5	15.6
	SD	11.9	0.0	2.2	3.2	1.0	3.1	1.9	1.9	1.7	4.4	1.1	3.1
	n	4	1	5	8	8	12	17	18	14	19	6	2
8	M	-8.4	-10.4	-8.6	-5.2	-1.4	-1.5	-1.2	0.5	-0.6	-2.3	-6.2	-6.2
	SD	4.5	8.5	6.4	4.7	2.1	3.8	2.9	2.1	1.6	3.2	5.2	5.1
	n	17	12	15	20	8	18	23	15	19	22	10	11
9	M	3.6	1.0	-1.0	-0.4	-2.4	0.2	2.1	0.7	0.0	-3.8	-1.2	2.1
	SD	6.5	9.4	9.4	6.4	4.7	2.7	2.7	1.9	1.9	5.3	4.6	9.3
	n	22	9	14	13	28	47	50	25	12	15	15	13
10	M	-4.5	-7.1	-0.4	-3.0	-2.2	-3.4	-2.8	-3.2	-2.3	-2.3	-1.7	0.9
	SD	6.6	8.8	6.3	3.6	3.0	2.4	2.8	2.4	1.6	4.3	6.4	5.1
	n	6	8	11	3	12	15	46	40	21	11	8	14
11	M	-2.4	-3.2	-4.5	-4.3	-2.5	-1.7	-1.7	-0.1	-0.7	-0.7	-1.3	0.6
	SD	6.9	8.2	10.9	7.2	3.6	2.1	2.5	2.4	2.8	4.1	4.4	8.3
	n	11	10	16	35	28	27	15	32	26	32	24	10

Table 8. continued

Chukchi Type		1	2	3	4	5	6	7	8	9	10	11	12
12	M	11.3	15.7	12.6	5.3	1.1	0.5	-0.1	-0.4	1.8	3.3	4.0	9.4
	SD	7.1	2.8	0.5	6.6	1.2	2.7	2.3	2.0	1.8	3.4	5.8	7.2
	n	15	4	4	12	15	11	58	37	14	12	12	3
13	M	-4.2	-4.9	-0.2	-3.3	1.8	2.4	4.0	2.5	0.8	-2.1	-3.7	-4.9
	SD	11.4	8.9	8.4	3.4	3.0	4.3	3.2	2.9	2.7	5.5	5.6	7.1
	n	8	28	28	13	37	35	13	22	28	15	10	16
14	M	1.2	-1.2	0.5	-1.0	1.4	0.6	-0.2	2.1	1.1	-3.3	-2.3	-2.3
	SD	9.9	12.0	7.3	7.2	4.1	3.3	1.2	3.6	2.5	5.9	6.9	6.6
	n	12	18	19	16	6	4	5	14	17	20	14	19
15	M	-1.9	-1.7	-6.4	-5.5	-8.2	-2.5	-2.3	-2.3	-2.2	-2.4	-2.1	-1.8
	SD	11.4	5.9	2.6	4.2	4.4	3.0	3.0	2.0	2.4	3.7	4.8	7.4
	n	2	3	4	12	8	21	26	27	20	26	7	6
16	M	-4.0	-8.5	-8.7	-8.1	-1.2	-1.9	1.7	-1.5	-0.2	-2.5	-10.6	-7.1
	SD	6.5	7.2	5.1	8.2	2.8	1.3	3.9	1.7	1.5	4.1	7.6	8.4
	n	21	13	24	7	4	5	2	4	9	7	7	16
17	M	4.7	3.7	6.6	2.1	-0.6	1.8	1.9	2.2	2.2	0.4	5.0	8.7
	SD	8.0	9.6	7.9	7.1	3.1	2.5	2.4	1.2	1.8	4.1	6.1	9.0
	n	15	7	13	15	16	26	16	21	7	14	16	7
18	M	11.1	5.0	15.0	-5.6	0.4	-2.4	-1.0	-1.7	-0.1	-1.7	-	-
	SD	.8	0.0	0.0	0.0	4.8	2.1	1.4	2.9	1.5	4.7	-	-
	n	2	1	1	1	3	7	4	7	4	4	-	-
19	M	-	-	4.4	-1.4	-4.3	-0.1	-1.0	-0.3	-2.1	-4.4	-5.6	-
	SD	-	-	0.0	3.6	5.1	4.1	2.5	1.9	1.5	3.0	0.0	-
	n	-	-	1	4	11	19	19	13	4	4	1	-
20	M	-6.7	10.0	7.8	3.2	2.2	-1.1	0.8	0.2	0.9	0.8	4.9	7.8
	SD	0.0	0.0	0.0	3.7	0.0	3.3	3.7	2.1	0.3	3.2	1.7	0.0
	n	1	1	1	5	1	7	5	3	3	7	4	1
21	M	-1.9	3.1	-6.6	-4.6	-1.8	0.1	-1.1	-1.3	-3.7	-5.1	-10.0	1.1
	SD	2.0	5.9	5.1	3.0	2.1	2.9	3.0	3.1	1.9	4.5	1.5	0.0
	n	2	2	6	9	4	12	11	12	8	7	3	1
22	M	-4.8	-11.7	-4.7	-6.5	-2.8	1.1	-	-1.7	0.8	-5.6	-8.7	-9.2
	SD	7.9	9.6	4.9	9.0	0.0	0.0	-	0.0	3.0	6.7	7.1	5.5
	n	10	10	15	4	1	1	-	1	5	6	4	15

M = mean departure (°C)
SD = standard deviation (°C)
n = no. of cases

Table 9.

Monthly Wind Direction at Kotzebue, 1955-1974, for Each Pressure Pattern Type

Chukchi Type	1	2	3	4	5	6	7	8	9	10	11	12
1	NE 75/46	NE 66/55	NE 63/68	NE/W 46/86	E/W 23/107	W/E 277/85	W/E! 122/127	E/W 66/94	E/NE! 73/53	NE 67/37	NE 71/35	NE 72/38
2	E 112/22	E 112/26	E 107/33	SE 117/28	SE!/W 142/82	W/SE 208/90	SE/W 199/90	SE! 133/67	E 116/56	E 105/22	E 104/14	E 108/31
3	SW/E/! 214/96	E 129/78	E/S! 150/84	S! 188/74	W/S 241/53	W 258/35	W/SW! 252/52	W/SW! 252/64	NW/SW 272/72	! 195/82	S! 166/71	E/W 108/92
4	N! 10/71	N/W 336/78	NE/W 336/84	NW/! 308/69	W/N 299/57	NW 284/46	W 276/49	W/N 325/49	N 11/41	N 28/39	NE/N! 22/43	NE/N! 28/62
5	W/NE 338/59	W/N 280/71	W! 256/72	W 286/56	W/NW! 286/65	W 282/41	W/NW! 304/70	W/N! 331/78	N! 350/67	E/NE! 57/54	NE/E 63/57	!/NW 318/86
6	E 98/33	E 89/39	E 82/62	E/S! 119/58	W/! 235/91	W/! 282/73	W 278/55	W/E! 106/127	E/W! 57/100	E/N 70/55	E 94/27	E 91/53
7	SE 153/27	S 180/0	W/SE 246/90	S! 165/47	SE 159/32	W/SE 236/68	S 202/45	S 176/60	W/SE 215/70	SE 155/42	S! 183/51	S 190/10
8	NE/N! 56/72	NW/! 280/76	W/E 312/87	NW 290/42	W 266/61	NW 294/20	W 282/56	NW 292/16	N! 336/66	N/E 27/64	E/NW 83/69	NW 325/43
9	E 109/19	E 114/16	E 106/35	E 119/56	SE/W 184/75	W 267/41	W/W! 276/60	SE/W! 217/87	SE/! 134/67	E 108/49	E 110/16	E 106/28
10	NW/E 315/85	W/E 250/80	NW 299/52	NW 310/14	NW 295/9	W 275/13	W 288/31	W 282/40	NW 303/40	W/W! 284/82	NW 319/66	NW 298/47
11	SE!/W 152/116	W/SE 258/72	E/W 194/115	W/! 248/64	W/SE 233/82	W 271/66	W/W! 274/42	W/SE 258/80	E/! 68/122	E/! 53/85	! 331/94	E/! 90/69

Table 9. continued

Key: upper line – observed modal wind direction
x/x indicates bimodality
x! indicates winds generally within 90° of x
! indicates no apparent modal direction
lower line – mean direction/standard deviation

Chukchi Type	1	2	3	4	5	6	7	8	9	10	11	12
12	SE! 152/46	SE 143/21	SE 145/15	S/E 161/42	S 187/28	S 184/56	S/SW! 207/50	S/W 205/52	S/SE 167/43	SE 155/39	SE 127/50	! 121/58
13	NE 74/21	NE 67/38	NE! 71/65	NW/E 1/71	NW/E 333/84	SW/NE 281/94	E/W/NE 25/85	E/N! 29/93	NE 67/42	NE 58/30	E 78/21	NE 72/25
14	E 89/25	E! 89/72	NE! 77/84	E 98/46	W/E 271/89	! 172/81	S! 200/71	!/SE 124/83	E 110/59	E 82/52	E! 73/49	NE 63/73
15	N/E 50/84	W/E 280/85	W 287/63	W 285/42	W 287/43	W 281/40	W 287/35	NW 299/47	NW 323/54	N 359/55	NW 344/28	! 14/113
16	NW/NW! 334/67	W/! 285/67	E!/W 46/104	W 286/26	W 257/21	W 288/11	W 285/5	NW 325/31	N 353/28	NE! 17/54	E 65/57	E 57/45
17	E 110/49	E 103/7	E 99/64	SE 123/50	E/W 203/155	W/S! 251/76	W/E! 260/96	SE 120/60	! 202/113	E 114/23	E 109/21	E/E! 96/57
18	NW/S 260/67	W 290/0	S 160/0	E 110/0	S! 219/58	W 262/48	S/W 225/61	W/S 259/47	! 230/93	E/W 167/89	– –	– –
19	– –	– –	SE 120/0	SE 165/59	W/S! 206/65	W 278/32	W 264/52	W 280/36	W/SE 240/95	E 93/13	E 90/0	– –
20	SE 140/0	W 290/0	– –	SW 224/63	S 160/0	W 269/39	S! 200/64	W/SE 252/72	W 269/50	SE/! 148/73	S! 178/56	W 250/0
21	N 20/20	NW 330/0	W! 289/56	N/W 322/41	NW 305/21	NW! 313/30	W/NW 299/40	N/W 327/37	N 355/9	N/NE 24/33	N 10/55	NW 340/0
22	E 94/56	NE 70/61	E 76/51	S! 220/70	– –	NW 330/0	– –	W 250/0	E/NW 40/54	NE 65/48	NE 63/8	E 55/59

Table 10. Season Precipitation - (mm) at Kotzebue, 1955-1974, for Each Pressure Pattern Type

Chukchi Type	(Nov-May) T(%1)/#(%2)	(June-July) T(%1)/#(%2)	(Aug) T(%1)/#(%2)	(Sept-Oct) T(%1)/#(%2)
1	384(33)/356(22)	115(12)/40(29)	181(18)/41(38)	204(20)/83(30)
2	239(20)/149(34)	105(11)/39(30)	142(14)/29(48)	151(15)/51(53)
3	53(5)/49(36)	147(15)/41(29)	51(5)/19(37)	52(5)/28(61)
4	83(7)/80(16)	2(0)/3(16)	11(1)/7(28)	28(3)/27(17)
5	23(2)/19(16)	20(2)/10(12)	33(3)/8(36)	8(1)/9(17)
6	16(1)/20(17)	18(2)/7(26)	41(4)/8(40)	9(1)/6(27)
7	30(3)/18(53)	56(6)/16(55)	55(5)/14(78)	83(8)/28(85)
8	11(1)/14(15)	6(1)/8(20)	3(0)/4(27)	16(2)/14(34)
9	24(2)/28(25)	60(6)/17(18)	39(4)/13(52)	28(3)/8(30)
10	14(1)/16(25)	33(3)/15(25)	110(11)/26(65)	31(3)/18(56)
11	49(4)/54(40)	55(6)/13(31)	52(5)/17(53)	61(6)/28(48)
12	63(5)/36(55)	151(15)/34(49)	158(16)/27(73)	88(9)/19(73)
13	25(2)/24(17)	17(2)/9(19)	1(0)/3(14)	38(4)/16(37)
14	31(3)/3(30)	23(2)/6(67)	18(2)/8(57)	39(4)/15(41)
15	10(1)/10(24)	39(4)/14(30)	9(1)/6(22)	41(4)/20(43)
16	2(0)/5(5)	0(0)/0(0)7	0(0)/0(0)4	3(0)/1(6)
17	17(1)/28(31)	25(3)/12(29)	31(3)/13(62)	21(2)/9(43)
18	10(1)/3(37)	5(0)/6(55)	5(1)/4(57)	13(1)/7(88)
19	1(0)/2(12)	14(1)/6(16)	11(1)/5(38)	8(1)/5(63)
20	14(1)/11(79)	3(0)/3(25)	9(1)/2(67)	11(1)/8(80)

Table 10 continued

Chukchi Type	(Nov-May) T(%1)/#(%2)	(June-July) T(%1)/#(%2)	(Aug) T(%1)/#(%2)	(Sept-Oct) T(%1)/#(%2)
21	2(0)/1(4)	1(0)/1(4)	4(0)/2(17)	1(0)/2(13)
22	1(0)/1(2)	0(0)/(0)1	0(0)/0(0)1	1(0)/2(18)

Key to Table 9.:

T - total precipitation (mm) with each type by "season"
%1 - percentage of "seasonal" precipitation accounted for by type
- total number of days with at least .01" precipitation this season
%2 - percent of seasonal precipitation days accounted for by type

Table 11. Monthly Mean Wind Speed (m s^{-1}) at Kotzebue, 1964-1974, for Each Pressure Pattern Type

Chukchi Type	1	2	3	4	5	6	7	8	9	10	11	12
1	5.0	4.6	5.0	4.1	3.8	4.2	3.1	4.5	5.1	6.4	6.3	4.4
2	10.7	9.3	8.7	8.2	4.4	4.2	4.5	5.1	5.7	9.8	10.0	9.7
3	5.9	5.7	2.2	3.9	3.4	4.1	4.5	4.0	4.4	6.4*	5.5	5.9
4	3.8	4.1	3.9	4.0	4.8	8.3*	6.8*	5.4	4.5	5.1	4.9	3.0
5	8.4*	4.4*	4.0	4.1	4.3	5.5	3.7	4.7	3.5	5.1	4.4	3.8*
6	6.3	4.4*	1.9*	4.8*	3.4*	1.4*	3.5*	4.8	3.8	3.3*	6.3	3.2
7	8.2*	-	6.6*	10.3*	5.5*	5.3*	5.0	4.7	7.8*	8.8	8.7	10.8*
8	3.9	3.4	5.7	6.9*	4.8*	6.4	6.6	5.7	2.7	4.8	6.2*	6.1*
9	6.0*	5.4*	4.4	3.5*	4.5	5.6	3.6	4.3	3.8	6.7	9.3	8.0
10	6.4*	7.4*	5.9	-	5.2	6.3	7.4	7.2V	7.7	2.5*	3.6*	5.7
11	5.7*	4.3*	4.9	5.2	4.8	5.8	4.8	3.8	4.7	5.0V	5.6	5.2*
12	9.6	5.2*	11.1*	8.1	6.7	2.8*	5.5	5.7	5.7	7.0	8.0	8.4*
13	2.0*	3.3	3.7	4.2*	2.7	3.5	3.1	4.1	4.2	5.2	5.4*	2.5
14	7.9*	6.4	2.5	5.8	3.6	3.2*	3.5*	4.2	6.2	5.2	4.4	4.6
15	3.5*	8.2*	10.7*	8.5*	7.0	7.2	6.0	8.2	6.7	5.8V	4.8*	3.7*
16	3.7	2.6*	3.4	3.5*	4.7	3.7*	3.7*	5.3*	5.0	4.9*	7.8*	3.2*
17	5.5	6.2*	6.5*	9.4*	3.0	4.8	3.6	4.5	5.2*	7.3	8.2	7.8
18	.7*	3.0*	-	10.0*	-	3.4*	-	5.6*	6.3*	10.2*	-	-
19	-	-	6.8*	3.0*	3.5	5.0	4.8	5.5*	4.5*	4.9*	4.7*	-
20	-	-	-	7.7*	4.2*	5.1	-	-	2.8*	7.0*	4.8*	-
21	3.7*	4.3*	4.5*	7.6*	5.3*	7.5	5.3	5.2	7.7*	4.6*	-	7.3*
22	3.3*	2.6*	3.7	-	-	1.1*	-	-	3.8*	4.4*	-	3.9

* denotes less than 5 cases

Table 12. Mean Monthly Sky Cover Values at Kotzebue, 1955-1974, for Each Pressure Pattern Type

Chukchi Type		(Month) 1	2	3	4	5	6	7	8	9	10	11	12
1	M	6.6	6.8	6.2	6.9	6.4	6.8	7.6	7.9	7.5	6.2	7.2	6.8
	SD	3.1	3.2	3.2	2.8	3.1	2.8	2.6	2.4	2.8	3.3	2.8	3.1
2	M	8.2	8.1	7.3	8.0	7.2	7.5	7.9	8.1	8.7	8.4	7.8	7.7
	SD	2.2	2.4	3.3	2.4	2.7	2.5	2.5	2.3	1.9	2.3	2.6	2.8
3	M	6.8	8.6	6.6	7.1	8.8	6.2	7.9	8.1	8.7	9.0	7.1	7.3
	SD	2.2	2.1	2.8	2.9	2.0	2.8	2.4	2.4	1.4	1.2	2.1	3.1
4	M	5.0	5.4	5.8	5.2	6.3	6.4	9.2	6.8	6.6	6.6	5.3	5.0
	SD	3.2	3.3	3.2	3.0	3.4	2.6	1.2	2.7	2.9	2.9	3.3	3.2
5	M	5.3	8.5	6.4	5.5	5.8	5.8	5.5	8.2	5.8	7.4	6.3	7.8
	SD	2.3	1.6	3.3	2.7	3.1	3.1	3.2	3.0	3.4	2.6	3.7	2.6
6	M	7.1	6.5	6.0	6.4	8.1	8.0	6.8	8.5	6.7	6.8	6.0	5.6
	SD	2.8	3.2	3.0	3.1	1.2	1.6	2.9	2.7	3.9	2.9	2.9	3.2
7	M	6.0	10.0	9.4	9.4	9.3	8.4	9.5	9.8	9.8	8.8	9.5	6.5
	SD	3.8	0	0.5	0.9	1.0	1.9	0.9	0.5	0.6	1.3	0.5	2.1
8	M	3.3	3.9	3.3	4.1	6.6	4.9	7.3	7.4	6.4	7.0	7.0	4.7
	SD	2.9	3.8	1.8	2.3	2.7	2.5	2.1	2.9	3.0	3.6	2.9	2.1
9	M	7.6	6.1	6.3	7.0	6.6	6.4	6.8	7.6	6.8	7.8	8.6	8.4
	SD	2.5	3.3	2.2	3.1	3.0	2.8	2.5	2.9	2.4	2.3	2.0	2.1
10	M	4.2	5.1	6.0	8.3	7.7	6.6	7.5	8.8	7.8	8.4	5.9	6.0
	SD	1.9	3.3	3.1	0.6	2.0	2.5	2.6	1.8	2.4	2.1	2.6	1.7
11	M	6.9	7.8	6.8	7.3	7.3	7.7	8.7	8.9	8.1	8.2	8.5	7.4
	SD	3.0	2.4	2.7	2.5	2.9	2.3	2.4	1.5	2.2	2.4	2.2	2.8
12	M	9.2	9.8	7.0	8.5	9.5	8.5	9.0	9.4	9.4	9.6	8.0	6.7
	SD	1.6	0.5	2.6	1.8	0.9	2.1	1.3	1.0	2.1	0.7	2.2	4.9
13	M	6.5	5.4	6.8	4.8	6.2	7.1	5.9	6.5	6.5	7.2	6.0	4.5
	SD	2.9	3.6	3.2	2.8	3.1	2.7	2.7	3.2	2.8	3.3	3.9	2.8
14	M	6.3	6.6	7.2	7.4	6.5	7.0	9.6	7.6	9.5	6.9	7.2	5.9
	SD	3.2	3.3	2.7	2.9	1.5	3.6	0.5	2.8	0.9	2.5	2.7	2.8

Table 12. continued

Chukchi Type		(Month) 1	2	3	4	5	6	7	8	9	10	11	12
15	M	6.0	8.3	4.8	7.1	5.4	7.3	8.1	6.8	7.3	6.3	4.4	8.6
	SD	1.4	1.5	2.5	2.8	3.5	2.4	1.9	2.5	2.8	2.9	2.8	1.7
16	M	4.1	4.1	2.4	4.2	2.3	6.5	7.0	2.0	3.6	4.9	5.1	4.2
	SD	3.2	3.7	2.2	3.2	2.3	3.0	1.4	1.4	2.2	2.8	3.2	2.8
17	M	6.6	5.8	7.8	9.1	7.1	7.3	7.4	8.7	8.6	7.7	8.1	8.0
	SD	3.2	3.3	2.5	1.0	3.0	2.5	2.8	1.9	1.0	2.0	2.7	2.3
18	M	8.5	6.0	10.0	6.0	9.0	9.3	7.5	9.1	8.8	9.0	-	-
	SD	2.1	0	0	0	1.7	1.6	2.4	1.6	2.5	0.8	-	-
19	M	-	-	10.0	5.5	7.0	7.1	7.9	7.5	8.8	5.5	9.0	-
	SD	-	-	0	3.9	3.1	2.2	2.4	2.8	1.3	3.0	0	-
20	M	5.0	7.0	-	9.2	10.0	6.4	8.5	9.3	9.7	8.7	7.5	10.0
	SD	0	0	-	1.8	0	4.1	1.3	0.6	0.6	1.1	1.7	0
21	M	4.0	5.0	3.5	2.6	5.8	4.7	6.0	5.8	2.3	5.8	4.5	-
	SD	2.8	0	2.4	3.3	3.7	1.2	3.1	2.6	1.5	4.0	2.1	-
22	M	4.5	3.4	3.2	3.8	-	4.0	-	10.0	5.2	7.0	2.5	3.5
	SD	1.4	2.6	2.6	3.0	-	0	-	0	3.7	3.7	0.7	3.1

Key:

M - mean value
SD - standard deviation

Table 13. Mean Dewpoint Depression (°C) at Kotzebue, 1954–1974, for Each Pressure Pattern Type

Chukchi Type	(Month) 1	2	3	4	5	6	7	8	9	10	11	12
1	5.2	4.2	4.5	3.5	4.2	3.9	5.0	4.4	4.1	3.2	3.5	4.0
2	3.6	2.6	3.6	2.2	3.5	3.9	4.5	3.4	2.3	1.9	3.1	2.4
3	4.1	3.3	2.4	2.0	2.1	3.3	3.6	2.8	2.8	1.7	2.0	3.0
4	5.0	5.1	3.7	4.2	2.2	2.4	3.1	3.3	3.9	3.4	4.0	4.2
5	5.6	4.5	3.9	4.4	2.7	3.4	6.0	2.6	3.4	2.8	3.5	6.1
6	3.7	2.7	5.0	3.9	2.0	4.1	2.2	2.8	3.5	3.6	4.1	3.0
7	2.4	-	3.1	1.5	3.9	2.2	3.2	3.1	2.2	1.7	1.0	1.7
8	5.0	4.9	4.0	3.7	1.7	2.6	4.1	2.8	3.0	2.9	3.6	4.4
9	2.5	4.6	3.1	3.4	2.4	3.4	4.9	2.6	3.6	3.1	3.2	5.3
10	5.3	3.8	3.1	2.9	2.0	2.1	3.2	2.8	3.3	3.1	3.6	2.5
11	4.2	5.8	3.2	2.4	1.9	3.0	2.4	3.2	3.0	1.8	2.9	3.2
12	1.9	1.1	2.8	1.4	1.3	3.9	3.2	2.9	1.7	1.3	2.2	4.4
13	3.1	3.9	4.2	4.6	3.0	5.2	5.5	4.9	4.8	2.7	3.6	6.0
14	4.6	3.0	4.1	1.8	2.4	4.7	2.0	3.8	2.7	3.1	3.0	4.4
15	6.1	3.9	4.4	2.3	2.5	3.3	2.0	3.6	3.8	2.5	2.5	4.4
16	4.2	4.7	4.7	2.8	1.9	1.7	7.2	4.0	3.2	3.1	3.3	5.3
17	3.7	3.1	3.3	2.8	3.1	3.8	4.2	2.5	3.1	2.8	2.9	1.7
18	-	2.8	-	3.7	-	2.2	-	2.4	1.9	2.2	-	-
19	-	-	2.2	6.7	2.6	3.8	3.8	2.8	2.5	1.7	5.6	-
20	-	-	-	2.8	1.1	2.6	-	-	2.2	1.5	1.9	-
21	5.6	3.6	5.3	3.3	3.0	5.6	5.2	4.2	3.9	3.3	-	5.0
22	5.0	3.1	5.2	3.3	-	7.8	-	-	2.8	3.7	-	6.5

Table 14. Mean Temperature Departure from Average at Kotzebue, 1955-1974, for Each Wind Direction

Month	(NW & N)	(NE)	(E)	(SE)	(S)	(SW)	(W)
1	-3.1	-1.9	1.9	9.0	12.4	10.5	.4
2	-3.0	-4.5	0.8	5.0	1.6	-4.2	-3.7
3	-1.3	-0.7	2.6	3.3	5.2	-5.0	-2.6
4	-2.4	0.3	1.7	2.2	3.1	-4.2	-4.1
5	-0.4	4.4	3.8	0.6	0.6	-0.8	-1.8
6	0.9	7.1	3.6	2.7	1.1	0.3	-1.3
7	0.3	6.2	3.6	1.7	0.6	0.8	-0.8
8	-0.6	1.8	2.2	1.6	0.5	0.5	-0.5
9	-1.3	0.4	1.1	2.7	1.6	0.2	1.7
10	-2.7	-3.5	-2.4	2.8	4.1	3.4	1.5
11	-1.7	-3.7	-0.7	5.4	6.2	6.9	2.0
12	-2.4	-3.4	0.4	10.0	12.8	4.4	1.9

Table 15. Sky Cover Amount and Associated Mean Temperature Departure from Average by Month at Kotzebue, 1955-1974

Month		Sky Cover Amount 1	2	3	4	5	6	7	8	9	10
J	1	-5.5	-3.6	-4.0	-2.0	.2	-.9	4.1	6.3	7.7	9.5
F	2	-7.4	-8.7	-4.9	-2.1	.2	-4.9	-.1	2.4	4.5	8.1
M	3	-4.8	-3.5	-2.9	-1.6	-.6	-1.5	.2	2.6	6.4	8.4
A	4	-4.7	-5.9	-4.4	-3.5	-3.8	-2.6	-1.5	1.1	3.2	4.1
M	5	-.8	.6	-.1	.7	.6	-.2	-.1	.7	.8	1.0
J	6	2.6	1.5	.8	.4	-.7	-.3	-.4	.1	-.1	-.6
J	7	3.1	.8	.9	1.4	1.6	.7	1.0	.7	.3	-.7
A	8	1.2	.6	1.5	.2	-1.1	.8	.5	1.3	.6	.0
S	9	-1.1	-.4	-1.1	.3	-.1	-.2	.0	.4	.4	1.1
O	10	-6.0	-5.6	-3.9	-4.0	-2.1	-2.2	-3.0	-1.5	.9	1.3
N	11	-7.4	-6.4	-4.6	-2.8	-2.3	-2.0	.2	1.4	3.3	3.3
D	12	-7.0	-5.0	-4.3	-1.4	-1.7	-.6	2.4	3.8	7.7	9.2

FIGURES

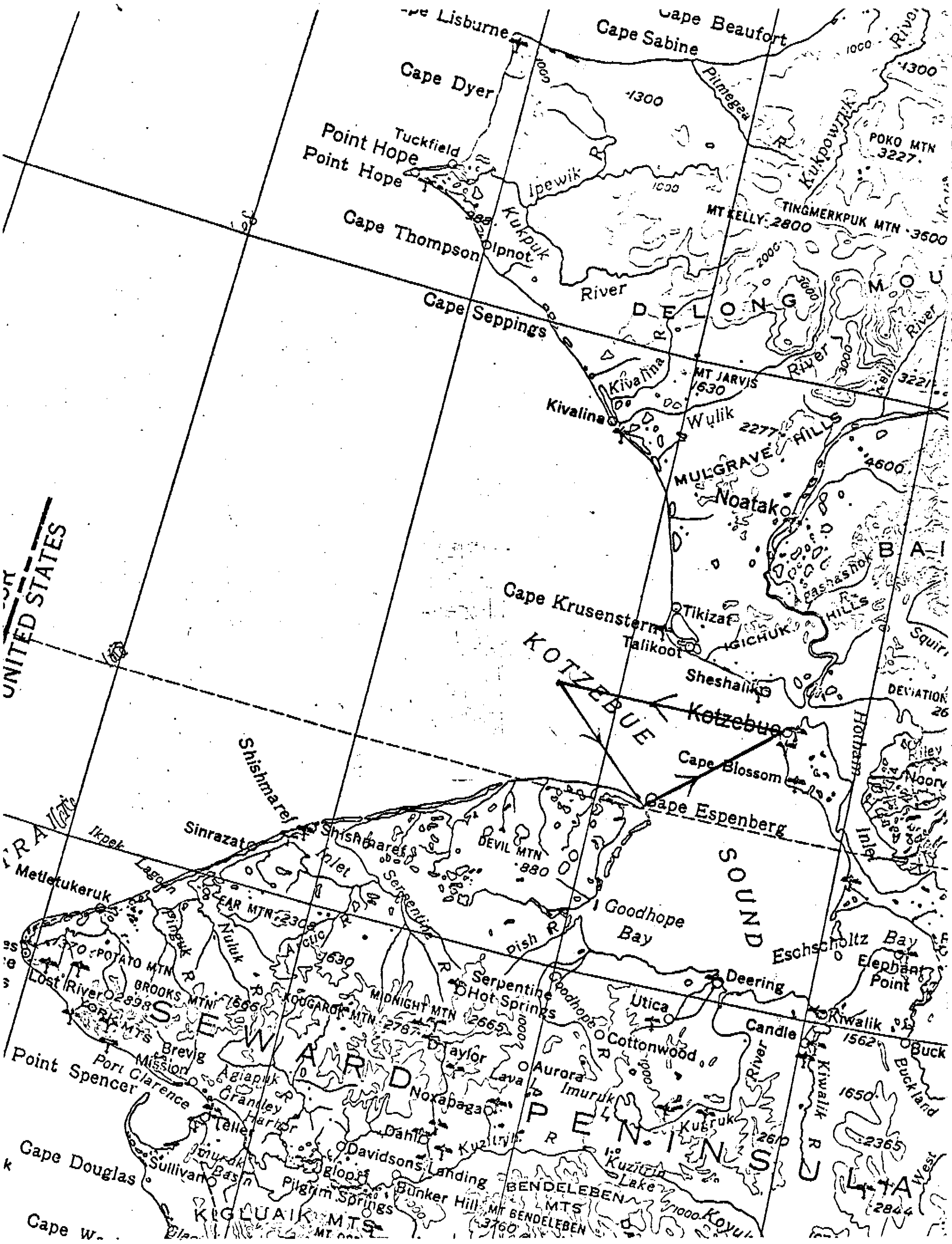


Figure 1. Chukchi Sea coast. Flight transect in Kotzebue area (1977).

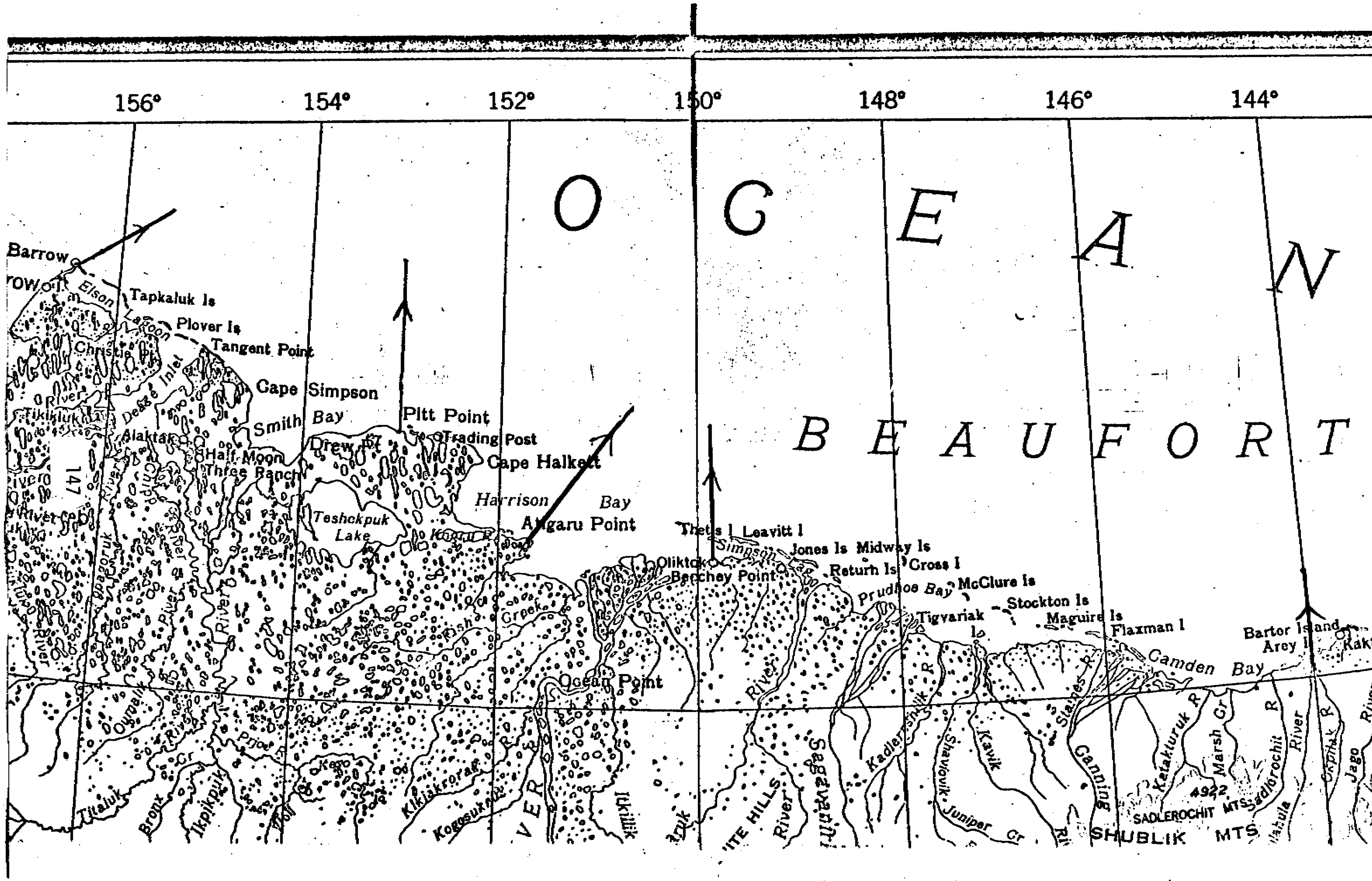
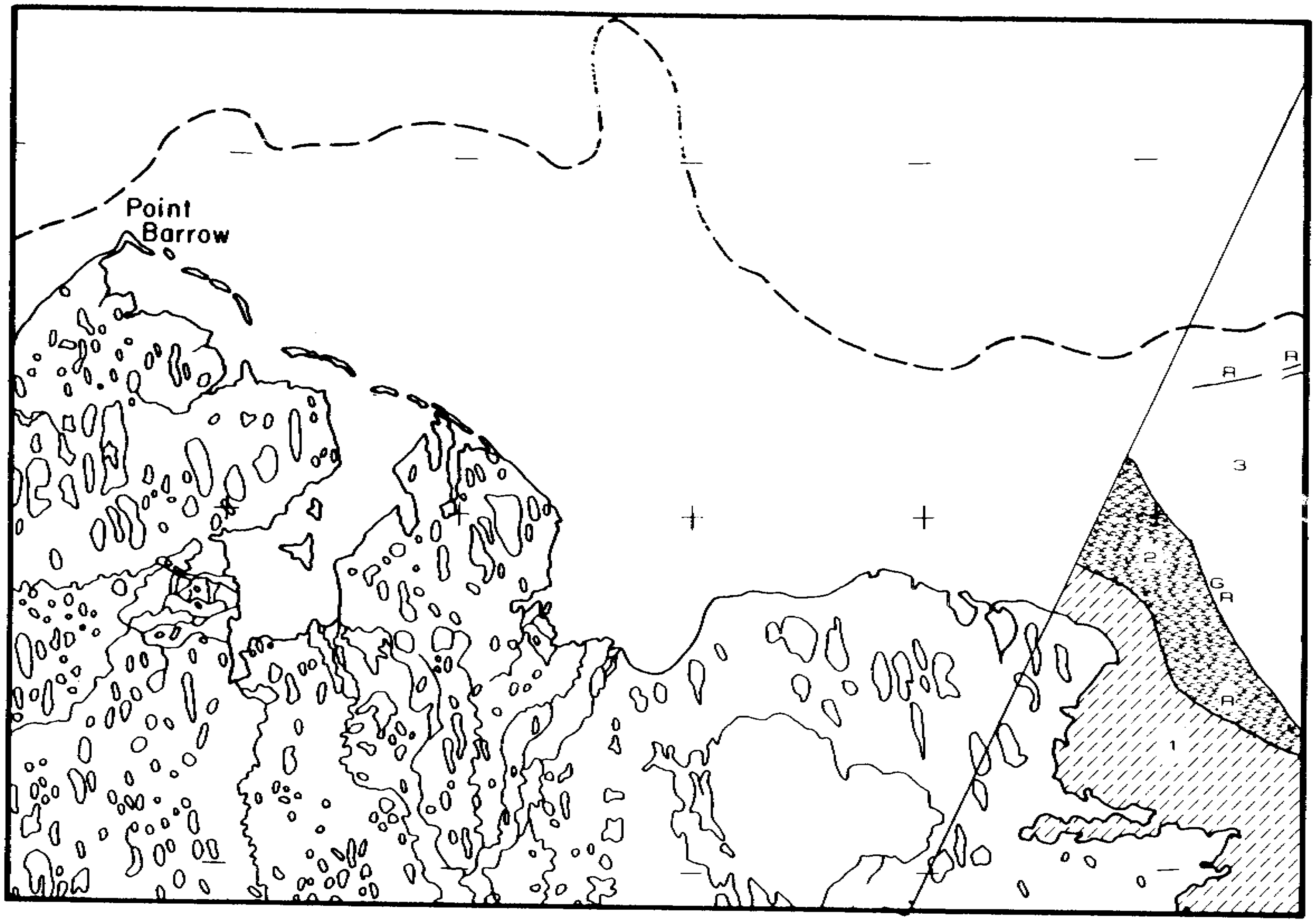


Figure 2. Beaufort Sea coast. Flight transects (1977).

Figure 3

16 March 1973: Scene 1236-21292

This is a late winter scene of the Harrison Bay area in which several zones of ice and some ridging can be seen. A zone of light toned, relatively smooth-looking ice (1) with no major deformational features extends along the coast in a band approximately 10 to 25 km wide. The seaward boundary of this zone is quite distinct, possibly due to ridging (R) along a former continuous ice edge. Zone 2 appears to be gradational between zones 1 and 3. It is generally darker in tone than zone 1 but appears more uniform than zone 3: An extensively ridged or hummocked zone (GR), possibly grounded, forms the seaward edge of this zone. The pack ice (3) is well consolidated with no apparent open water. The ice in outer Harrison Bay is composed of giant or larger sized floe elements in a darker matrix. There appears to be some ridging (R) in this zone.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

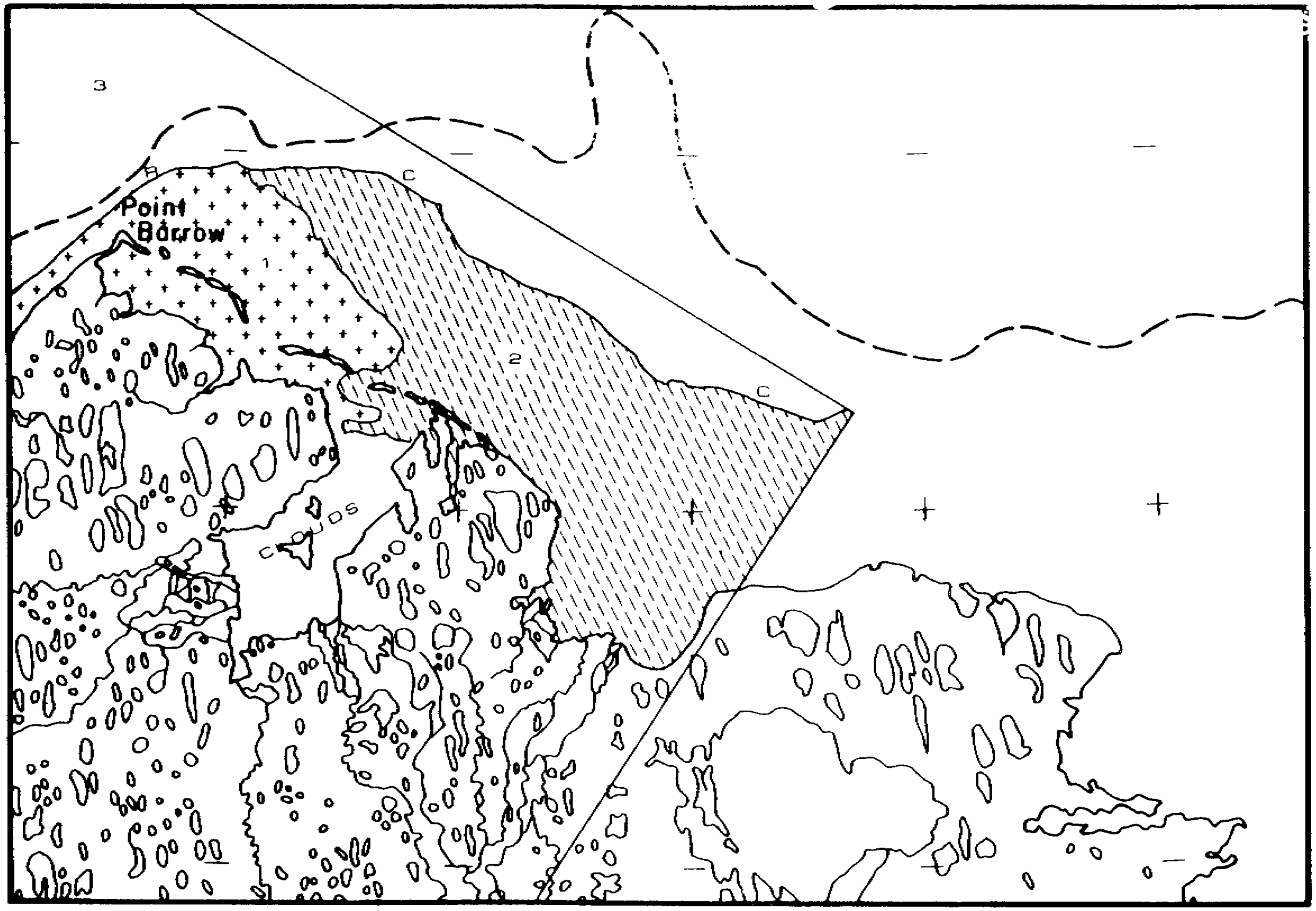
BEAUFORT SEA COAST: BARROW SECTOR

16 MARCH, 1973

Figure 4

14 May 1973: Scene 1295-21575

This early spring scene covers the area from Pt. Barrow to Smith Bay. The continuous ice edge (c) is very distinct on this date and coincides closely with the continuous ice edge of 23 March. There appears to be ridging (R) along the boundary, especially to the west and northwest of Pt. Barrow. The pack ice (3) is not consolidated. Floes (small to giant size) are in approximately 7/10 concentration. There appears to be two different grey tones in the fast ice, a lighter tone (1) in the western part and a darker tone (3) in the eastern part. No major deformational features can be seen in the continuous ice zone, although this may be partly due to obstruction by clouds.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

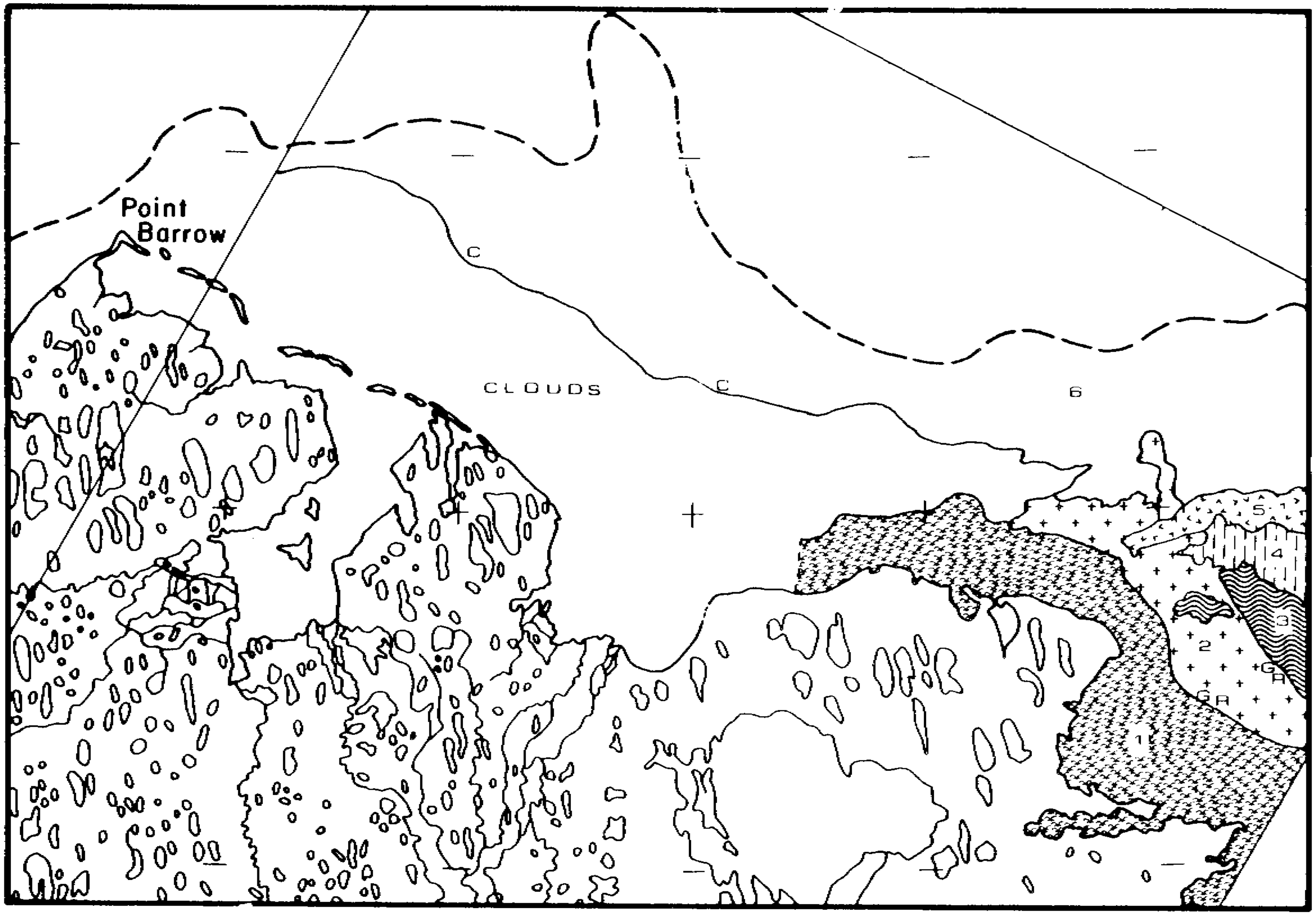
BEAUFORT SEA COAST: BARROW SECTOR

14 MAY, 1973

Figure 5

30 May 1973: Scene 1311-21461

In this spring scene, puddling has just begun. Cloud obstructs much of the ice, most notably over the western half of the continuous ice. Therefore mapping of grey tones in the continuous ice could not be accomplished in this area. The continuous ice edge (c) seems quite well defined in the western half of the frame, but is somewhat uncertain in the eastern half. The darkest, most puddled zone (3) is located in outer Harrison Bay. There are also many small light areas within this zone. The near shore ice (1) is the next most puddled, followed by zones 5 and 4, respectively. Zone 2 has the lightest tone, probably because puddling has not progressed very far. This zone is bounded by ridges (GR) in the eastern part of the frame. Both the shoreward and seaward ridges have been present and stationary since 16 March. The pack ice (6) is quite well consolidated (approximately 9/10 concentration).



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

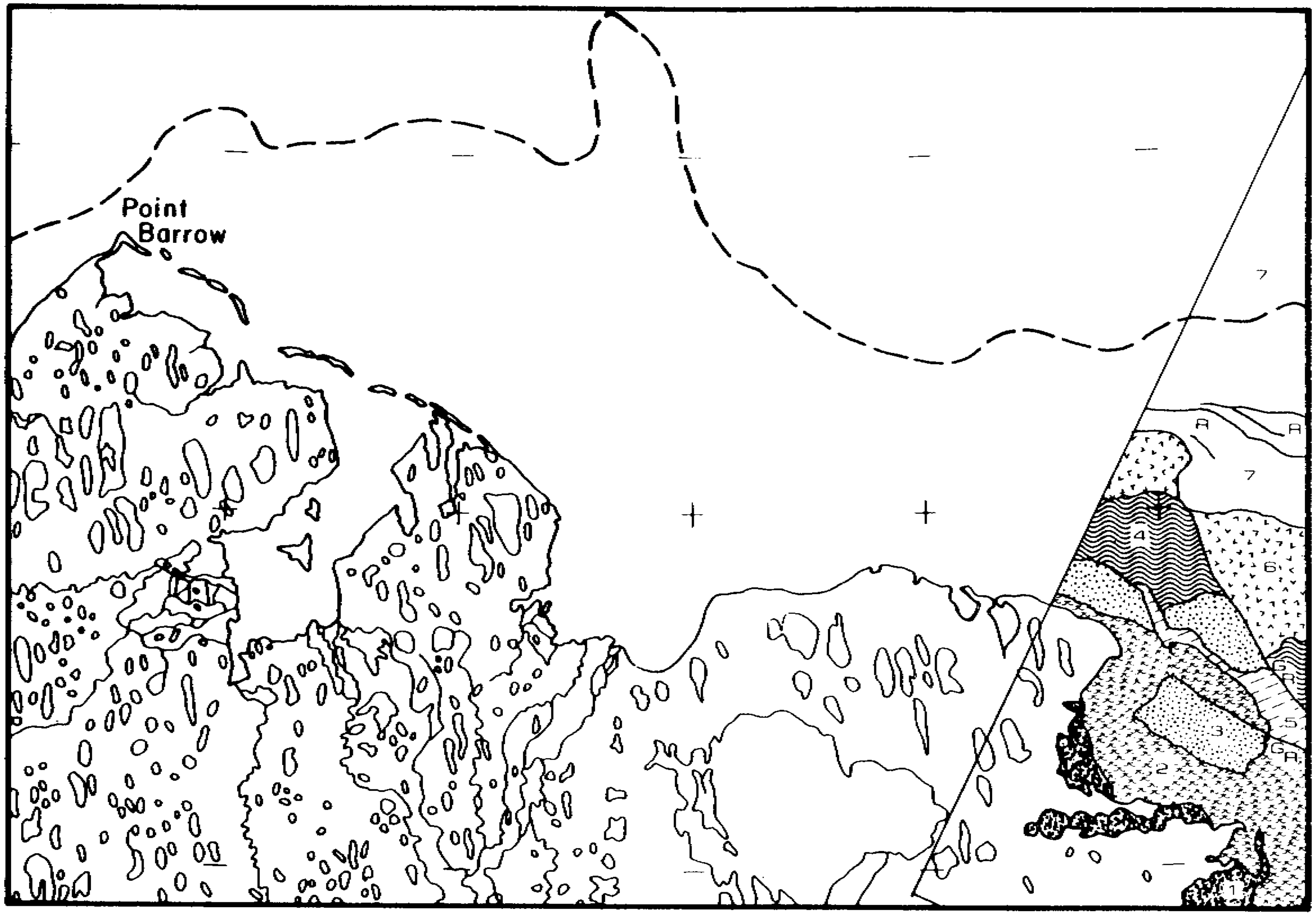
BEAUFORT SEA COAST: BARROW SECTOR

30 MAY, 1973

Figure 6

14 June 1973: Scene 1326-21284

In this late spring scene, the continuous ice edge is difficult to distinguish. There is much variation in the tone of the ice due to surface meltwater and roughness differences. The pack ice (7) is quite well consolidated, with little if any open water. Some ridging (R) is present in the shoreward part of the zone. In some places along the coast (1) the ice has either melted out or has been flooded by meltwater. The nearshore ice (2) does not appear deformed. There appears to be extensive puddling in this zone in varying stages. Since this zone appears light in band 4, the puddling is probably not very deep. Drainage has occurred in several areas in zone 2, and drainage cracks are present in interior Harrison Bay. The remainder of the continuous ice appears to contain many deformational features. Mapping in this area was based on differential grey tones. Without additional types of imagery (SLAR, CIR) detailed interpretation of roughness and age characteristics cannot be accurately accomplished. Zone 4 appears darkest in all bands, so is probably most heavily puddled. There are also some light areas within zone 4. Zones 3 and 6 are composed of mottled light and dark tones and are probably in various stages of puddling. Overall, zone 3 appears darker than zone 6. Zone 5, lightest toned in all bands, is possibly ice that has drained. This zone is bounded by ridges (GR) that have been stationary since 16 March.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

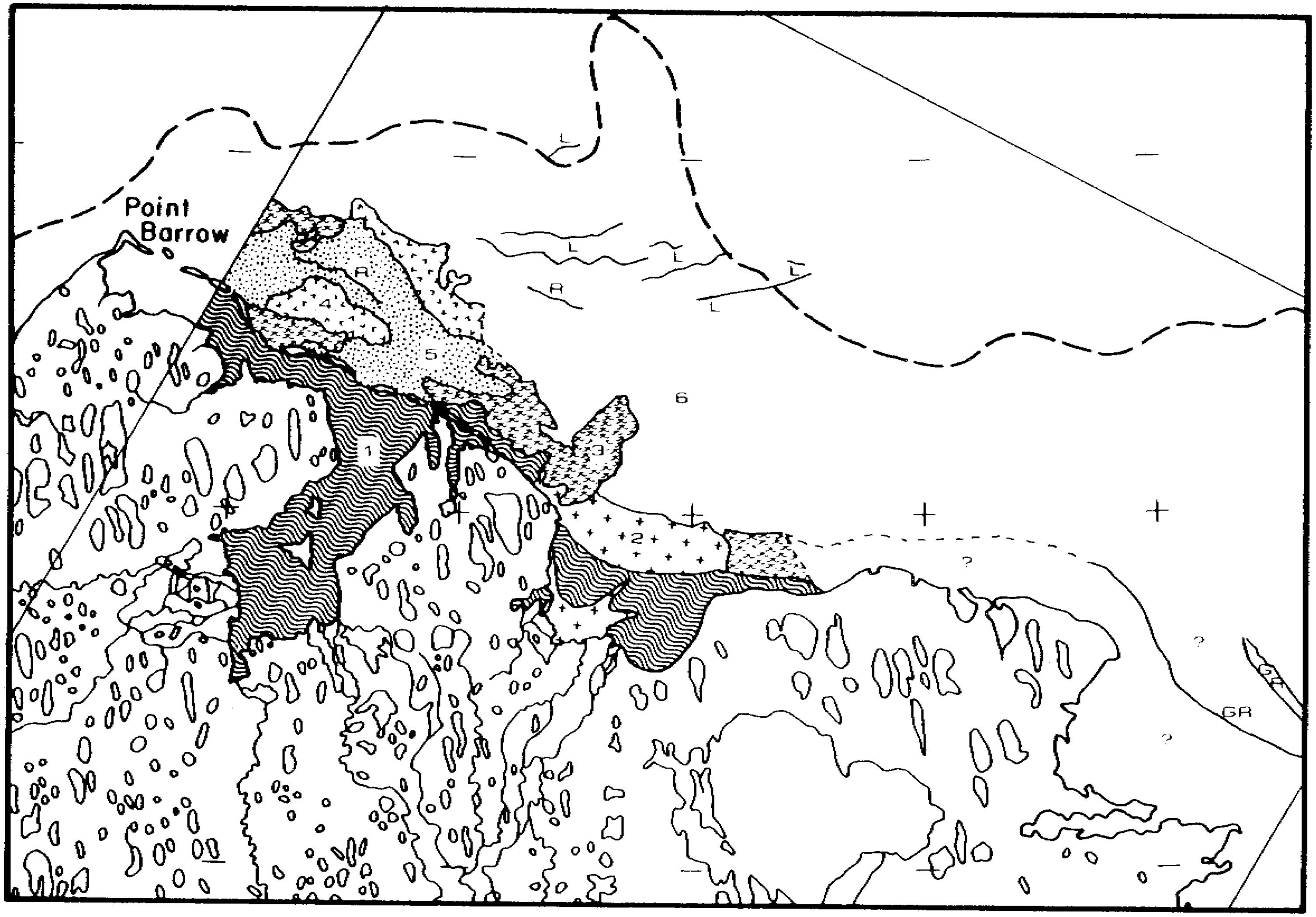
BEAUFORT SEA COAST: BARROW SECTOR

14 JUNE, 1973

Figure 7

17 June 1973: Scene 1329-21455

In this late spring scene there is very little open water although puddling and melting of the ice has progressed. Clouds cover much of the ice, especially from Smith Bay eastward, but mapping of significant large features was still possible. Question marks on the map indicate areas where mapping of grey tones was not possible due to clouds, and dashed lines indicate boundaries that are uncertain due to cloud obstruction. Zone 1, which includes most of the nearshore ice, is the most heavily puddled. There appears to have been melting or flooding of the ice adjacent to the coast in several places, but there is little, if any, open water in this zone. Light lineations, possibly drainage or tension cracks, are present in Admiralty and Smith Bays and some drainage may have occurred. The next most heavily puddled ice is in zone 3, which contains mottled light and dark tones with the darker tones predominating. Zones 4 and 5 are less puddled than zone 3. Zone 4 is a fairly uniform tone, in which puddling is at an early stage, while zone 5 is characterized by a lighter tone and somewhat rough-looking texture. There may be a ridge (R) in this zone. Puddling may be inhibited by deformational features in these two zones. The lightest toned ice (2) is located close to shore. The lack of water on the ice appears to be due to drainage. The continuous ice edge is not apparent on this frame. The pack ice (6) is quite consolidated with the exception of several areas of leads (L). There is a possibly ridge (R) shoreward of the leads. The ridges (GR) in outer Harrison Bay have remained stationary since 16 March.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

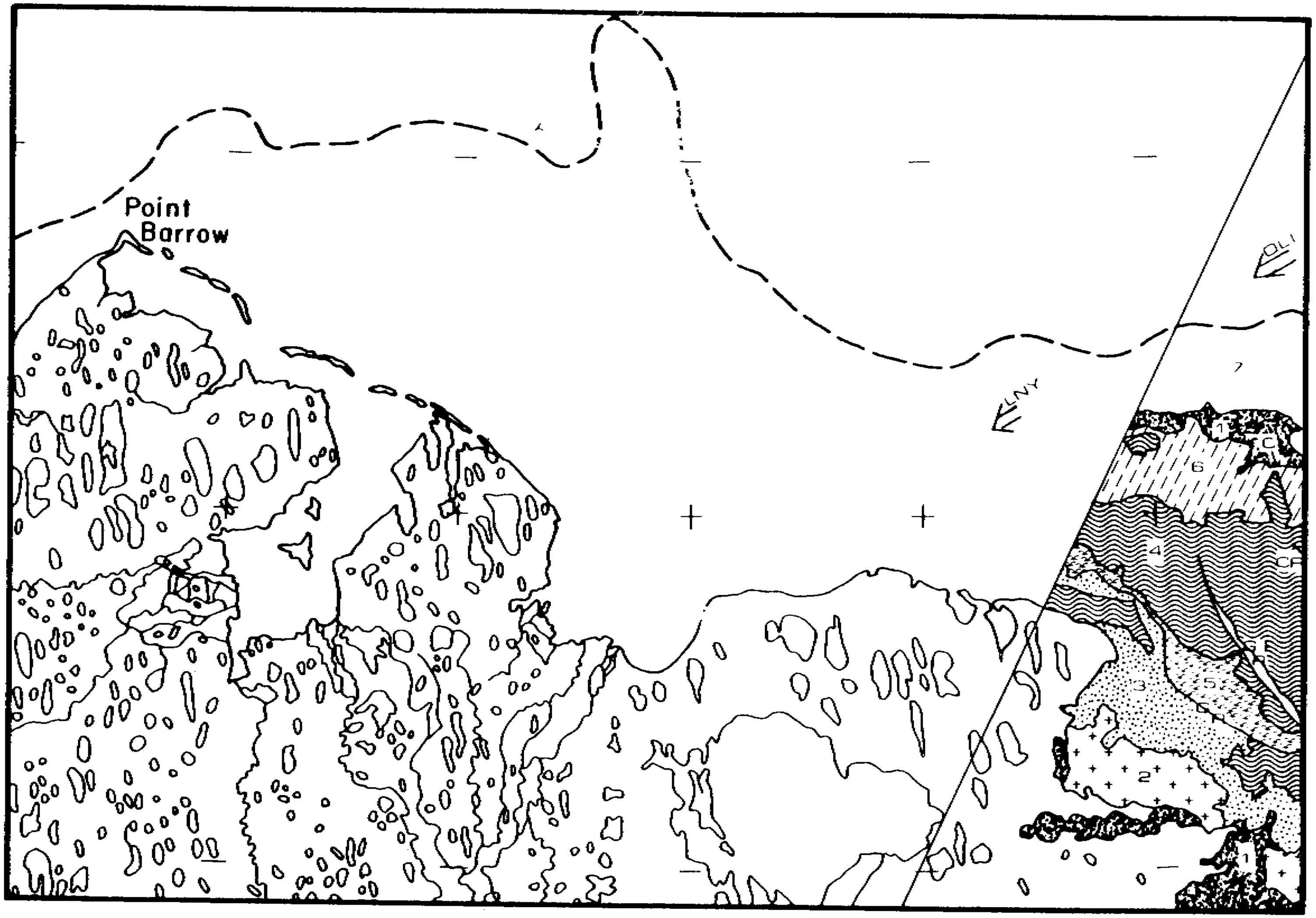
BEAUFORT SEA COAST: BARROW SECTOR

17 JUNE, 1973

Figure 8

2 July 1973: Scene 1344-21283

In this early summer scene the character of the ice has changed greatly. There is much more open water present, due to melting, flooding of ice, and movements in the pack ice. The continuous ice boundary is marked by a band of open water (1) located west of a grounded ridge system (located in the Prudhoe Bay sector of the frame). The pack ice is fracturing and moving westward and the continuous ice appears to be melting. No movements in the continuous ice could be detected since 14 June. Winds, shown by double arrows on the map, were from the ENE on 1 July for Oliktok (OLI) and Lonely (LNY) at magnitudes of 5.4 m/sec and 4.0 m/sec, respectively. There is a great deal of variation in the amount of surface meltwater throughout the continuous ice zone. Zones were mapped within this area based on similar grey tones. Areas of open water (1) are present along the coast and include small amounts of ice. Much of the nearshore smooth ice (2) has drained since 14 June. Zone 4 appears to be the darkest, most heavily puddled ice, although there are many light areas within this zone. There are some cracks in the ice (CR) on the eastern edge of the zone. Some of this ice may be older than first year, but this distinction cannot be accurately made without SLAR and CIR imagery. Zone 3 is also quite dark, however there are a larger number of light areas within this zone than in zone 4. Zone 6 is also composed of mottled tones, however the light tones predominate. Zone 5 is quite uniformly light toned ice which has drained since 14 June. Two ridge systems (GR) are mapped, the seaward system being more extensive. Both have been present and stationary since 16 March.



2 JULY 1973

SHOREFAST SEA ICE

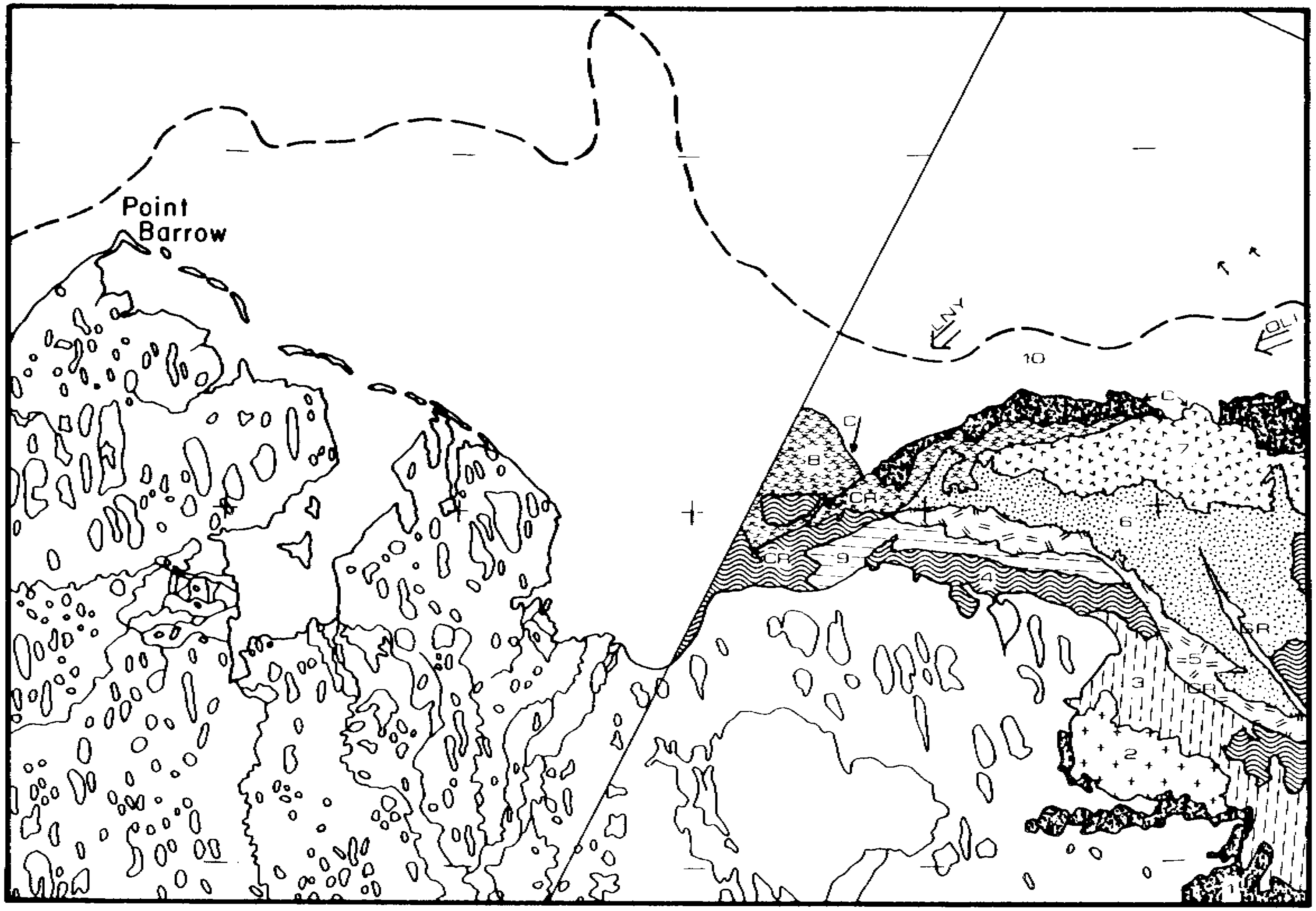
SURFACE MORPHOLOGICAL CHARACTERISTICS

BEAUFORT SEA COAST: BARROW SECTOR

Figure 9

3 July 1973: Scene 1345-21342

This is an early summer scene covering the area from Harrison Bay to the eastern edge of Smith Bay. There have been some small movements (approximately 2 km), shown by arrows on the map, in the pack ice (10) since 2 July. Winds, shown by double arrows on the map, on 2 July at Lonely (LNY) and Oliktok (OLI) were from the ENE and East at 4.5 m/sec and 4.9 m/sec, respectively. The continuous ice boundary (c) is quite readily defined. There are many different zones present in the continuous ice. Zone 1 consists of open water and small amounts of ice in several places along the coast and along the continuous ice edge. Smooth-looking, drained ice (2) is located in Harrison Bay. Zone 5 also appears to be drained ice, but not as smooth-looking as that in zone 2. Shoreward of the edge of the continuous ice is ice of very light tone (7). Although the ice is not of a completely uniform tone, it has probably drained, at least in part. There may be some ice that is older than first year in this zone, but it is very difficult to distinguish without additional types of imagery. Zones 3, 6, 8, and 9 are in intermediate stages of puddling. They all consist of mottled light and dark tones. Zones 3 and 6 are quite similar, but zone 6 appears darker overall. Zone 8 is a more uniform medium grey tone with smaller areas of light and dark tone. Zone 9 is lighter overall than the other intermediate zones. It appears intermediate in position and puddling characteristics between zones 4 and 5. The most heavily puddled zone (4) is located next to the coast west of Harrison Bay. It consists of a relatively uniform, dark tone. Two ridge systems (GR) that have been present and stationary since 16 March are mapped. A large crack (CR) is present in the western part of the frame, extending across zone 8 and along the zone 8/zone 4 boundary.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

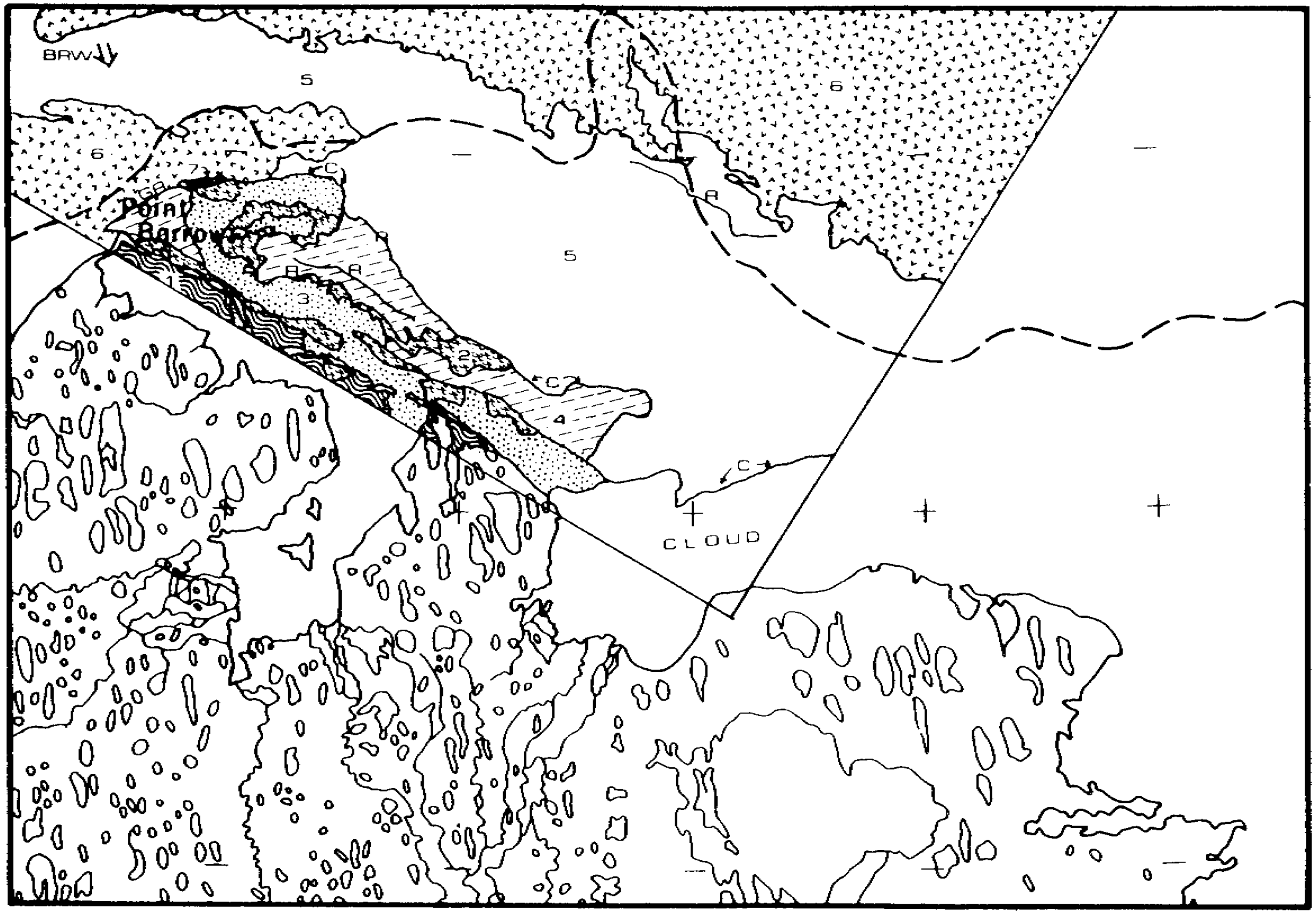
BEAUFORT SEA COAST: BARROW SECTOR

3 JULY, 1973

Figure 10

7 July 1973: Scene 1349-21564

In this summer scene, covering the area from Pt. Barrow to western Smith Bay, the ice is still quite continuous. There are some areas of open water (7) in the pack ice just outside the continuous ice edge (c). Winds for 6 July at Barrow (BRW) were 2.4 m/sec from the NNW. Pack ice movements on this frame cannot be measured, however, due to a lack of earlier summer coverage in this area. Two zones are present in the pack ice: zone 5 is the darker, apparently more puddled zone, while zone 6 is lighter in tone. There appears to be a ridge (R) present in zone 5 approximately 55 km seaward of Smith Bay. The area from the coastline to approximately 4 km shoreward of the barrier islands is not covered by this frame and clouds obstruct the view of the ice seaward of Smith Bay. Therefore, a limited amount of the continuous ice is shown. There appears to be heavy puddling or flooding in zone 1, but very little open water. Zone 2 is also quite puddled, appearing relatively dark in all bands. There are some light areas in this zone as well. The lightest toned ice (3) has probably drained by this date. Zone 4 is characterized by a mottled tone, but overall appears quite light. There are several ridge systems (R) in this zone. These ridges may be grounded, since they have been stationary since 17 June. Possibly some older ice is present in this zone, however this cannot be determined without using other types of imagery. Northwest of Pt. Barrow, along the northwest boundary of zone 4, is a larger ridge system (GR), possibly grounded. It appears to coincide with the 14 May and 23 March continuous ice edges.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

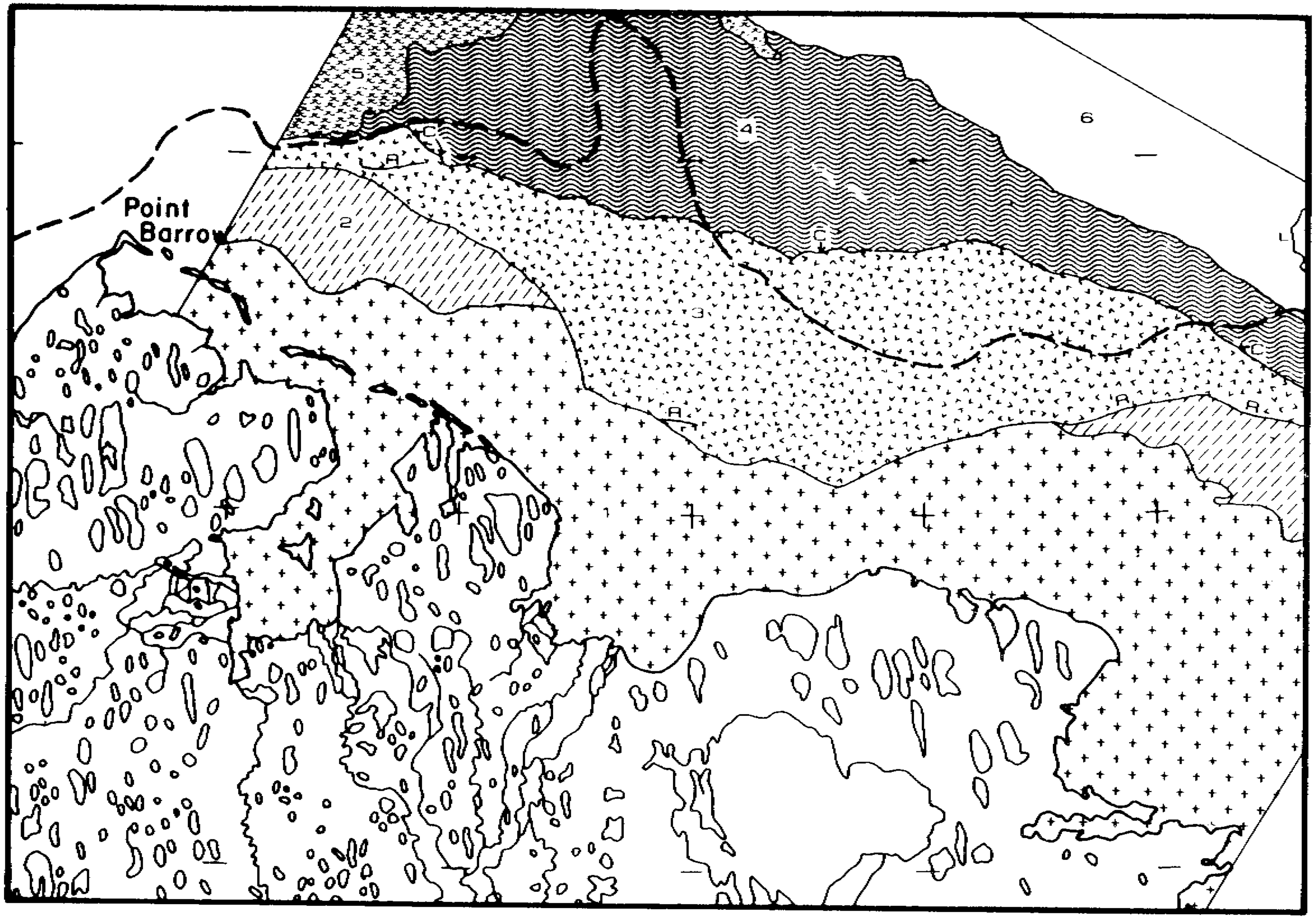
BEAUFORT SEA COAST: BARROW SECTOR

7 JULY, 1973

Figure 11

9 March 1975: Scene E-1959-21284

In this winter scene, the continuous ice edge (C) is very distinct. Seaward of this edge is a large lead area (greater than or equal to 10 km wide)(zone 4) that appears to be refreezing from seaward to shoreward edges. There are a number of vast to giant sized floes in the western part of this zone. Seaward of zone 4 are two zones of pack ice. Zone 5 is composed of variously sized floes, mainly light toned, in a matrix of darker toned, younger ice. There are also some small open water areas in this zone. Light toned, fairly smooth-looking ice makes up zone 6. Several leads, the largest of which is mapped (L), are present in this zone. Three zones are visible within the continuous ice. Zone 1 is light toned, smooth-looking ice with a very distinct boundary with zone 3. The uniform tone of zone 1 grades into the slightly darker tone of zone 2. This ice appears rougher, with lighter toned floe-like objects in a slightly darker matrix. Overall, zone 3 is darker toned ice than either zone 1 or 2. Light toned vast sized floe-like objects are present in a darker, younger ice matrix. There are some ridges (R) present, mainly on the zone 2/zone 3 boundary.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

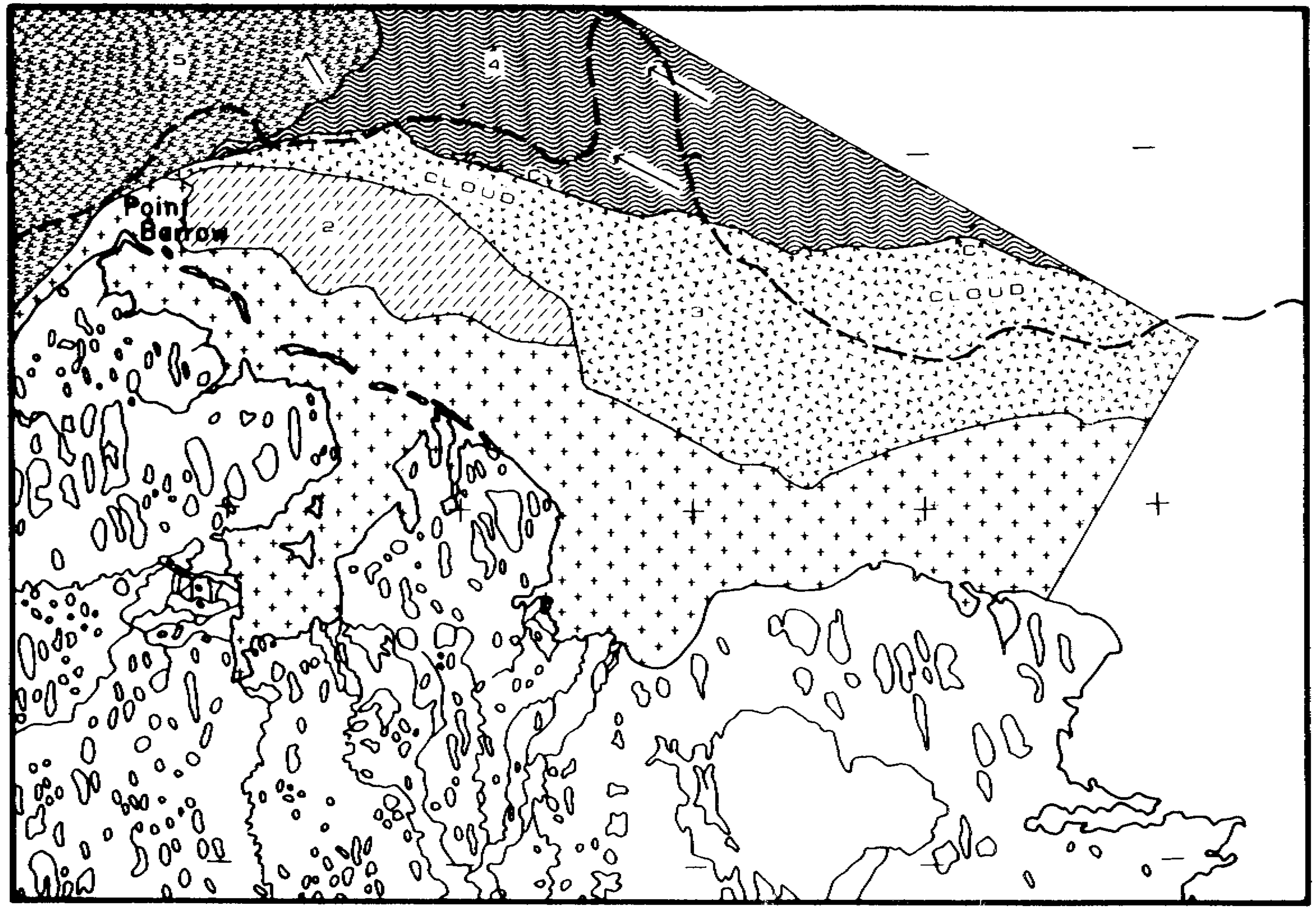
BEAUFORT SEA COAST: BARROW SECTOR

9 MARCH, 1975

Figure 12

10 March 1975: Scene E-1960-21342

This frame covers the area from Pt. Barrow nearly to Harrison Bay. The continuous ice edge (C) is distinct, and has not moved since 9 March (at least in the area of overlap between the two frames). Zones 1 through 5 appear the same as they did on the previous frame; therefore their descriptions can be obtained from the 9 March text. The seaward boundary of zones 1 (in the eastern half of the frame) and 2 (in the western half of the frame) closely follows the 10 fm contour. No ridges or leads were observed on this frame, perhaps partly due to clouds covering much of zone 3. The giant floes in the top part of the frame have moved approximately 10 km west and northwestward since 9 March (shown by arrows on the map).



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

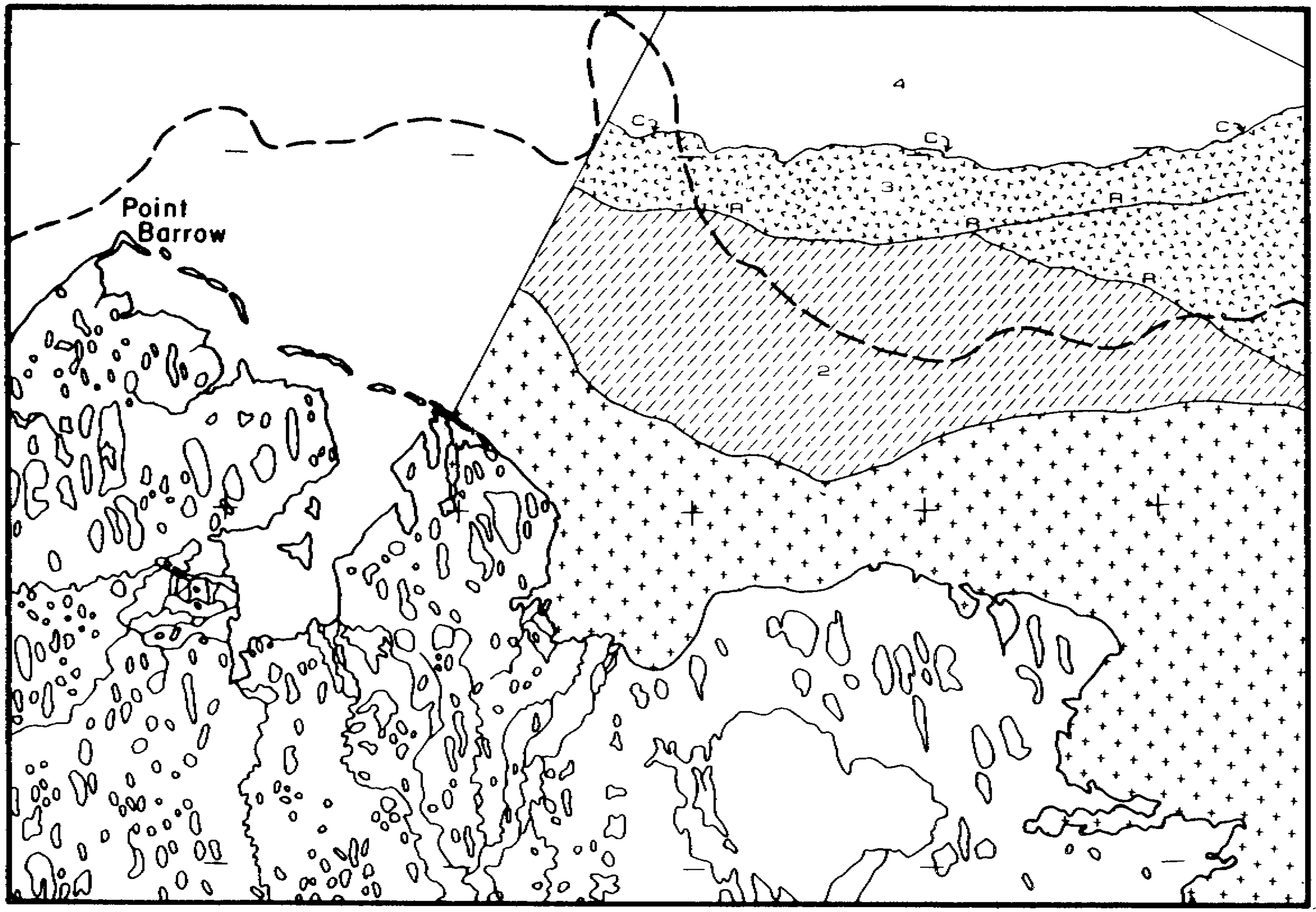
BEAUFORT SEA COAST: BARROW SECTOR

10 MARCH, 1975

Figure 13

26 March 1975: Scene E-1976-21221

This winter frame covers the area from Harrison Bay to Dease Inlet. The continuous ice edge (C) is very distinct, since some open water is present along the shoreward edge of the pack ice in a band approximately 5 km wide. Otherwise the pack ice (4) is quite consolidated, with little open water. Three zones are present in the fast ice. Zone 1 is light toned smooth-looking ice. The zone 1/zone 2 boundary is not very clear. Zone 2 is slightly darker, and looks less smooth than zone 1. There appears to be lighter toned floe-like objects in a slightly darker matrix. The zone 2/zone 3 boundary is the former (early March) continuous ice edge. Ridges (R) are now present along this boundary. The ice in zone 3 appears rougher, the floe-like objects are more distinct, and the matrix ice is darker than the zone 2 ice.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

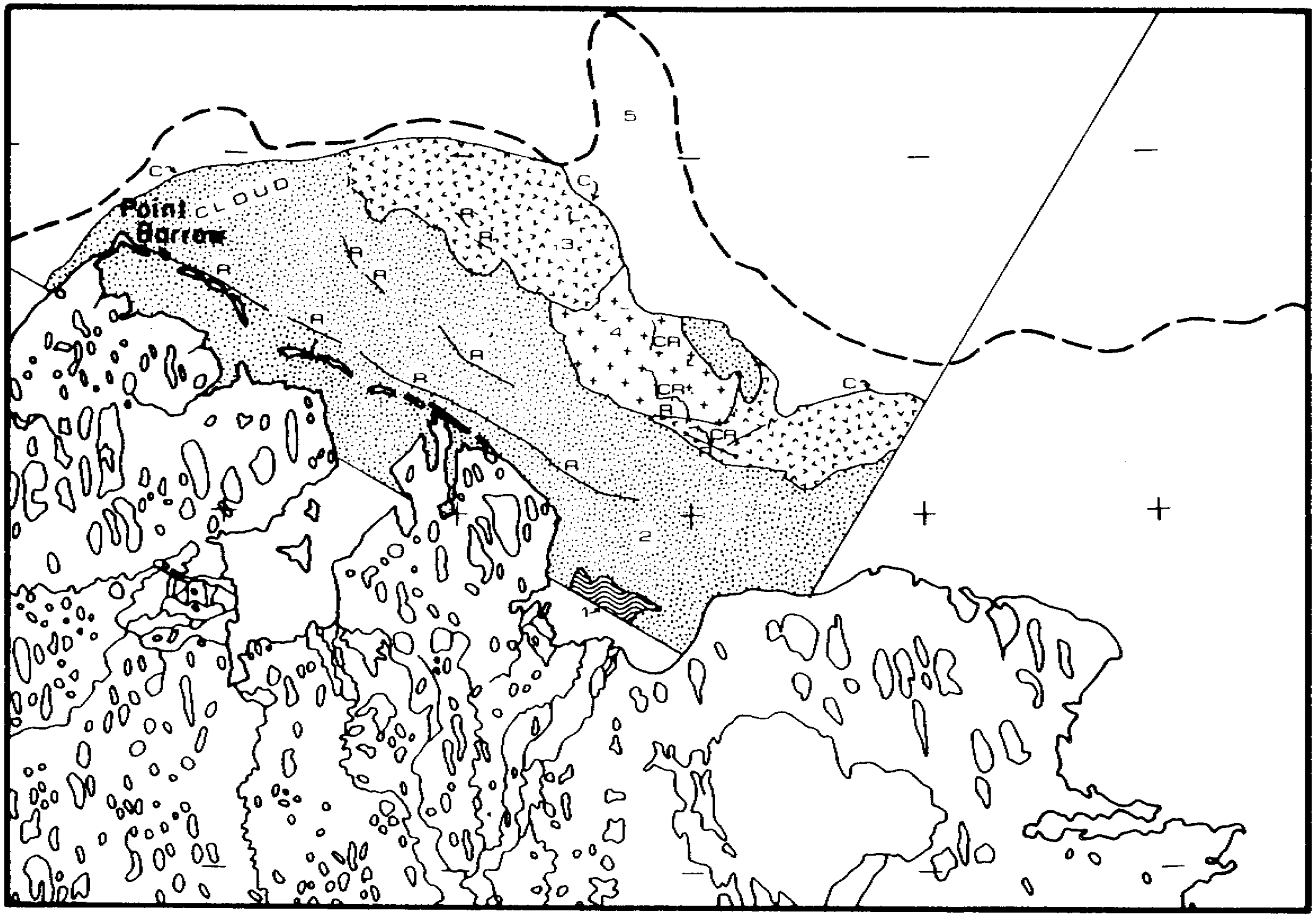
BEAUFORT SEA COAST: BARROW SECTOR

26 MARCH, 1975

Figure 14

18 June 1975: Scene E-2147-21452

In this late spring scene, puddling of the ice has begun. The continuous ice edge (C) is very distinct and has remained the same since 9 April. The pack ice (5) is fairly well consolidated, with the exception of an approximately 500 km^2 area of open water and floating ice (less than 25% ice) on the shoreward edge of the zone. Within the continuous ice there appears to be four different zones based on melt characteristics. Light clouds cover the ice north and northeast of Barrow and the ice shoreward of the barrier islands, however, so these areas could not be mapped in great detail. There appears to be open water (1) in a small area in Smith Bay, although it is difficult to be certain. Ice is present in this area on 6 July, so zone 1 may be heavily flooded ice. Zone 2 is dark toned ice overall. The ice appears lighter in the west, but this may be due to the cloud cover. There are many small, light lineations and some larger lineations that may be ridges (R). Overall, this ice appears quite smooth, especially in the shoreward areas. Zone 3 is darker than zone 4 and lighter than zone 2. There are several prominent dark areas within this zone, but otherwise the ice appears lightly mottled. There may be some older ice on the shoreward edge of the "eastern" segment of zone 3. There are some cracks (CR) in this zone and some ridging (R) on the zone 3/zone 2 boundary., Zone 4 is the lightest toned ice. It appears quite smooth in the east and rougher in the west. There are some large cracks (CR) in this zone. By 6 July, this ice will be seen to be breaking up.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

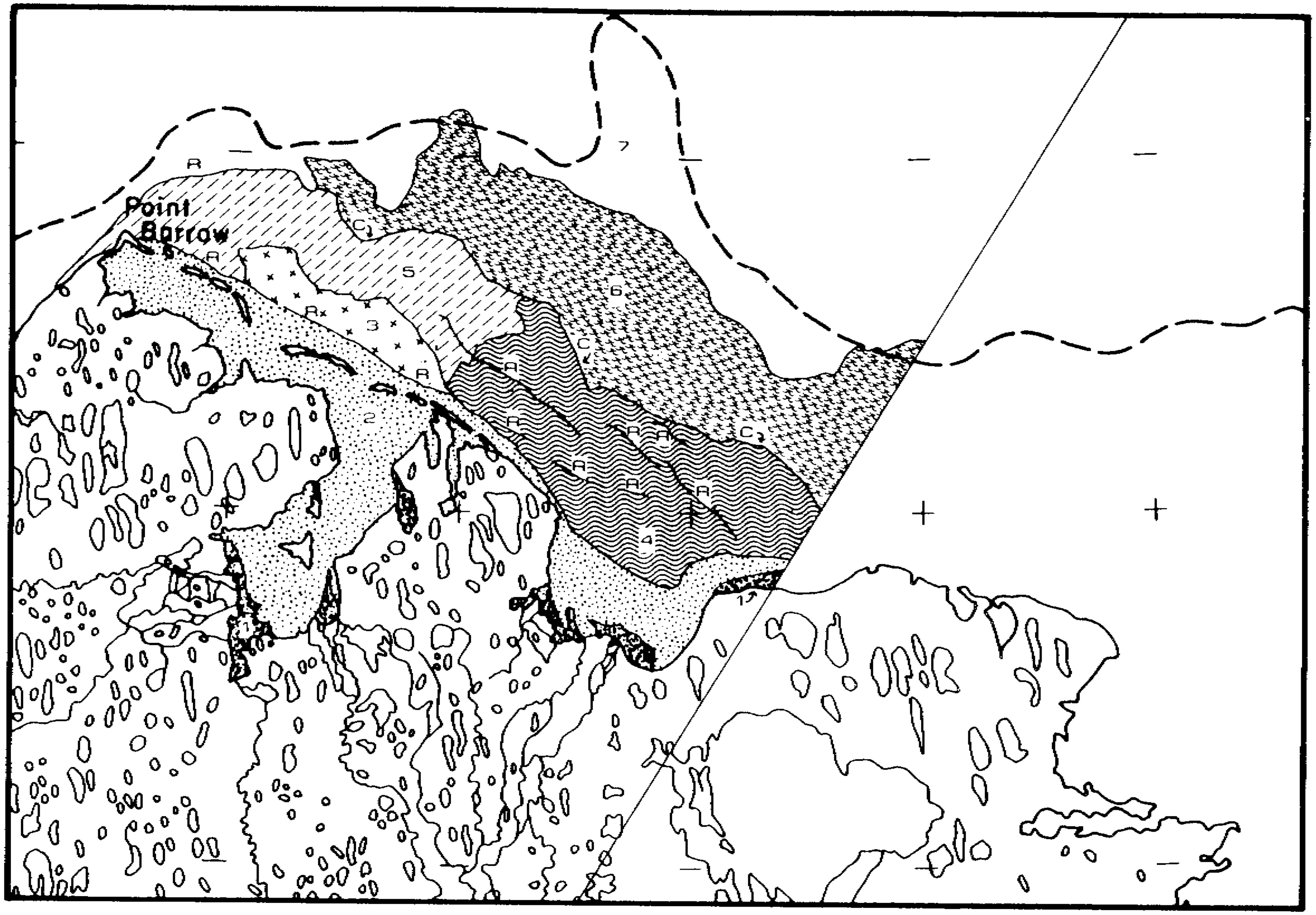
BEAUFORT SEA COAST: BARROW SECTOR

18 JUNE, 1975

Figure 15

6 July 1975: Scenes E-2165-21452 (top) and E-2165-21454 (bottom)

By the time of this early summer scene, the ice has darkened considerably. Part of the continuous ice edge of 18 June (northeast of Pt. Barrow, marked as a ridge, R) has remained, but appears to have moved approximately 3 km to the southeast. It is difficult to tell, however, due to cloud cover on 18 June. The remainder of the continuous ice edge (C) has changed. Two zones are present in the pack ice. Zone 6, which is partly former continuous ice, is composed of open water (less than 25%) and variously sized floes. There is much variation in the tone of the ice, from heavily puddled to very light toned, possibly drained ice. Five zones are present within the continuous ice. Open water (1) is present along the shore in a narrow band, especially in Dease Inlet and Smith Bay. Zone 2 is composed of very dark, fairly uniformly toned, smooth-looking ice. There are darker areas near Pt. Barrow and in Smith Bay and lighter areas in Dease Inlet. There is a ridge (R) along the seaward boundary of the zone, which has remained stationary since 18 June. Zone 3 consists of uniformly toned ice that is slightly lighter in tone than the other zones within the continuous ice. Zone 4 ice is similar to zone 2 ice, but zone 4 has more light lineations and is a lighter tone. Zone 4 also has less light lineations, is slightly darker, and appears slightly smoother than zone 5. There is some ridging (R) in this zone. Zone 5 appears quite rough with many light lineations. It is a fairly dark tone overall, but not a uniform tone. Some large, dark, smooth-looking areas resemble zone 4 more than the rest of zone 5, but since zone 5 contains such a variety of tones and textures, these areas have been included in zone 5.

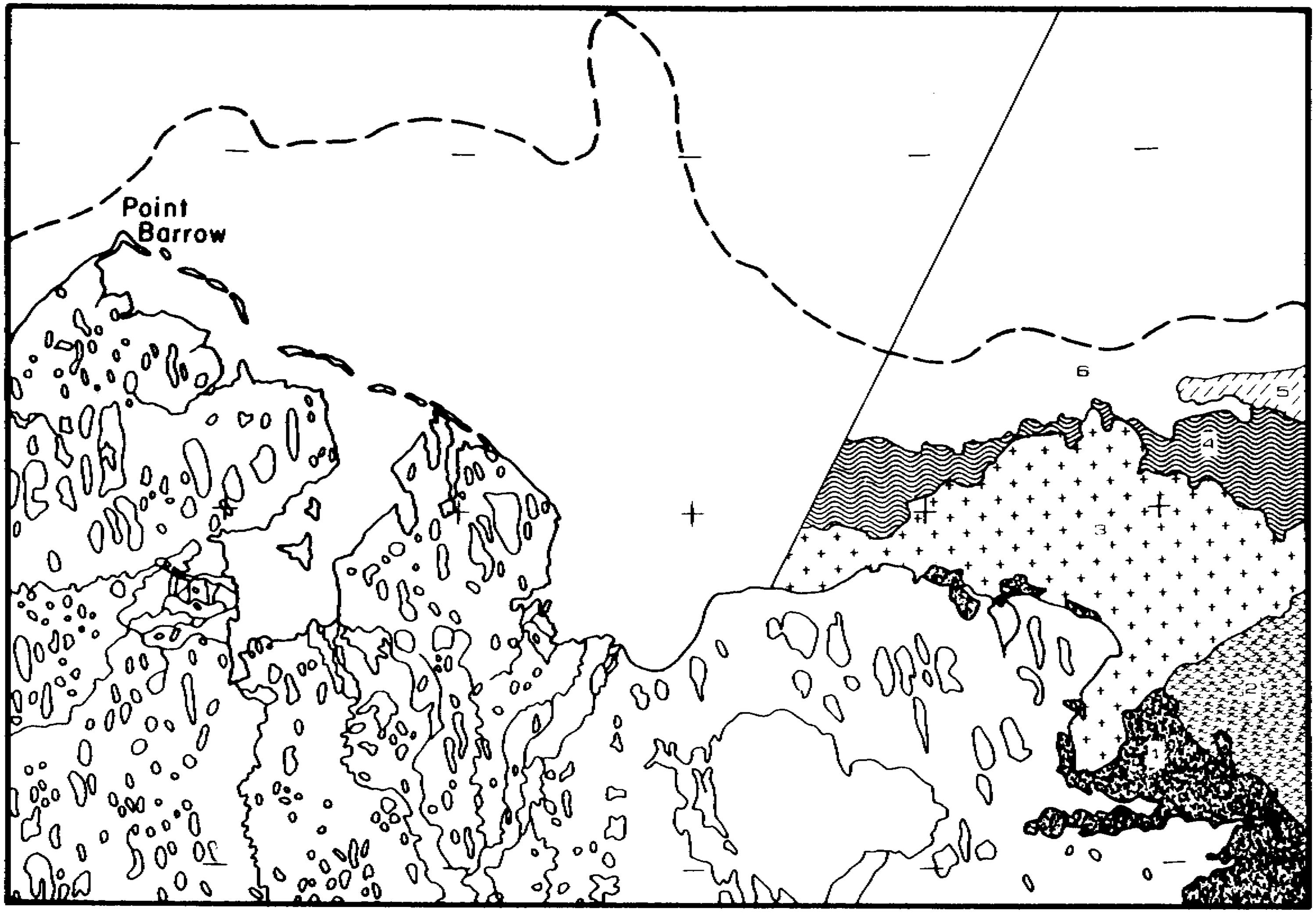


SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
BEAUFORT SEA COAST: BARROW SECTOR
6 JULY, 1975

Figure 16

20 July 1975: Scene E-2179021223

This summer scene covers the eastern part of the sector. The continuous ice is now a large semi-attached body of ice, mapped as two zones (2 and 3), based on melt characteristics. The "continuous ice" edge is very close to that of 9 April. Open water (1) is present along the coast in a band approximately 10 to 15 km wide. There is little floating ice in this zone. There is much variation in tone and roughness throughout zone 2. Overall, the zone 2 ice is quite dark. The shoreward part of this zone appears ragged, with some open water. There is also some ridging in this zone. Zone 3 ice appears quite smooth, being a fairly uniform tone overall. There are some areas of open water and some areas of darker toned ice within this zone. Seaward of zones 2 and 3 is an open water area with much variously toned ice (zone 4). In the eastern part and the extreme western part of this zone, the ice is fairly consolidated (approximately 90% ice), while in the central part, there is little ice (less than 10% ice). Two zones were mapped in the pack ice. Zone 5 is lighter toned, continuous pack ice, while zone 6 is slightly darker with some small areas of open water.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

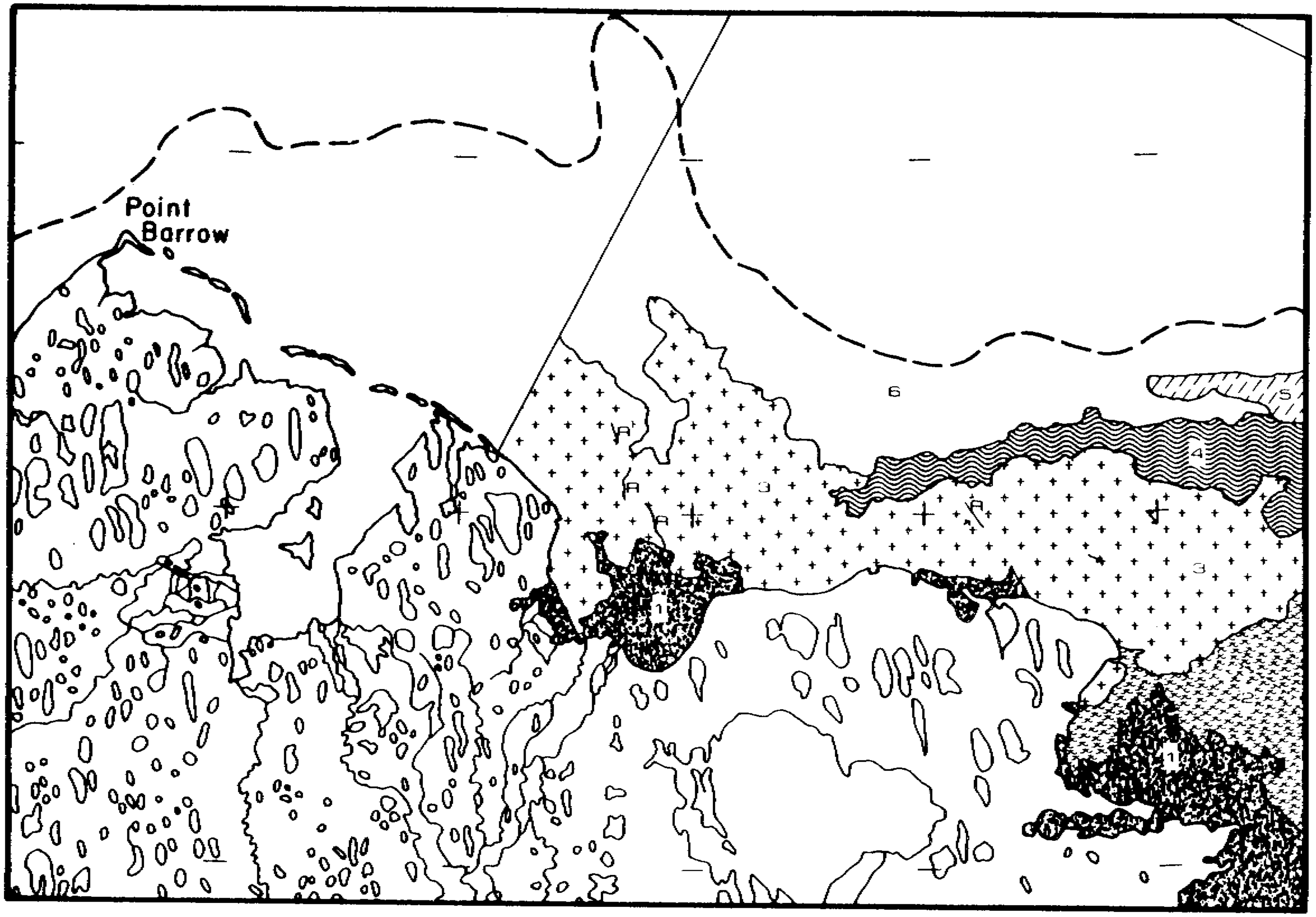
BEAUFORT SEA COAST: BARROW SECTOR

20 JULY, 1975

Figure 17

21 July 1975: Scene E-2180-21281

This summer scene covers the area from Harrison Bay to Smith Bay. There is good overlap with the previous frame (20 July) so movements have been noted on the map. Movements were mainly to the south and east and generally less than or equal to 2 km. Direction and location of movements are shown by arrows, the length of which show the amount of movement. Zone 1, located along the coast, is mainly open water with small amounts (less than 10%) of floating ice. Overall zone 2 is fairly dark toned ice, but there is much variation within the zone. Surface characteristics appear to vary between smooth- to rough-looking ice. There are some light lineations that may be ridges (R). Zone 3 is a lighter tone than zone 2, but it is still fairly dark. The ice is quite uniformly toned, so it appears smooth. However, there are some open water areas and some light lineations, possibly ridges (R). The western and seaward parts of zone 3 seem to be breaking up. Zone 4 consists of open water with floating ice. The highest percentage of ice (greater than or equal to 80%) is in the eastern part of the zone, while the western part is nearly ice free. The texture, size, and tone of the ice varies greatly. Two zones are present in the pack ice, which is well consolidated on this frame. Zone 5 is light toned, uniformly mottled ice, while zone 6 is darker and a less uniform tone.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

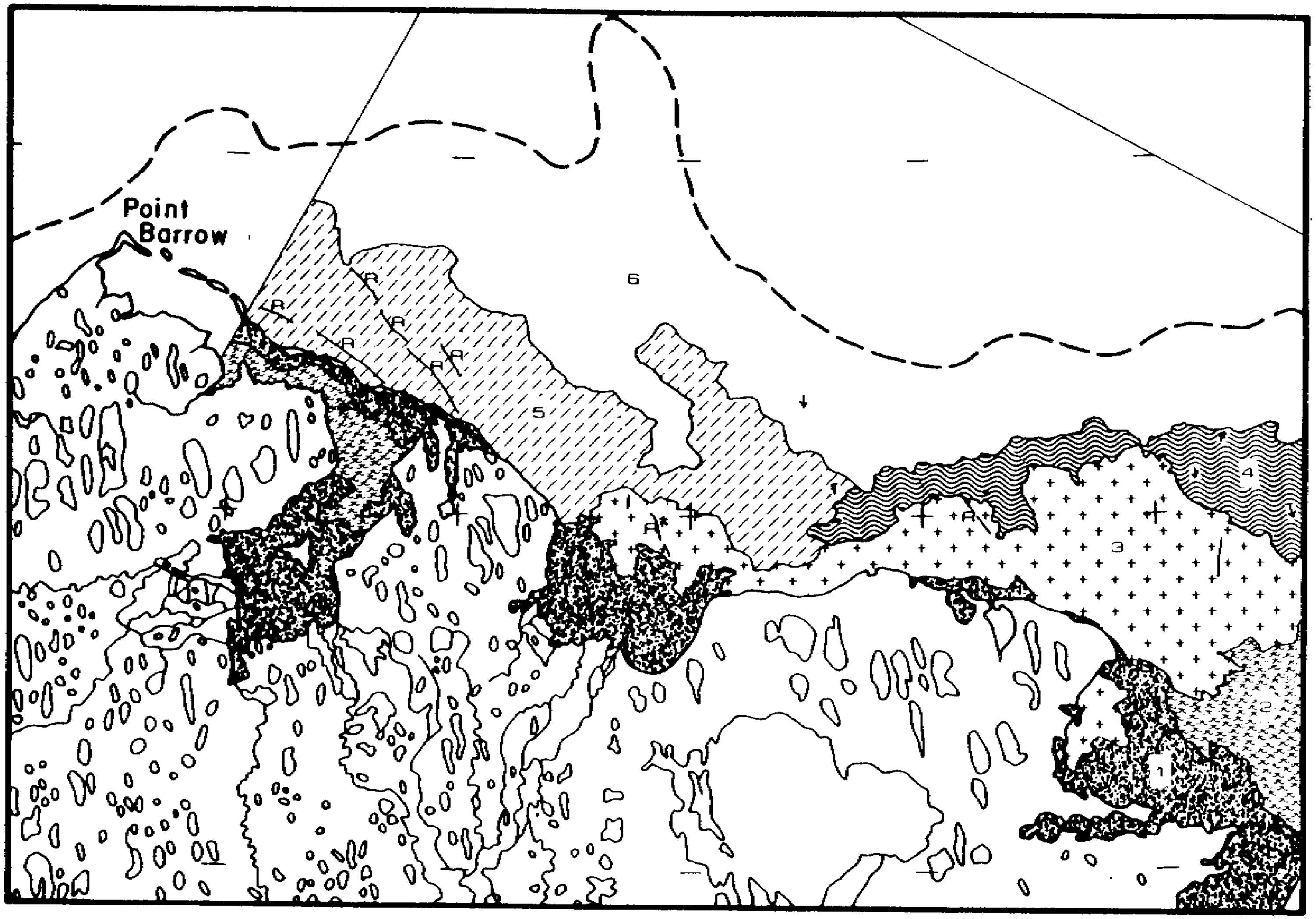
BEAUFORT SEA COAST: BARROW SECTOR

21 JULY, 1975

Figure 18

22 July 1975: Scene E-2181-21340

This summer frame covers the area from Harrison Bay to just west of Dease Inlet. Thin clouds cover the western part of the frame. There has not been a great deal of change from the previous frame, but some movements were mapped. They are shown by arrows on the map; were less than 2.5 km in length; and were generally to the south. A ŧ symbol indicates no motion. Zone 1 is open water with some floating ice. It is difficult to draw the boundary west of Smith Bay due to cloud cover. Zone 3 appears to be adding much broken up ice to zone 1 in Harrison Bay. Overall zone 2 is dark toned ice with some variation in tone; the ice is lighter to seaward. There is quite a lot of open water in this zone, especially in the shoreward part. The zone 2 ice mapped in Dease Inlet may be simply cloud cover, since it is difficult to see the ice. However, the ice appears similar to the Harrison Bay zone 2. Zone 3 is medium grey toned, smooth-looking ice. Large cracks and disintegration in the southeastern part of the zone show that this ice is in an advanced stage of decay. Zone 4 appears very dark due to much open water. There is a lot of floating ice in this zone, and it is most concentrated in the eastern part (approximately 85%). There is much variation in the tone and texture of this ice. It is difficult to determine the amount of ice in the western part due to cloud cover. Zone 5 is darker toned ice than the pack ice, but otherwise looks similar (this may be due partly to cloud cover). A ridge (R) is present on the shoreward edge of the zone. The ice appears very cohesive. Zone 6 is fairly light toned, continuous pack ice.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

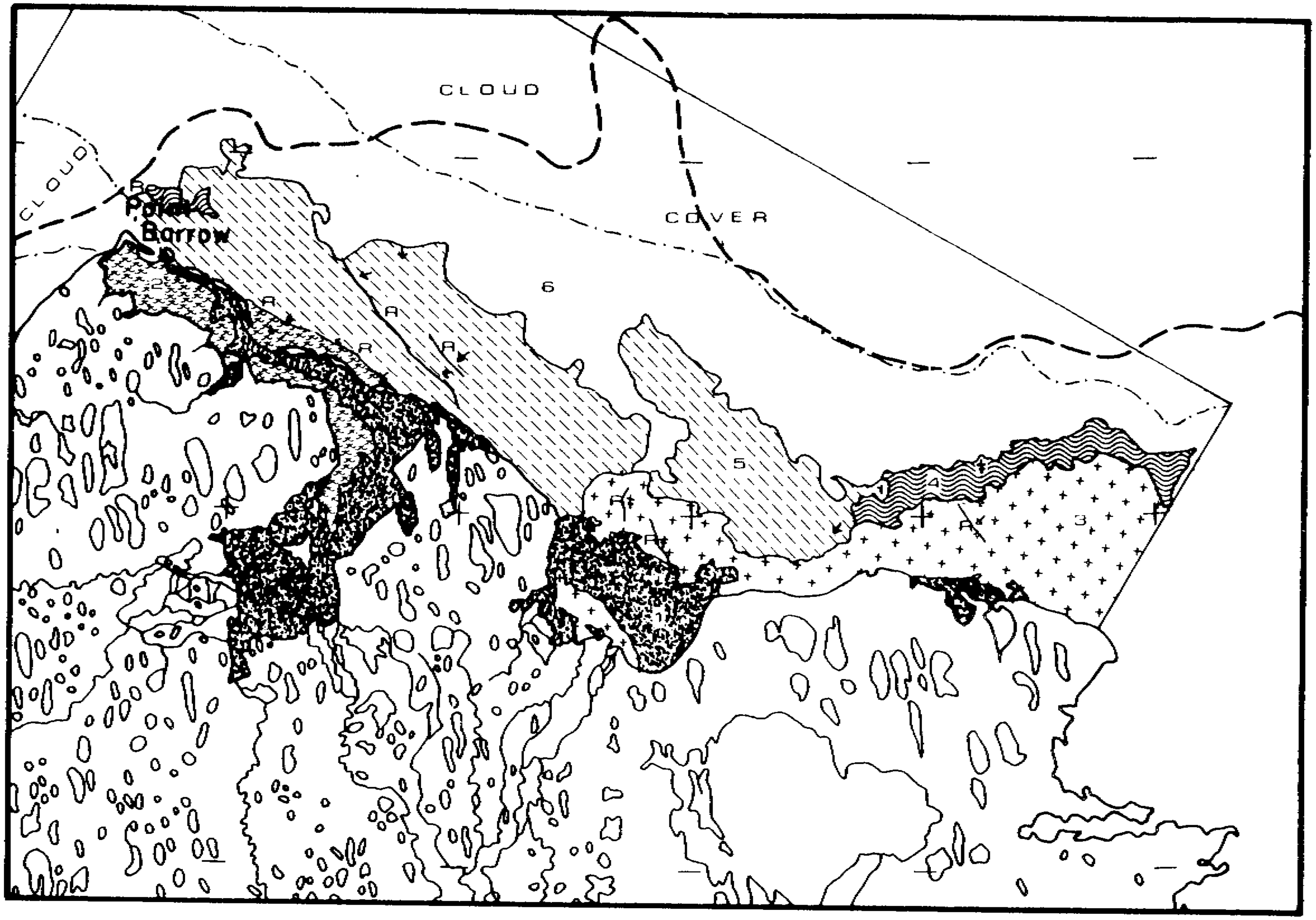
BEAUFORT SEA COAST: BARROW SECTOR

22 JULY, 1975

Figure 19

23 July 1975: Scene E-2182-21394

This frame covers the area from Pt. Barrow eastward, nearly to Harrison Bay. Clouds cover the area northwest of Pt. Barrow and along the seaward part of the pack ice. There has not been a great deal of change from the previous frame. Movements have been mapped (arrows), and were generally 0.5 to 1 km in length, to the west and southwest. A ‡ symbol indicates no movement. Zone 1 is mainly open water with small amounts of ice (less than 10%). Most of the ice is located in Smith Bay and the seaward half of Dease Inlet. Zone 2 consists of smooth-looking nearshore ice. The ice is fairly dark overall, but includes some large light toned (drained) areas. A ridge is lcoated along the seaward edge of zone 2. It has moved shoreward less than or equal to 1 km since 18 June. Zone 3 is medium grey toned smooth-looking ice. There are some darker areas along the seaward boundary that appear ready to melt out or break up. There are also many small open water areas and several light toned lineations (possible ridges) within this zone. Zone 4 is open water with many big to vast sized floes (approximately 20% ice). Zone 5 is medium grey tone overall, but with much tonal variation. The ice appears similar to zone 3, but looks rougher. There are some small open water areas in this zone, and some darker areas indicating more water on the surface of the ice. There are a number of light lineations in this zone; some appear to be ridges (R). The ridge (R) on the zone 5/zone 6 boundary north of Pt. Barrow is in the same location as the fast ice edge on the 10 March frame. The shoreward boundary of the pack ice (6) is somewhat arbitrary due to gradual tonal changes of the ice. The boundary north and northwest of Pt. Barrow cannot be mapped due to cloud cover. The pack ice is fairly light toned. There are many small areas of open water, but otherwise the ice is continuous.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

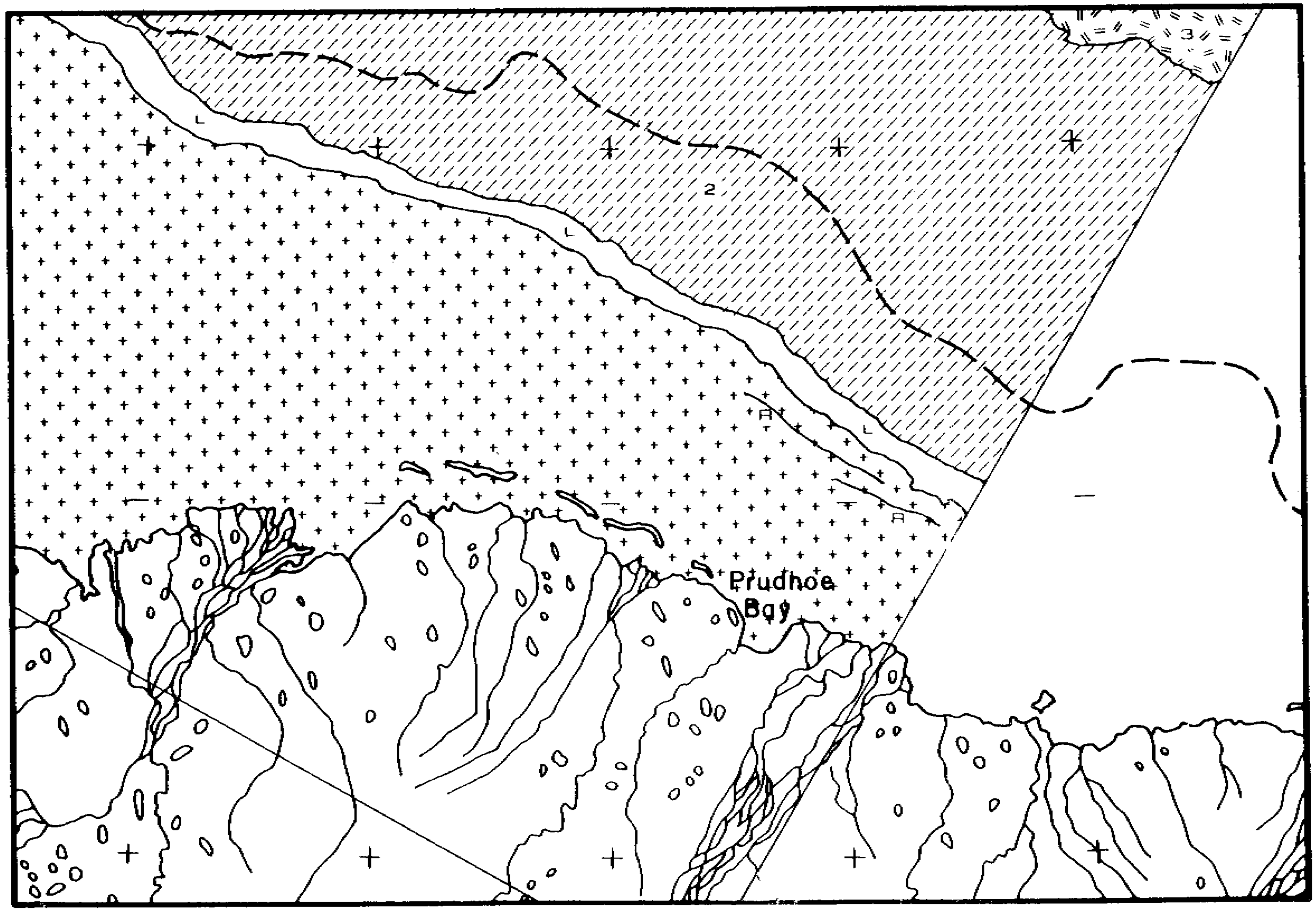
BEAUFORT SEA COAST: BARROW SECTOR

23 JULY, 1975

Figure 20

6 March 1975: Scene E-1956-21113

In this winter scene a large lead (L) (approximately 5 km wide and 25 to 70 km offshore) extends across the frame running parallel to the coast. There appears to be open water along the shoreward edge and refreezing ice along the seaward edge. Shoreward of the large lead is a zone of uniformly light toned ice that appears quite smooth. However, there are two distinct ridges (R) approximately 30 km northeast of Prudhoe Bay in this zone. There may also be some ridging on the edges of the large lead. The ice seaward of the lead (zone 2) is also light toned, but not as uniformly as in zone 1, so it does not appear as smooth. Zone 3 consists of fractured pack ice; mainly variously sized floes in a darker matrix. There is little open water present in this zone.

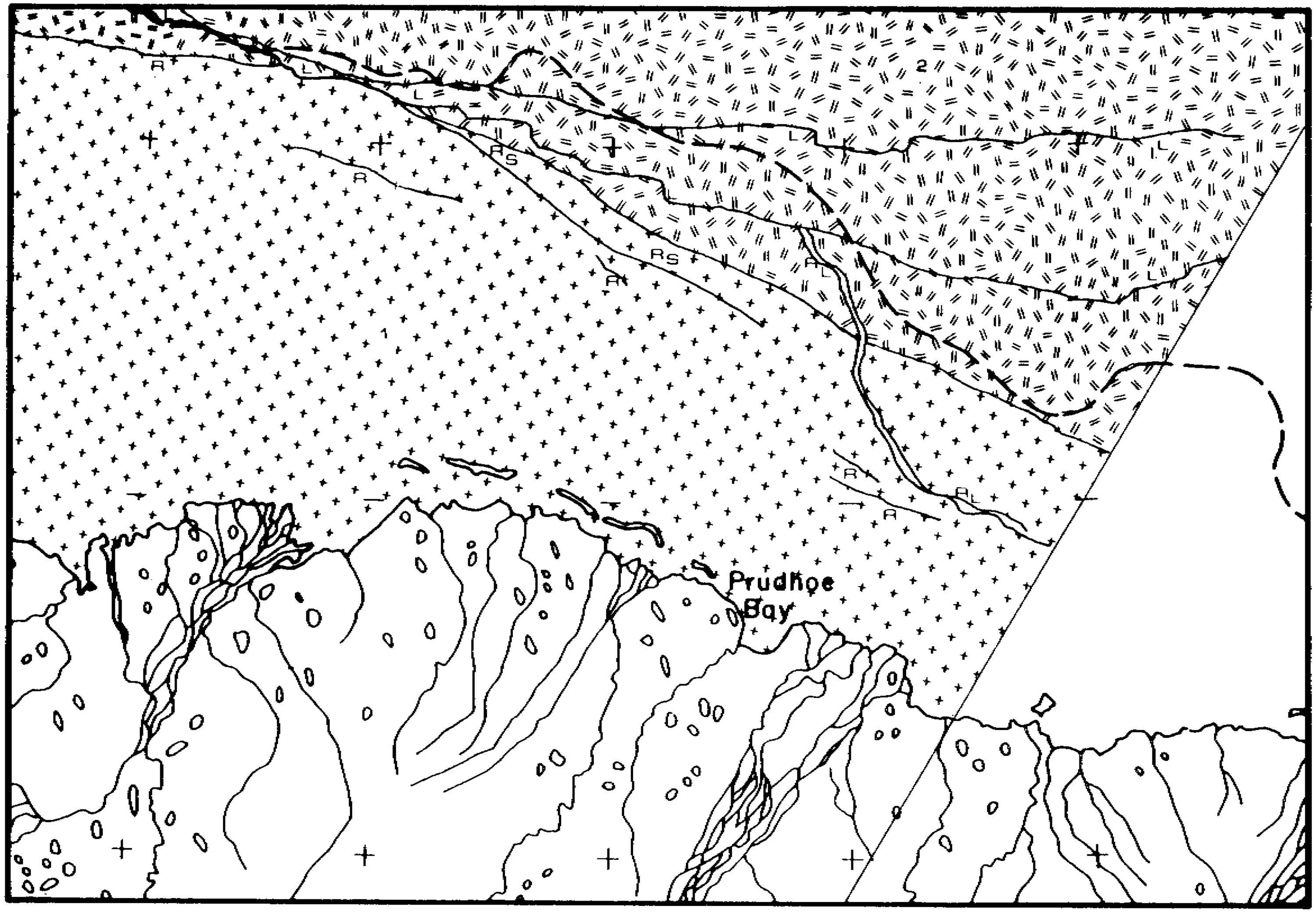


SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
BEAUFORT SEA COAST: PRUDHOE SECTOR
6 MARCH, 1975

Figure 21

20 April 1975: Scene E-2088-21170

Many features are visible in this late winter frame. The shoreward part of zone 1 is fairly smooth-looking light toned ice. However, there are a number of ridges in the seaward part of this zone. A major ridge system (RS) is located approximately 70 km northwest of Prudhoe Bay near the 10 fm contour and "will be seen to survive the 1975 melt season and remain in place through the winter of 1975-76" (Stringer, 1976: OCS Principal Investigators' Reports, vol. 4, p. 480). The ridges (R) northeast of Prudhoe Bay on the 6 March frame are present and appear to have remained stationary. Overall, zone 2 consists of rougher-looking ice than zone 1. Many leads (L) criss-cross this zone. The largest of these leads, just seaward of the major ridge system, extends across the frame. Another large lead (RL), which appears to be refreezing, extends southward into zone 1. Smaller leads or fractures have broken up the pack ice seaward of the largest lead.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

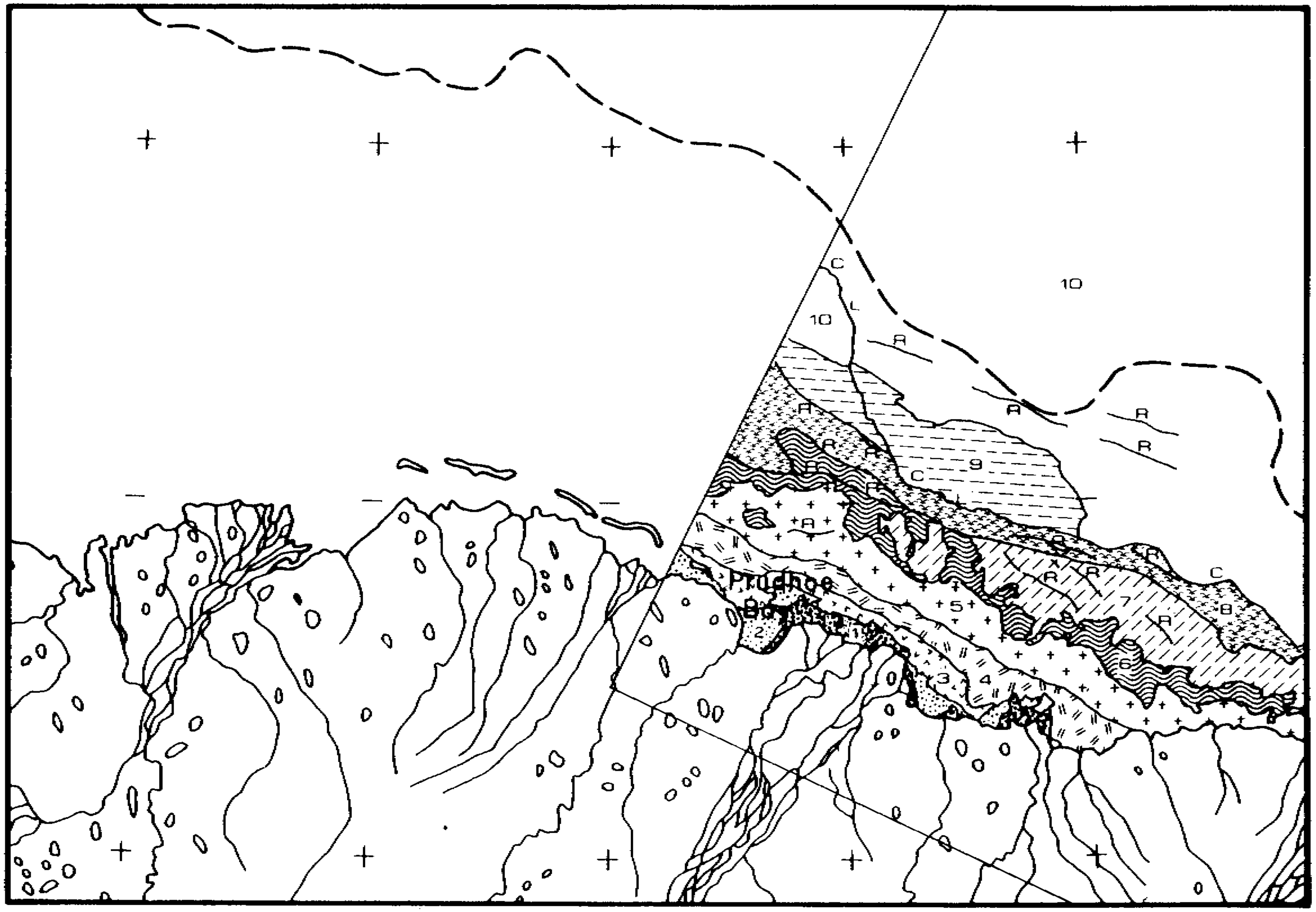
BEAUFORT SEA COAST: PRUDHOE SECTOR

20 APRIL, 1975

Figure 22

28 June 1975: Scene E-2157-20595

This late spring frame covers the area from the eastern edge of the sector to Prudhoe Bay. The continuous ice edge (C) is quite distinct on this date, and the continuous ice is in many different stages of puddling. Zone 1, located mainly at river mouths, is a very dark tone in all bands and may be open water and/or heavily flooded ice. Zone 2 is a lighter tone than zone 1, but is darker in all bands than the other zones. The ice appears smooth and of a uniform tone; it is probably heavily puddled ice. Light toned rougher-looking ice characterizes zone 3. Zone 4 is darker than all zones excepting zones 1, 2, and 6. This zone has many small light lineations within it, so it does not appear smooth. Zone 5, which is lighter than all zones except zones 8 and 10, is somewhat similar in tone to zone 3. However, zone 5 appears quite smooth, with interesting light toned, "blurred" lineations. It is light toned in all bands, so there is probably a limited amount of water on the ice. This ice will be completely gone by the time of the next image (18 July). Zone 6 is nearly as dark toned as zone 2, so puddling is probably in an advanced stage. However, this zone contains many lighter areas within it. The shoreward boundary of zone 6 is very distinct. There is a large ridged area (R) in the western part of this zone. Both the ridge on the zone 6/zone 8 boundary and the ridge approximately 2 km to the south have been stationary since the 6 March frame. Zone 7, a medium grey tone, appears similar to zone 4, but looks somewhat rougher due to the many large and small light lineations within this zone. The continuous ice edge (C), which follows the 10 fm contour quite closely, forms the seaward boundary of zone 8 for much of its length. Overall, this zone is light toned ice, but has quite a lot of tonal variation. There are a number of ridges (R) within this zone, and overall the ice looks quite rough. Zone 9 is a darker tone than either 8 or 10, with much variation within the zone. The continuous ice edge runs through this zone. This continuous ice edge/lead (L) is in the same location as a large lead on the 20 April frame. Further east, along the continuous ice edge, a lead (L) is present on the 28 June frame that is in the same location as the large lead on the 6 March frame. The shoreward edge of this winter lead also shows as a ridge (R) in the western part of the zone 8/zone 9 boundary on 28 June. The pack ice (10) is quite light toned, appearing similar to zone 8. This ice is fairly well consolidated in the shoreward part of the zone, then grades into more broken up ice to seaward. There is some ridging in this zone. The shoreward ridges have been stationary since 20 April.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

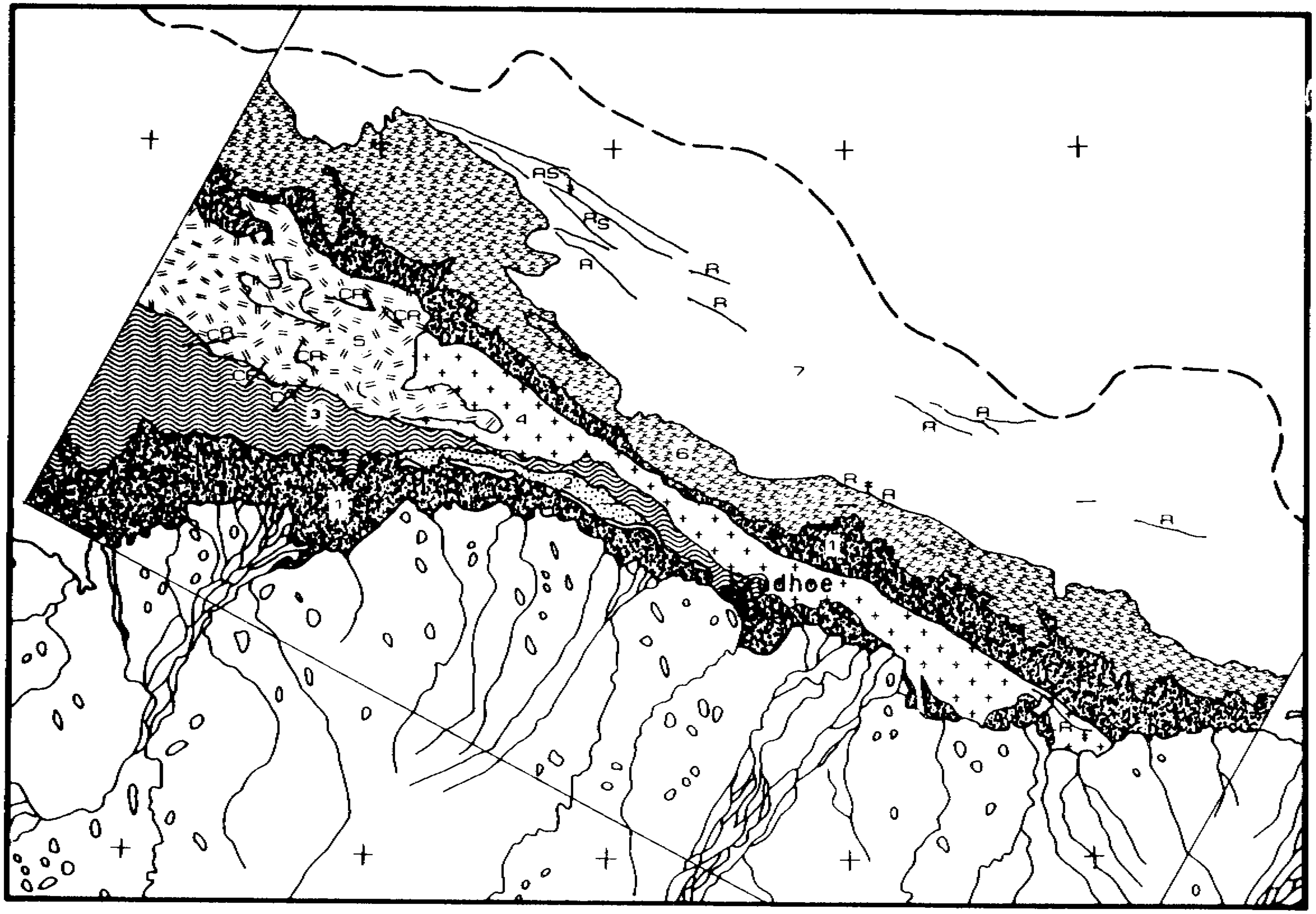
BEAUFORT SEA COAST: PRUDHOE SECTOR

28 JUNE, 1975

Figure 23

18 July 1975: Scene E-2177-21110

In this summer frame the "continuous" ice remains attached to the coast in the eastern part of the sector, however open water (1) is present in bands approximately 5 to 10 km wide on the shoreward and seaward sides of the ice. There is some floating ice in the seaward band. The "continuous" ice was divided into 4 zones (2, 3, 4, and 5) based on puddling differences. Zone 2 is located just seaward of the barrier islands. It is fairly light-toned ice overall with some light lineations and some darker areas within the zone. Zone 2 looks similar in tone to zone 4, but appears somewhat rougher. Zone 3, the darkest toned ice, also has some light lineations within it. Overall, the texture of this ice appears quite rough. Zone 4 is uniformly medium grey toned, so it appears quite smooth. There are some small areas of open water within this zone. The seaward boundary of this zone is approximately the same as the 28 June zone 4/zone 5 boundary. Zone 5 is similar in tone to zone 4, but the many light lineations give the ice the appearance of being quite rough. There are several large light toned areas within the zone, the largest of which is outlined. Many cracks (CR) are present in zone 5, and the ice along the seaward edge of this zone seems to be moving into zone 1. Zone 6 consists of fairly dark toned ice overall, but there is much variation within the zone. There is some smooth-looking ice, mainly in the central and eastern parts of the frame, but overall the ice looks quite rough. Much of the ice along the shoreward edge of zone 6 seems to be moving into the open water (zone 1). An oblong-shaped, light toned area in the west-central part of the frame has been outlined. Although most of the ice to seaward is cloud covered, the shoreward part of zone 7 contains many interesting features. This zone consists of fairly consolidated pack ice, with many small areas of open water. Overall, the ice is a medium grey tone with quite a rough texture. There are many ridges in this zone, especially in the west-central part of the zone. The ridge (R) northeast of Prudhoe Bay on the zone 6/zone 7 boundary have been stationary (‡) since 6 March. The major ridge system (RS) northwest of Prudhoe Bay has been stationary (‡) since 20 April. Within the area of overlap between the 18 July and 28 June frames (the western half of the 18 July frame), no movements could be detected. It appears that there has been *in situ* melting of the 28 June zones 2, part of 3, and most of 5, and little movement of the ice.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

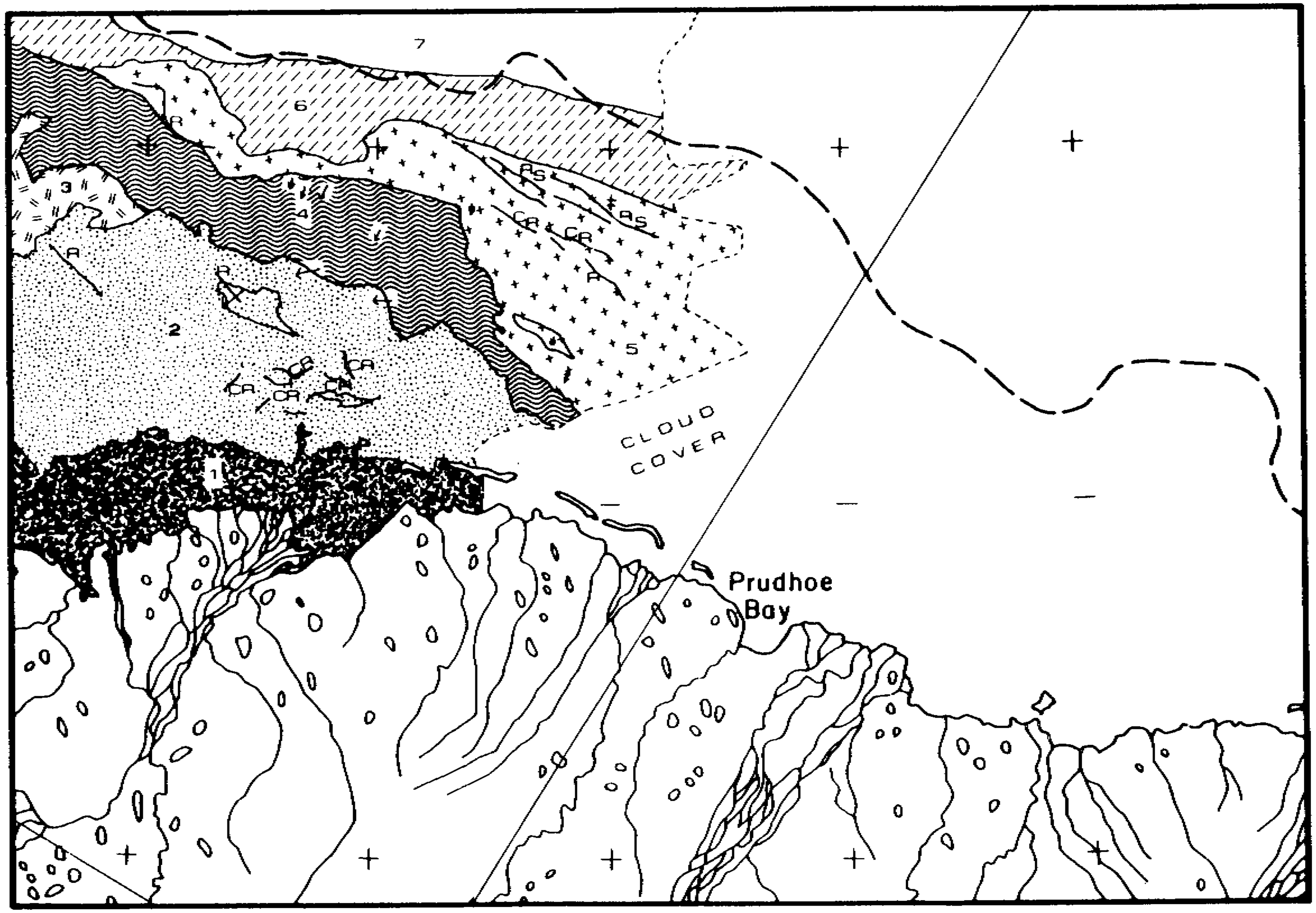
BEAUFORT SEA COAST: PRUDHOE SECTOR

18 JULY, 1975

Figure 24

20 July 1975: Scene E-2179-21223

The eastern portion of this summer frame is covered by clouds. However, there is still sufficient overlap with the previous frame (18 July) to chart movements (shown by arrows on the map; the length of which indicates the amount of movement. A ‡ symbol indicates no motion.). Zone 1, open water, extends along the coast in a band approximately 5 to 15 km wide. There is a small amount of floating ice in this zone. The remaining "continuous" ice is designated zones 2 and 3. Overall, zone 2 is quite dark, but with much variation within the zone. There are some light lineations (which may be due to ridging) and light areas (the largest is outlined), as well as many cracks (CR) and open water areas. There is more open water in this zone than in the same area on the previous frame (18 July, zones 3, 4, and 5). The shoreward edge appears more "ragged" than it did on the previous frame, probably due to additional ice melting and movement into zone 1. Zone 3 is a fairly uniform, medium grey tone that appears fairly smooth overall. The boundary with zone 2 is quite distinct. Zone 4 consists of open water and variously-sized floes. There is a greater amount of ice in the western part of the zone than in the eastern part. There have been a number of movements, mainly toward the south in this zone since 18 July (see map). Zone 5 is medium-grey toned ice with much tonal variation within the zone. There are many small open water areas in this zone. Overall, the ice looks quite rough. The major ridge system (RS) northwest of Prudhoe Bay has not moved since 20 April. There is also a large, very light toned feature in the western part of the zone that may be a ridge (R). Zone 6 is lighter toned ice than that in zones 5 or 7. There is little open water in this zone. Zone 7 is fairly well consolidated pack ice.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

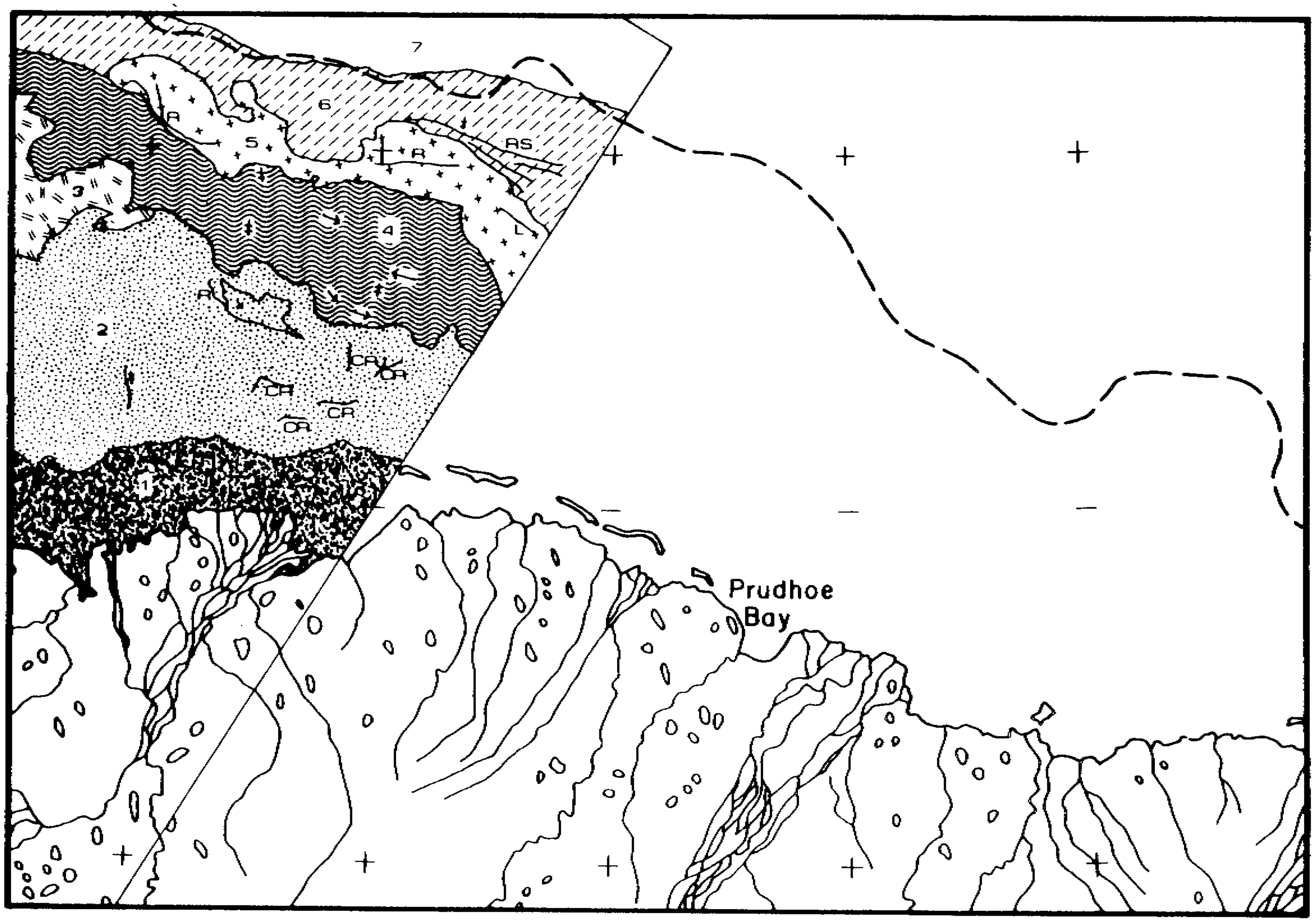
BEAUFORT SEA COAST: PRUDHOE SECTOR

20 JULY, 1975

Figure 25

21 July 1975: Scene E-2180-21281

This summer frame covers the western part of the sector; having good overlapping coverage with the previous frame (20 July). There are no major differences in the two frames, however there has been quite a lot of movement (direction and magnitude of which are shown by arrows on the map) in the open water area between the "continuous" ice and the pack ice. Features which have not moved are denoted by a + symbol. The tonal boundaries and characteristics are essentially the same for the two frames; therefore the reader is referred to the key for 20 July. The major ridge system (RS) and the ridge (R) in the western part of zone 5 have not moved since 20 July.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

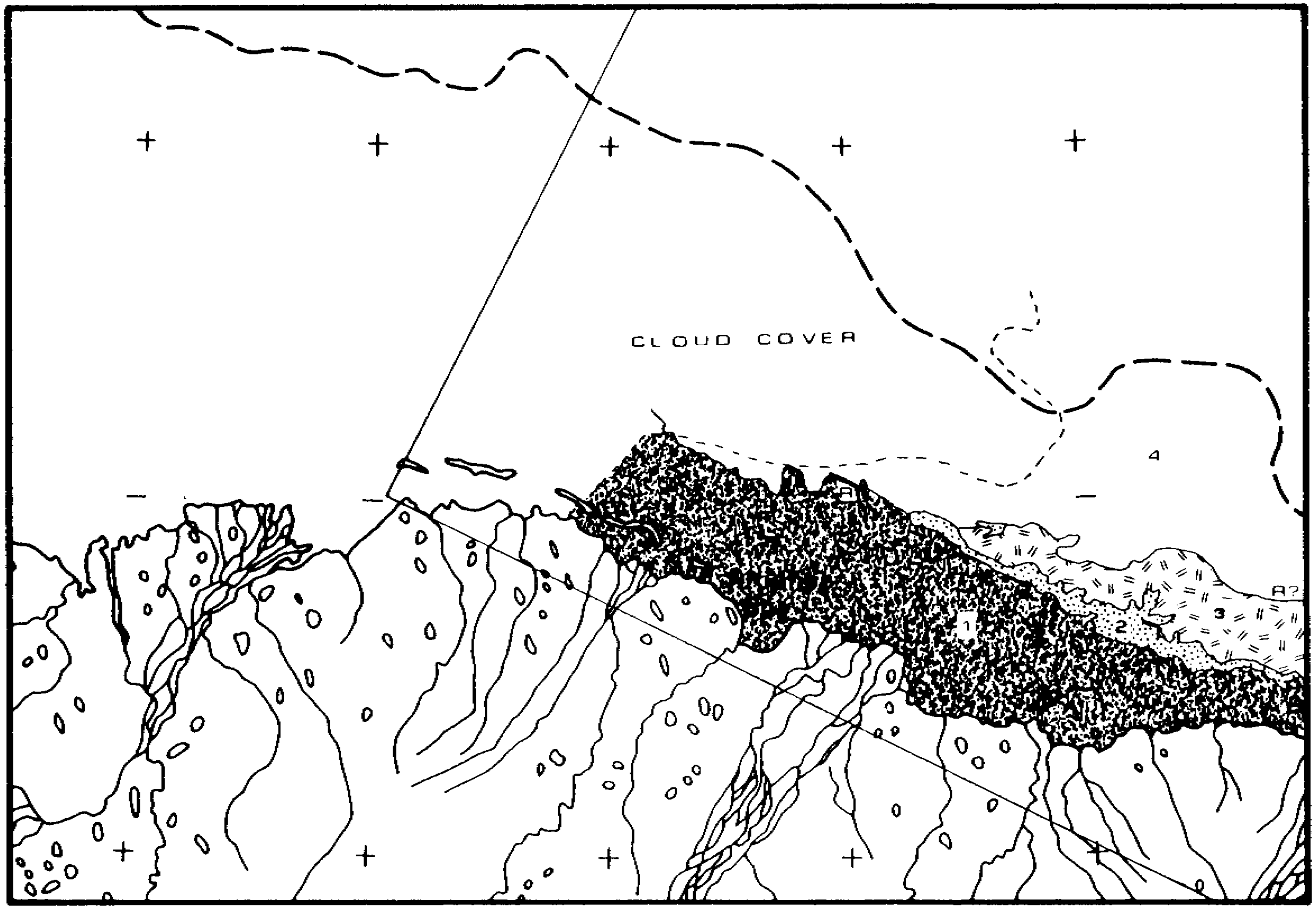
BEAUFORT SEA COAST: PRUDHOE SECTOR

21 JULY, 1975

Figure 26

4 August 1975: Scene E-2194-21050

In this late summer scene, clouds cover much of the western part of the frame and the pack ice. Open water (zone 1) extends along the coast in a band 5 to 25 km wide. This frame covers much of the same area as the 18 July frame, so comparisons can be made. The large body of "continuous" ice present in late July is completely gone. The pack ice edge is approximately the same on both frames (very close to the 10 fm contour). There appears to have been some tonal lightening in the pack ice since 18 July, however it is difficult to tell due to the cloud cover. The ridge 30 km northeast of Prudhoe Bay has not moved since 6 March. Several zones were distinguished in the ice based on tonal differences. Zone 2 is the darkest toned ice. It has quite a uniform tone, so it appears smooth. This ice looks ready to melt or break away and move into zone 1. Zone 3 is transitional between zones 2 and 4: it looks smoother and slightly darker in tone than zone 4 and more mottled and lighter toned than zone 2. Zone 4 is mainly cloud covered, however the ice appears well consolidated with some small areas of open water. There may be some ridging along the boundary with zone 3. Ice in zone 4 is a mottled tone and appears quite rough.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

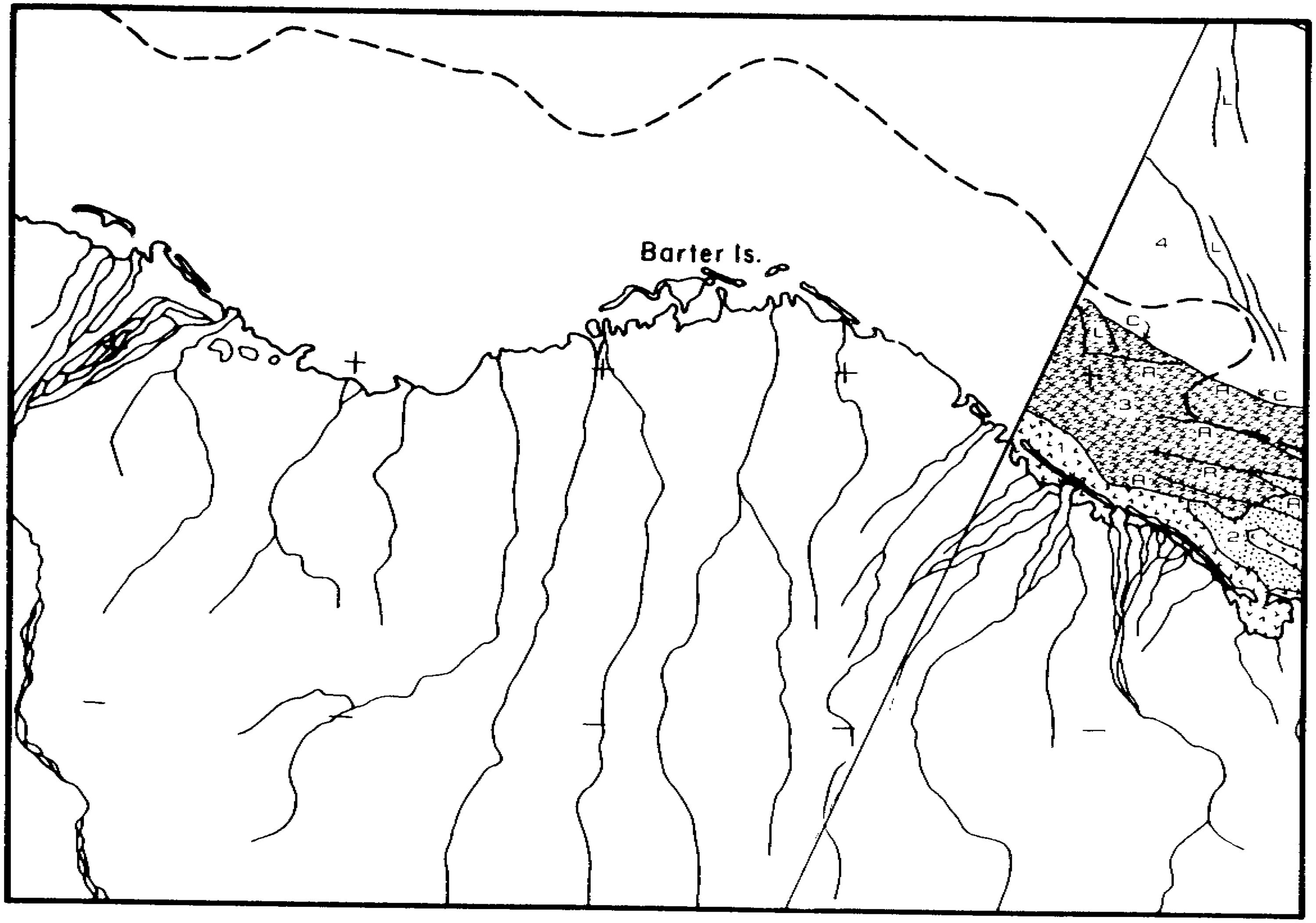
BEAUFORT SEA COAST: PRUDHOE SECTOR

4 AUGUST, 1975

Figure 27

8 March 1973: Scene E-1228-20435

In this winter scene, covering the eastern portion of the sector, many features are visible. There are a number of ridge systems (R), from 5 to 30 km from shore, running parallel to the coast. These ridges may be evidence of former continuous ice edges. The present continuous ice edge (C) is quite distinct on this date. The pack ice (4) is well consolidated, but there are many leads (L) and refrozen leads visible. Three zones have been delimited within the continuous ice based on grey tones and apparent "texture". The near shore ice (1) is light toned and smooth-looking. No major deformational features are present in this zone. Zone 2, which is also quite light toned, appears somewhat rougher in texture and several ridge systems are present. Zone 3 appears darker and rougher than zones 1 and 2. In some areas within this zone there are lighter toned floe-like objects surrounded by a darker matrix.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

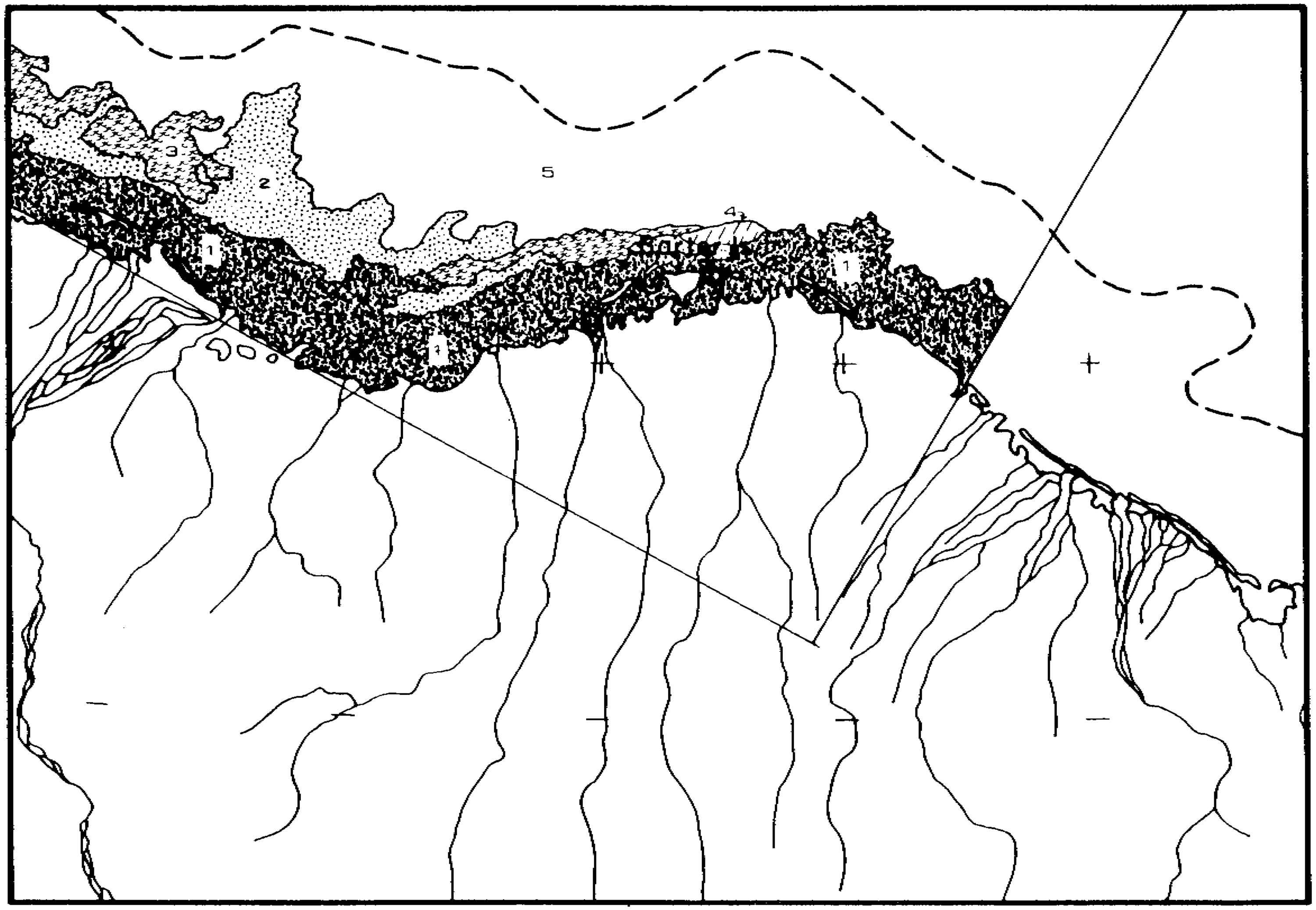
BEAUFORT SEA COAST: BARTER IS. SECTOR

8 MARCH, 1973

Figure 28

16 July 1973: Scene E-1358-21052

By this date most of the near shore ice is gone and open water (1) is present along the coast in a band approximately 5 to 10 km wide. There is quite a lot of floating ice in this zone, mainly along the seaward boundary. The average temperature at Barter Island from 1-15 July was 39°F, which is 1.8°F below normal. June temperature averages were also below normal (-0.1°F). Therefore, it appears that these relatively low temperatures are sufficient to melt nearshore ice. Several other zones of ice were differentiated on this frame. Zone 3 is the darkest toned ice, however there are small light areas within it. Zone 2 is lighter toned, mottled ice. The seaward boundary of this zone is quite arbitrary, since the tonal characteristics seem to blend gradually into the surrounding ice. Zone 4 is the lightest toned ice. It appears to be composed of a large ridged area that may be forming a barrier to the pack ice. Movements and stationary features cannot be determined on this frame since there is no earlier coverage of this area and comparisons cannot be made. The pack ice (5) is very well consolidated with little open water visible.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

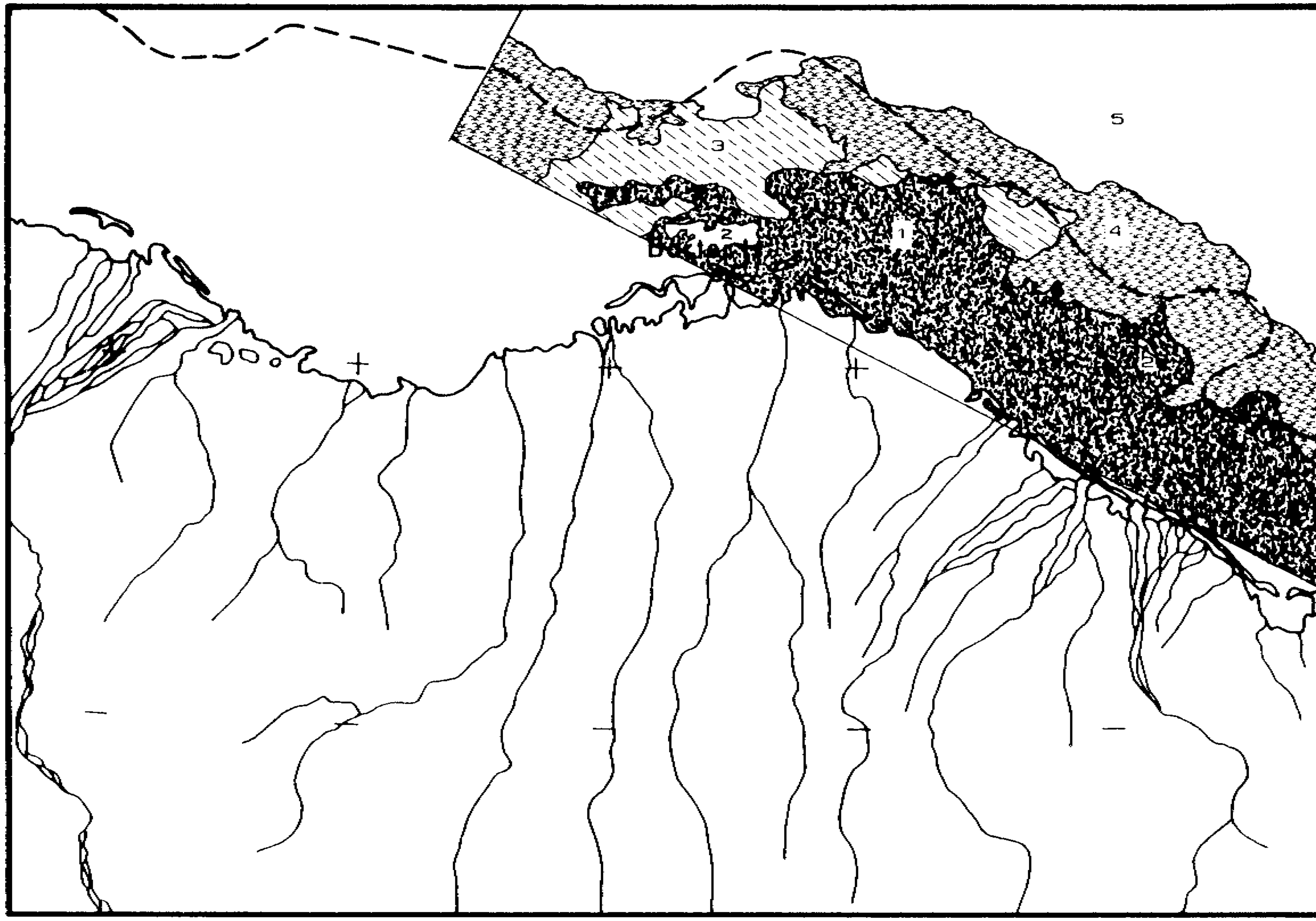
BEAUFORT SEA COAST: BARTER IS. SECTOR

16 JULY, 1973

Figure 29

1 August 1973: Scene E-1374-20534

In this late summer frame, open water and presumably floating ice (approximately 4/10 ice)(1) are present along the coast in a band approximately 10 to 20 km wide. Located within this zone and designated by a 2 are two ridged areas. The larger area, approximately 4 km northeast of Barter Island, has been stationary since 16 July, however there appears to have been some melting on the eastern side. The smaller area could not be determined on images taken earlier in the year, but appears to be a ridged zone. A number of the floes within zones 1, 3, and 4 are of a much brighter tone and appear somewhat deformed on their surfaces. This ice may be older than first year, although it is difficult to determine without additional types of imagery. This ice appears somewhat similar to the zone 2 ice, but distinct ridging cannot be distinguished. The remaining three zones were distinguished on the basis of ice concentration, as was zone 1. Zone 3 appears quite dark overall and has an ice concentration of approximately 6-7/10. Zone 4 appears lighter than zone 3 with an ice concentration of approximately 8-9/10. Zone 5 is composed of well consolidated pack ice. There is very little, if any, open water in the portion of this zone that is included on the map (in the seaward part of the frame, approximately 100 km from shore, there are small areas of open water).



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

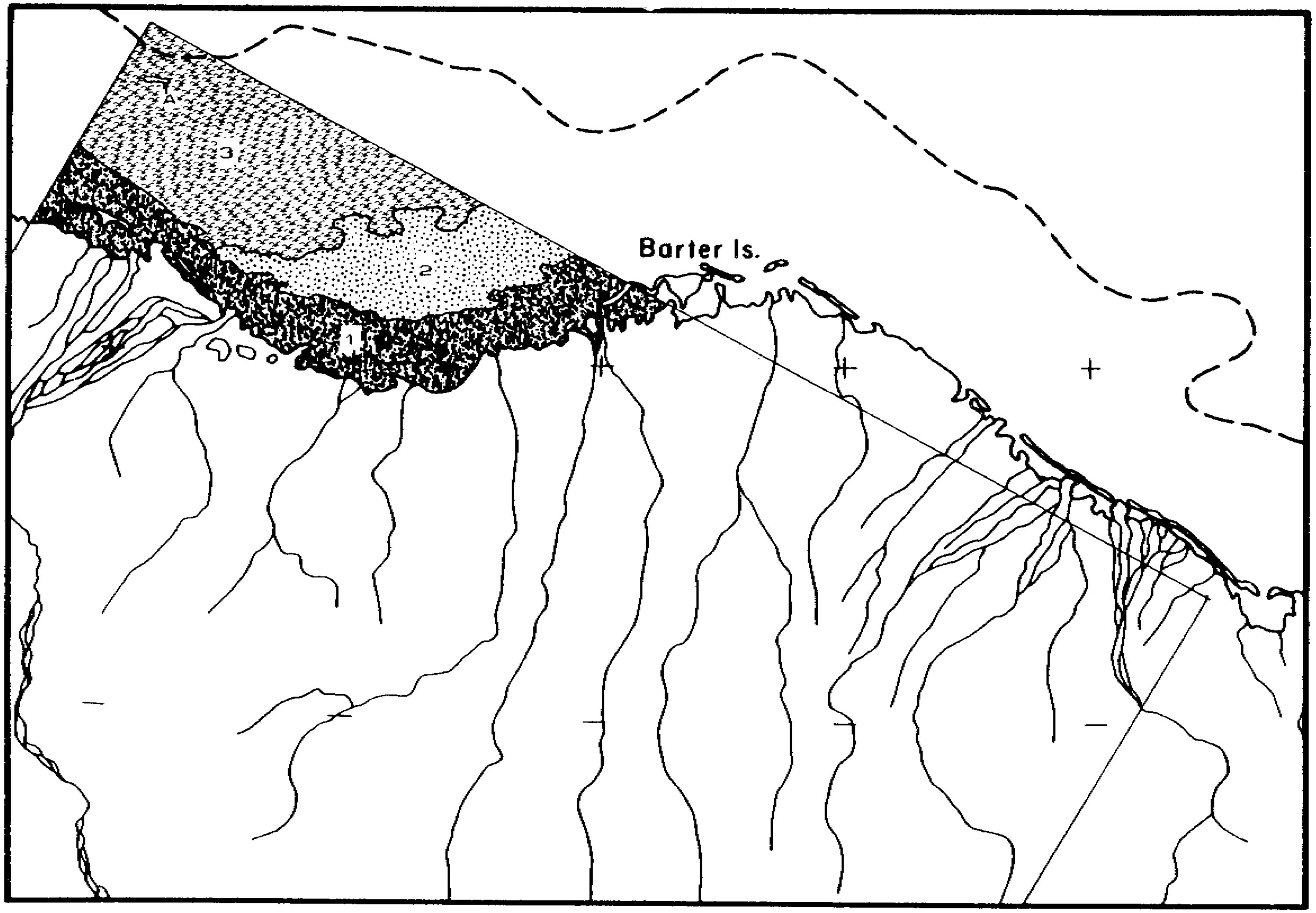
BEAUFORT SEA COAST: BARTER IS. SECTOR

1 AUGUST, 1973

Figure 30

2 August 1973: Scene E-1375-20595

This frame covers the area south and west of the previous frame (1 August), therefore recent ice movements cannot be mapped. Three zones were distinguished based on ice concentration. Zone 1 extends along the coast in a band 5 to 10 km wide and contains very little ice. Zone 2 is composed of approximately 8-9/10 ice, so it is fairly light toned overall. There are several vast-sized floes of very light tone in this zone that may be older than first year, but this cannot be determined without additional imagery. Zone 3 is darker overall than zone 2, having an ice concentration of approximately 5-6/10. There is a large oblong feature (A) in the northern part of the frame that appears to be quite deformed. This feature is not present in the mid-July imagery and this area is not covered by later frames, so it is not known whether this ice is grounded.



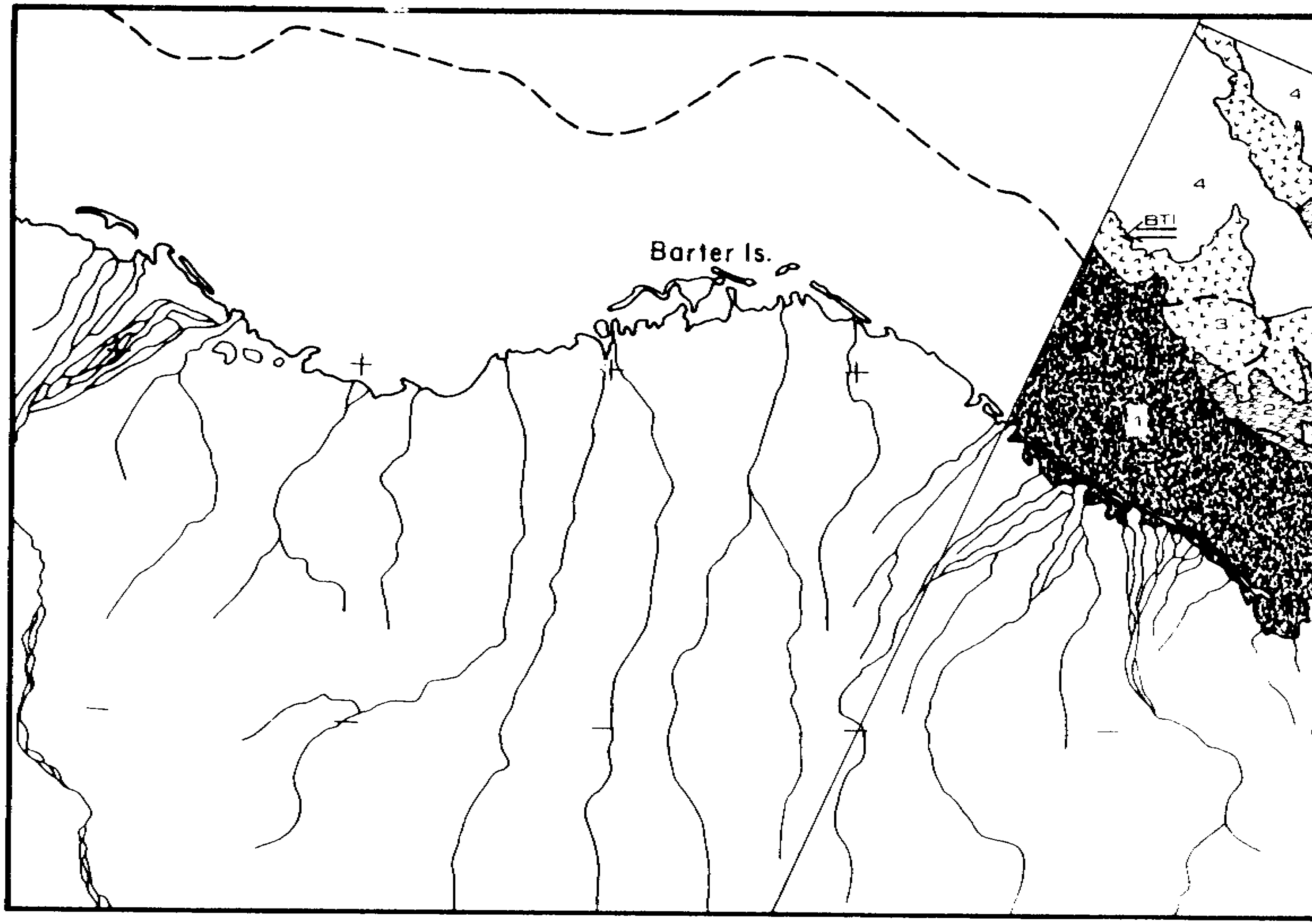
SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
BEAUFORT SEA COAST: BARTER IS. SECTOR

2 AUGUST 1973

Figure 31

17 August 1973: Scene E-1390-20423

The eastern part of the sector is covered by this late summer frame. There is some light cloud cover over the ice, but several zones were still distinguishable based on ice concentration. Zone 1 has the least amount of ice, approximately 3/10. Some of the larger, lighter toned floes appear somewhat deformed and may be older ice, but without additional types of imagery it is very difficult to be certain. There appears to be ice built up in a narrow band on the seaward sides of the barrier islands, however. At Barter Island, winds were from the east on 15 and 16 August at an average speed of 5.2 m/sec (shown by a double arrow on the map). These rather high winds were probably at least part of the cause of this ice build-up. There is no other summer or fall coverage of this area, so it is not known whether this ice was a lasting feature. The only overlapping coverage of this area is in March and April, and none of the ice features present in those frames are visible in this late summer frame. Zone 2 is composed of open water and ice in approximately 5/10 concentration. In zone 3 the ice is more consolidated, being in about 8/10 concentration. The ice is most concentrated in zone 4, in which there are only a few small areas of fragmented ice in which open water is present.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

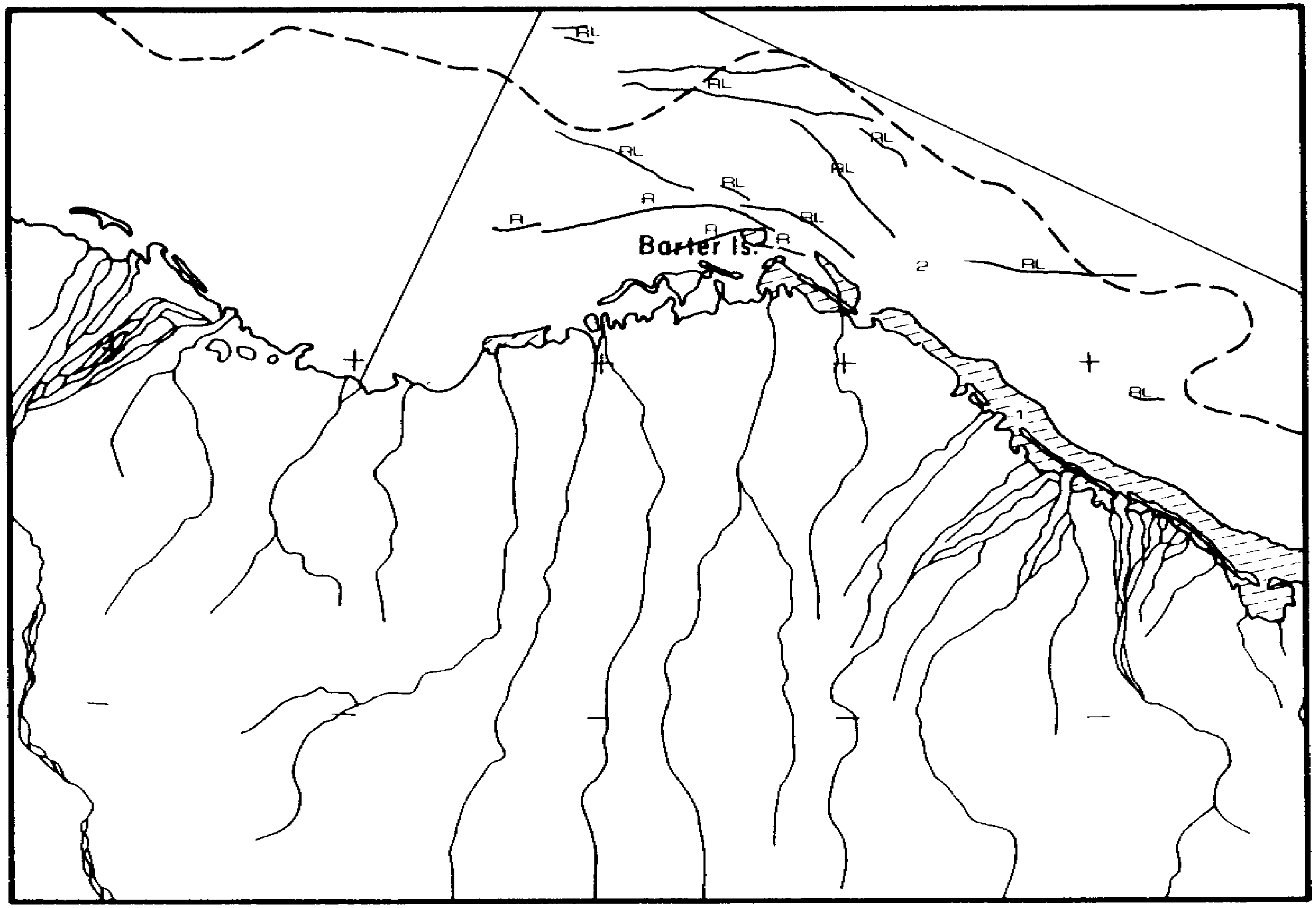
BEAUFORT SEA COAST: BARTER IS. SECTOR

17 AUGUST, 1973

Figure 32

5 March 1974: Scene E-1590-20495

In this late winter frame, many ridges (R) and refrozen leads (RL) are present. Two contrasting grey tones are apparent. A lighter tone (1) is located at various places along the coast in a zone approximately 3 to 5 km wide. This zone seems to disappear until the 21 June frame, in which several of these areas are present. Zone 2 consists of darker and somewhat less uniformly toned ice. The ridges and refrozen leads are located in this zone.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

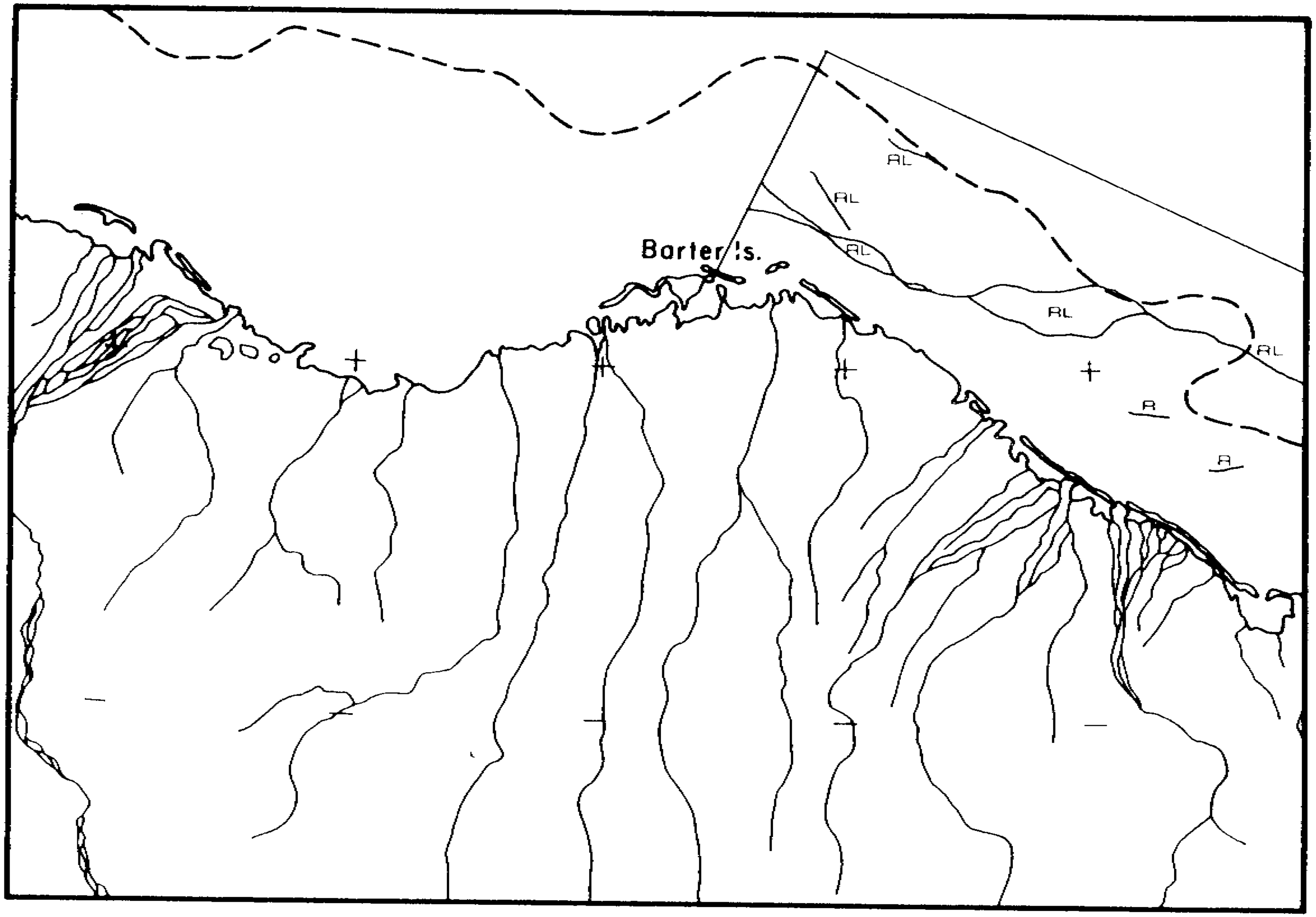
BEAUFORT SEA COAST: BARTER IS. SECTOR

5 MARCH 1974

Figure 33

9 April 1974: Scene E-1625-20432

There is a large area of refrozen leads (RL) located from 10 to 25 km offshore. Some small ridges (R) are located shoreward of this zone. Overall, the ice is a fairly uniform light tone. The rivers have noticeatly darkened by this date.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

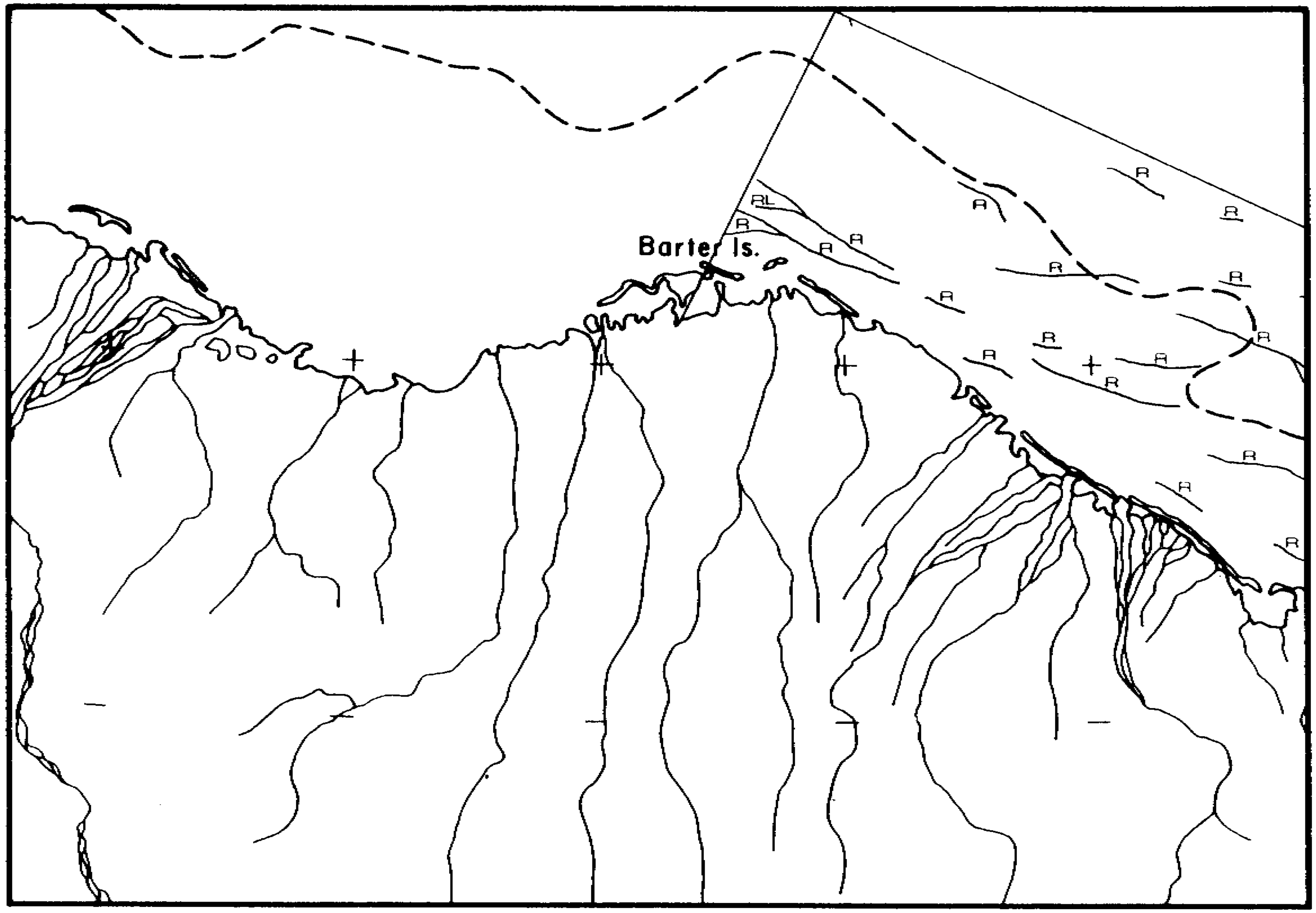
BEAUFORT SEA COAST: BARTER IS. SECTOR

9 APRIL 1974

Figure 34

15 May 1974: Scene E-1661-20423

By this date, most of the rivers appear very dark. Overall, however, the ice has remained quite light toned. There are many well-defined ridges (R) present on this frame, many of which have been present and stationary since the March and April frames.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

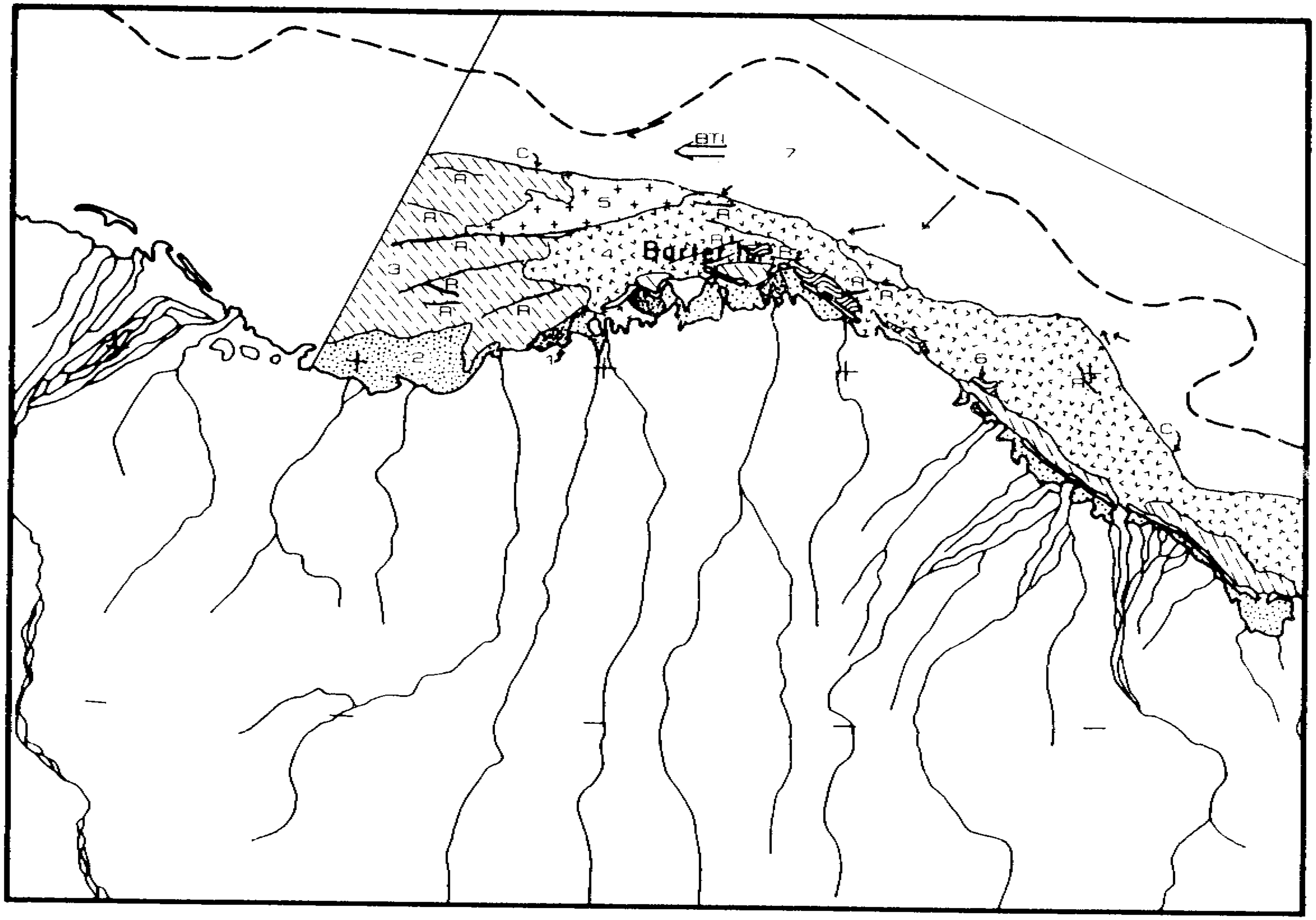
BEAUFORT SEA COAST: BARTER IS. SECTOR

15 MAY 1974

Figure 35

21 June 1974: Scene E-1698-20470

In this late spring scene, the continuous ice extends along the coast in a band 7 to 35 km wide. Seaward of the continuous ice edge (C) is a zone of open water and then a zone of fairly compacted pack ice (7). Floe movements in the pack ice from 21 June to 22 June are shown by arrows on the map. Winds from 20 to 22 June at Barter Island, shown by a double arrow on the map, were from the east at 8 m/sec. The continuous ice is in various stages of puddling, as is shown by the 6 mapped zones. Many ridges (R) are present. A ‡ indicates those ridges which have not moved since the 5 March frame. Zone 1, the darkest tone, consists of open water, flooded, and/or very thin ice and is located at the mouths of major rivers. Zone 2 is also a very dark tone, although no open water is apparent. This ice looks quite smooth. Comparing bands 4 and 7, it is believed that the water on the ice is quite shallow; some drainage cracks are visible. Overall zone 3 is fairly dark in all bands, although there is much variation within this zone which produces a mottled appearance. There are many distinct ridges in this zone. Zone 4 appears very similar to zone 3, however puddling does not seem to be as far advanced since the ice is a lighter tone overall. The ice that is the lightest toned in all bands is designated zone 5. It is also slightly mottled but appears more uniform than either zone 3 or 4, possibly due to drainage. Zone 6 consists of small areas of smooth looking, dark toned ice. Several of these areas were present on the 5 March frame, in which they were light toned. They are also distinguishable on the color infrared imagery.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

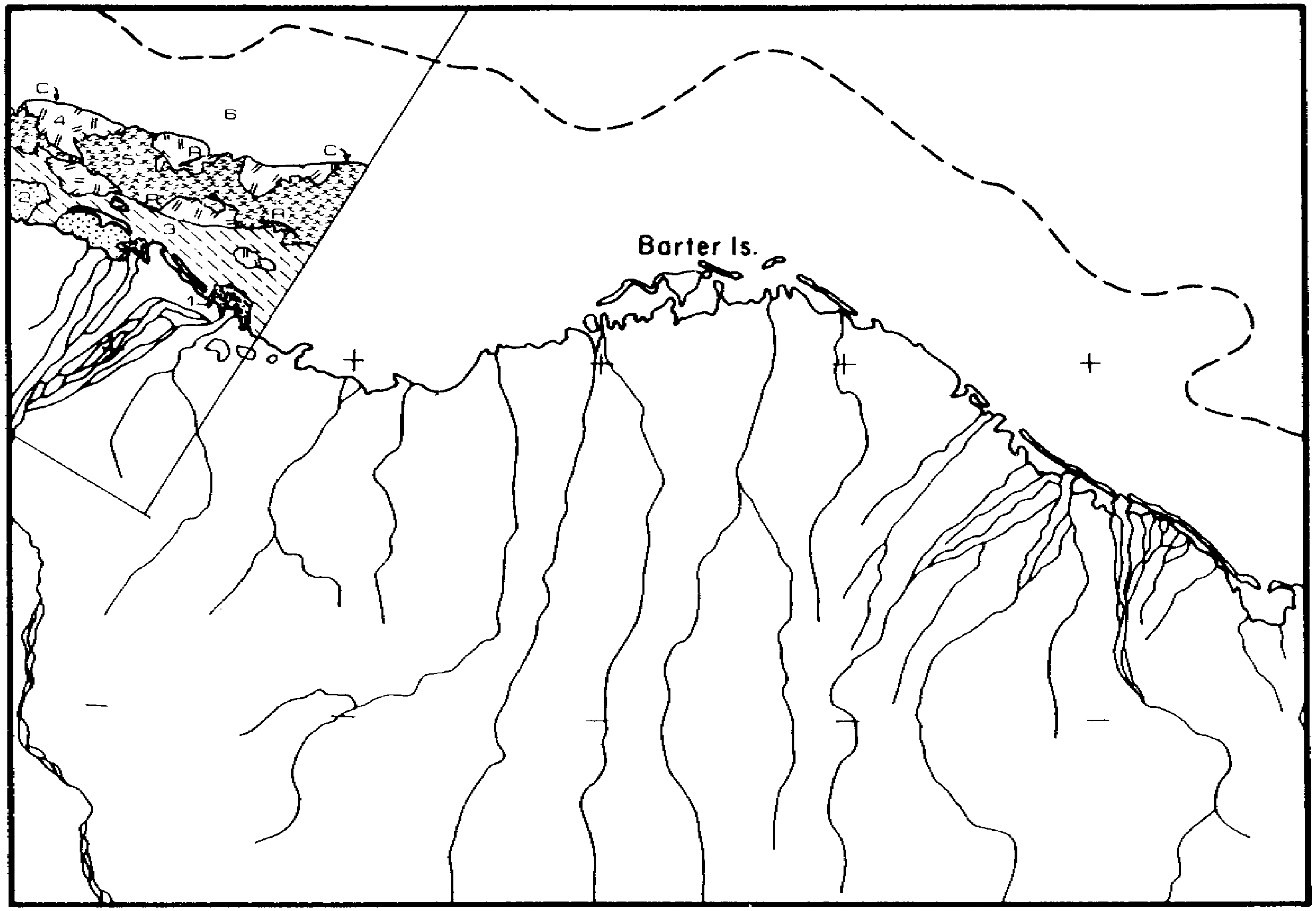
BEAUFORT SEA COAST: BARTER IS. SECTOR

21 JUNE 1974

Figure 36

25 June 1974: Scene E-1702-21093

This frame covers the western part of the sector, which has not been mapped previously in 1974. The pack ice (6) is fairly well consolidated on this date. Little open water is present shoreward of the continuous ice edge (C). Zone 1, which consists of two small areas at the mouth of the Canning River, appears to be open water, with some floating ice. Smooth looking, fairly dark toned ice (2) is located shoreward of the barrier islands. Many drainage cracks are present in this zone, and some drainage has probably occurred. Zone 3, the lightest toned ice overall, is quite mottled and appears rough. Zone 4 is slightly darker than zone 3, but otherwise looks very similar to it. Zone 5, the darkest toned ice, appears quite uniform in tone. There are many small, light lineations present, however. Movements could not be determined for this frame, since no earlier imagery was available.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

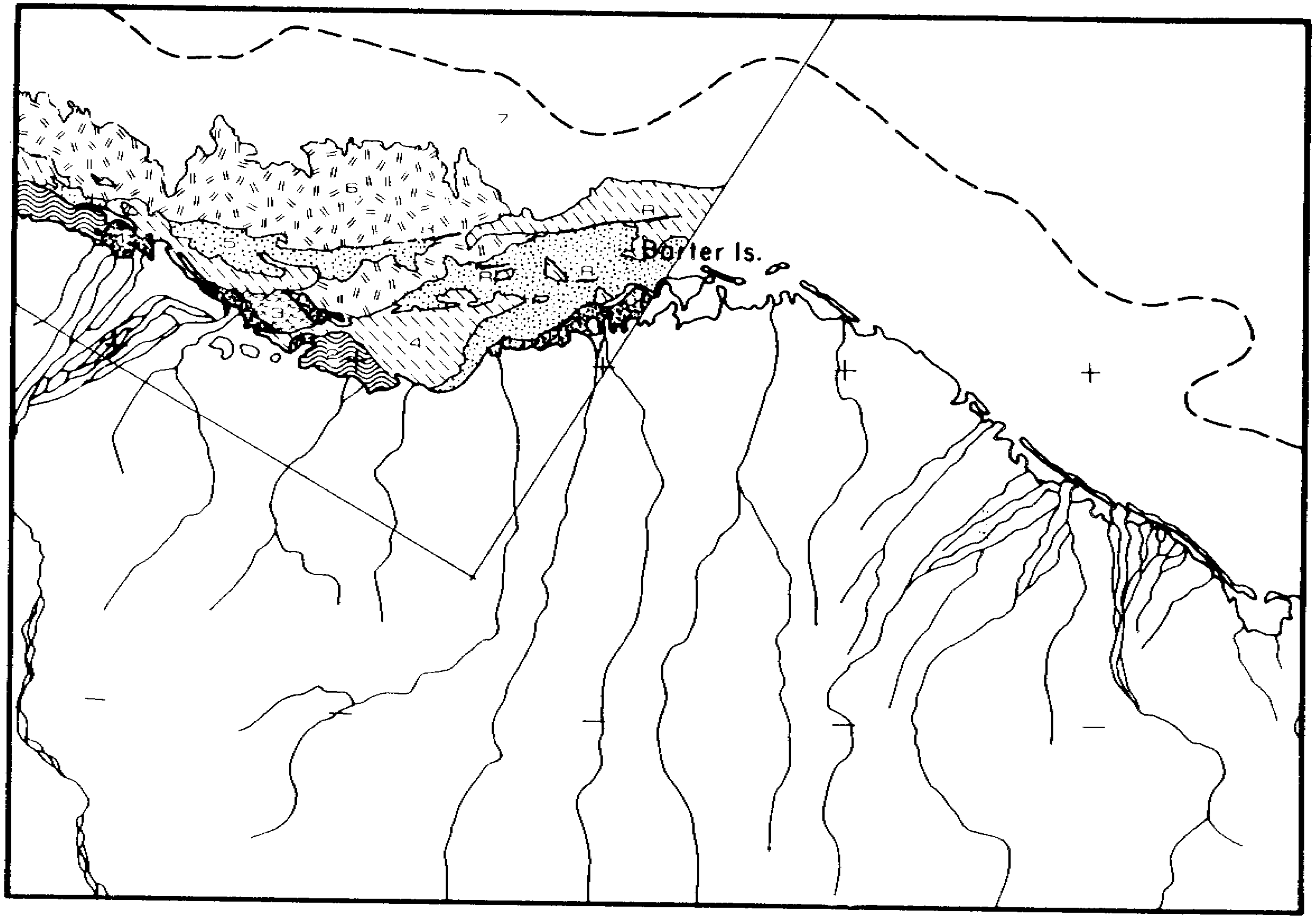
BEAUFORT SEA COAST: BARTER IS. SECTOR

25 JUNE 1974

Figure 37

12 July 1974: Scene E-1719-21031

This summer frame covers the western half of the sector. Overall, the ice has darkened considerably since 25 June but it is still quite continuous. Open water is present in several fairly small areas (1), mainly along the coast. Zone 2 consists of smooth looking nearshore ice that is a medium grey tone. There appears to be slightly more water on this ice than was present on the 25 June frame. A small area of fairly dark toned ice (3) is located between two open water areas. This ice appears to be ready to break up. The lightest toned ice on this frame (4) has a somewhat mottled appearance, indicating some puddling differences within the zone. Zone 5, which is fairly dark overall, shows a great deal of puddling variation. The darkest toned ice (6) is fairly uniform in tone, with the exception of numerous, relatively small light toned areas. The pack ice (7) is quite well consolidated on this date. No ice motions could be detected after comparing this frame with earlier ones. The large ridge located approximately 10 km north of Barter Island has remained stationary since 5 March.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

BEAUFORT SEA COAST: BARTER IS. SECTOR

12 JULY 1974

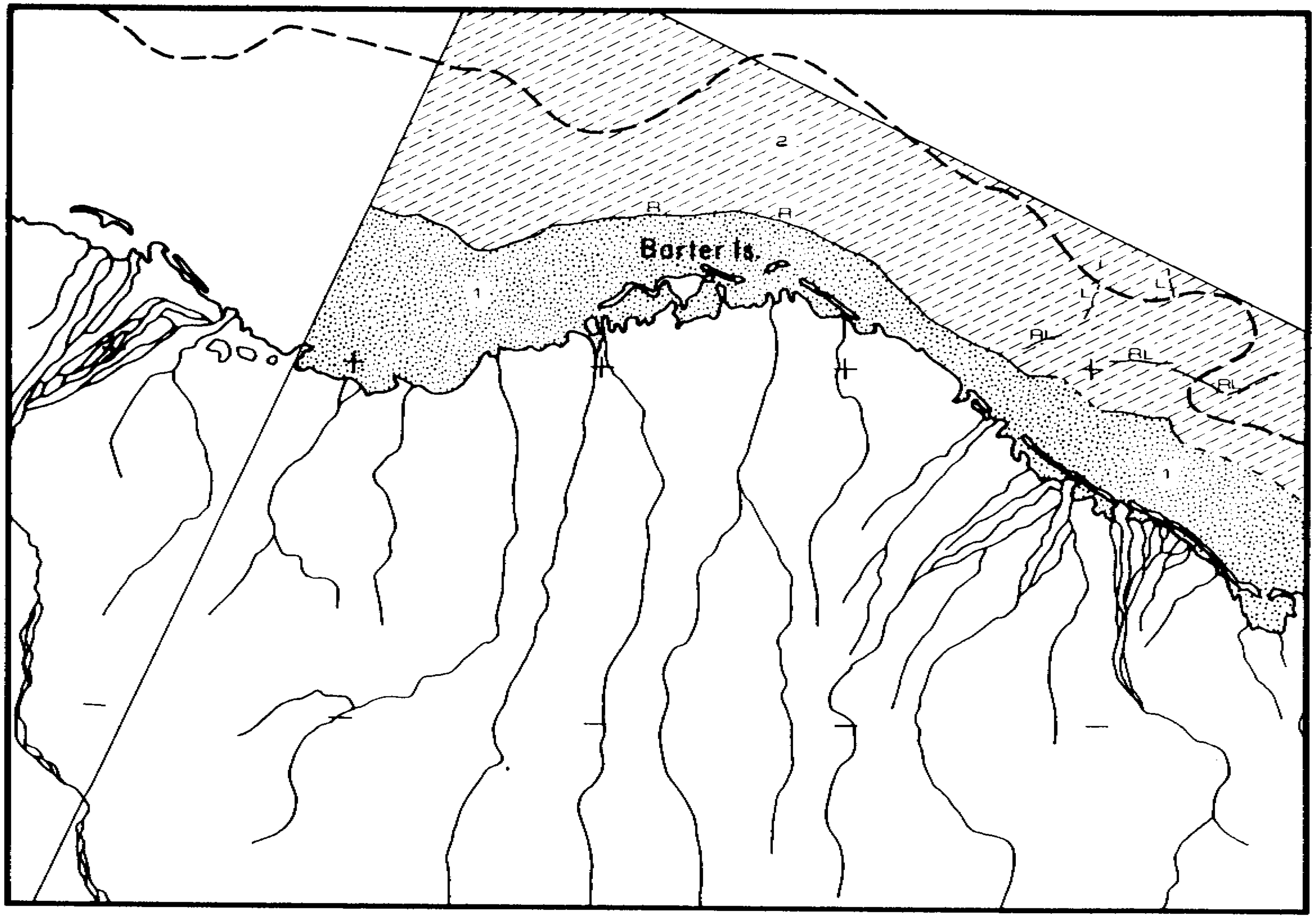
20 September 1974: Scene E-1789-20493

This fall frame covers the western part of the sector. It is mainly open water, excepting a band of loose ice (approximately 3/10 ice) that is located from 1 to 20 km offshore. This frame was not mapped.

Figure 38

28 February 1975: Scene E-1950-20375

In this winter scene the ice is quite consolidated with very little open water present. Light toned smooth-looking ice (1) extends along the coast in a band 5 to 25 km wide. There appears to be some ridging (R) along the seaward boundary of this zone. This boundary (shown by dashed lines where uncertain) follows the 10 fm contour quite well in the western 3/4 of the frame. Zone 2, which consists of light toned floe-like objects in a darker matrix, does not appear as smooth as zone 1. There are a few small leads (L) and larger refrozen leads (RL) present in this zone.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

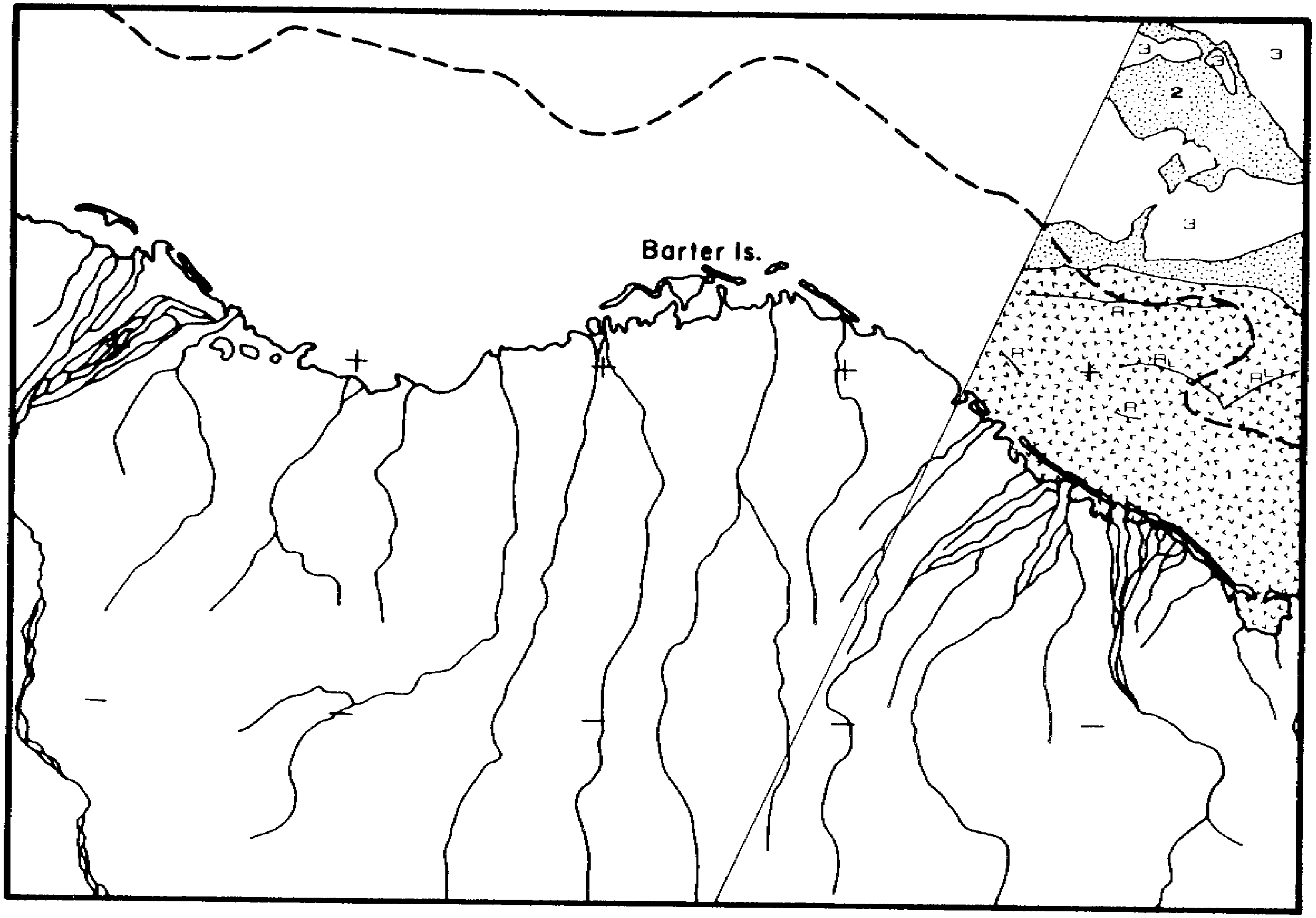
BEAUFORT SEA COAST: BARTER IS. SECTOR

28 FEBRUARY, 1975

Figure 39

16 March 1975: Scene E-1966-20254

This winter frame covers the eastern part of the sector. The continuous ice (1) extends along the coast in a band 25-40 km wide. There are several ridges (R) and refrozen leads (RL) present within this zone. The ridge closest to shore was on the 28 February continuous ice edge. There may also be some ridging along the continuous ice edge on this frame. Beyond zone 1, the ice is quite broken up. Zone 2 is composed mainly of open water, refreezing ice, or newly refrozen ice. Giant-sized floe-like objects of very light tone compose zone 3. Several of these objects appear to have cracked off from the main body of the ice and moved to the southwest into zone 2.

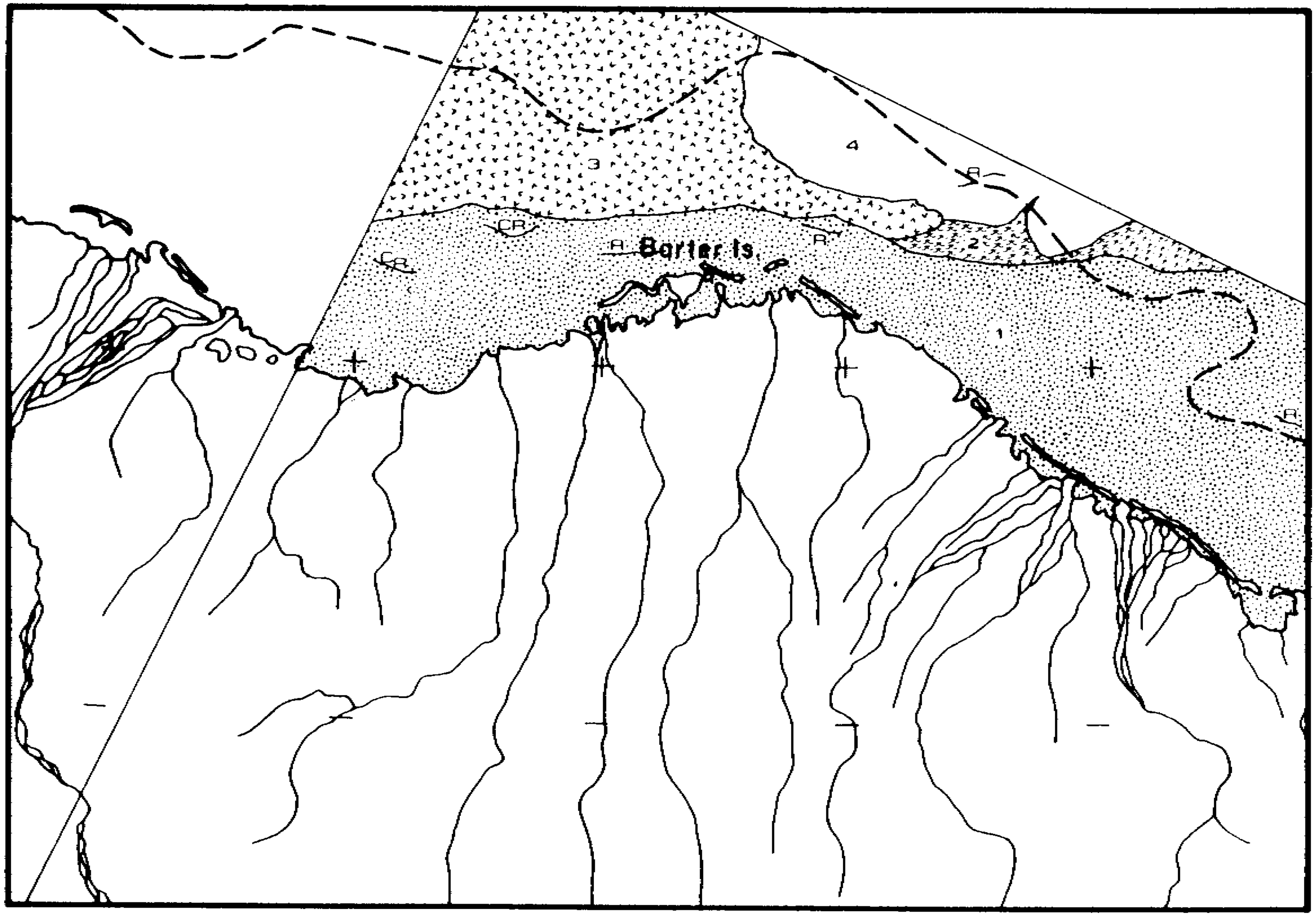


SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
BEAUFORT SEA COAST: BARTER IS. SECTOR
16 MARCH, 1975

Figure 40

18 March 1975: Scene E-1968-20370

This frame covers most of the sector, but clouds obstruct the ice in the eastern part. Zone 1 is composed of light toned nearshore ice. The seaward boundary follows the 10 fm contour fairly well in the western part of the frame. There are a number of small ridges (R) and two cracks (CR) present in this zone. This frame overlaps the previous frame (16 March) in the eastern portion. However, the overlap is mainly in the cloud covered portion of zone 1. Zone 2, an area of darker toned, rougher-looking ice, coincides with the western part of the 16 March zone 2. There appears to have been approximately 10 km of southwestward movement since 16 March. Variously sized (mainly big to vast) light toned floe-like objects in a darker matrix compose zone 3. Zone 4 is light toned consolidated ice. A small ridge (R) is present in this zone.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

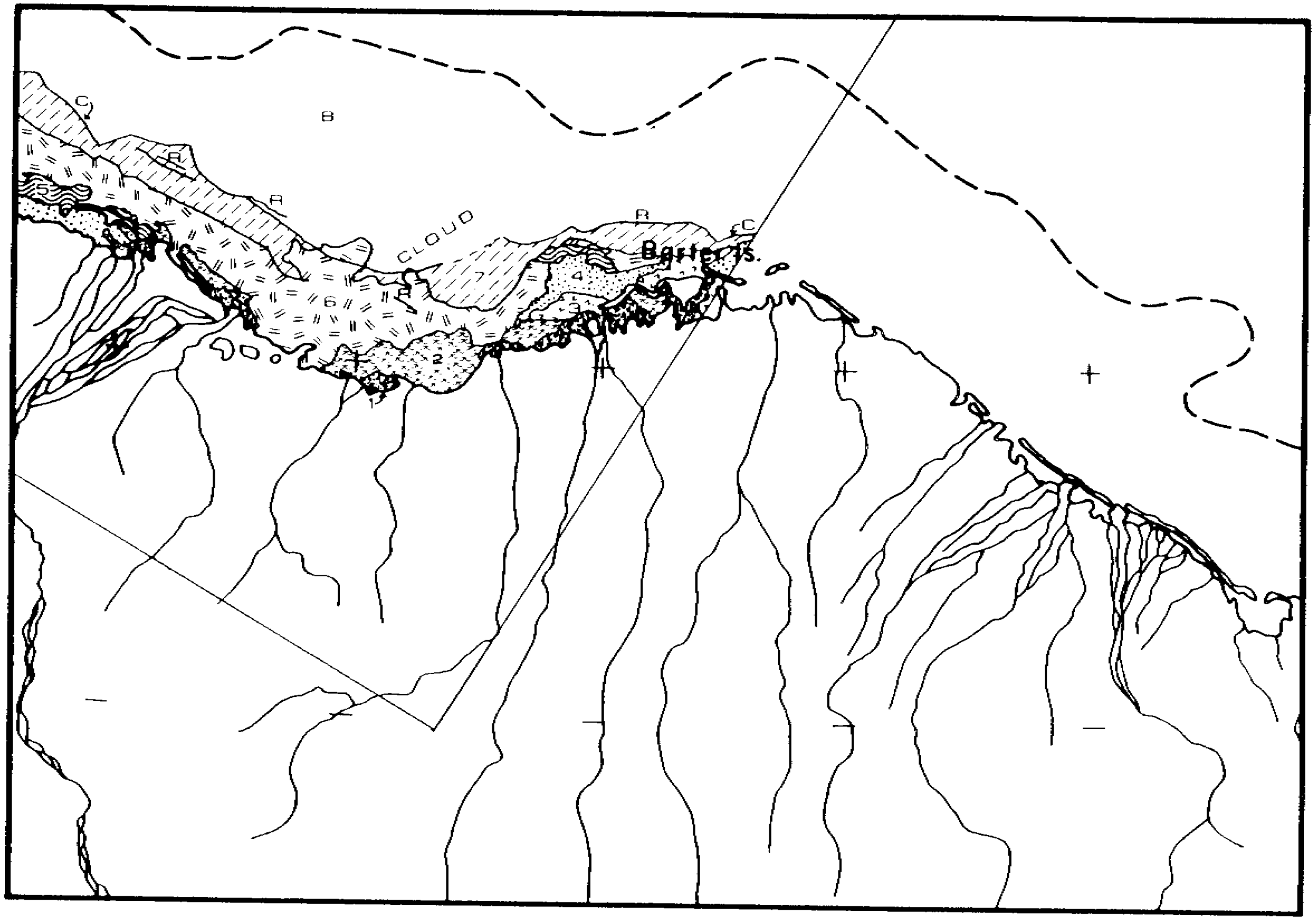
BEAUFORT SEA COAST: BARTER IS. SECTOR

18 MARCH, 1975

Figure 41

28 June 1975: Scene E-2157-20595

This late spring scene covers the area west of Barter Island. The continuous ice edge (C) is quite distinct on this date. There has been much puddling of the ice shoreward of this boundary. Zone 1, located mainly at river mouths, is a very dark tone in all bands and may be open water and/or heavily flooded ice. Zone 2 is a lighter tone than zone 1, but is darker in all bands than the other zones. The ice appears smooth and of a uniform tone; it is probably heavily puddled ice. Zone 3 is a fairly dark tone and appears quite smooth. There are some lighter lineations within this zone. Light toned, smooth-looking ice with an abrupt seaward boundary comprises zone 4. This ice appears very light on band 4, so there is probably a limited amount of water on the ice. Another zone of ice that is dark in all bands is zone 5. It is only slightly lighter in tone than zone 2, and puddling is probably in an advanced stage. There are some small light areas within this zone. Zone 6 appears quite similar to zone 3, being a fairly dark tone overall with many light lineations (some may be due to ridging) and some areas of lighter tone. The ice appears smoother along the shoreward side of the zone and rougher to seaward. Zone 7 is bounded to seaward by the continuous ice edge, which follows the 10 fm contour quite well. The shoreward boundary with zone 6 is quite distinct also. This zone is a very light tone and appears quite rough. There is some ridging (R) in this zone. The ridge approximately 10 km north of Barter Island has been stationary since 28 February. The pack ice (8) is fairly consolidated to shoreward and somewhat more broken up to seaward.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

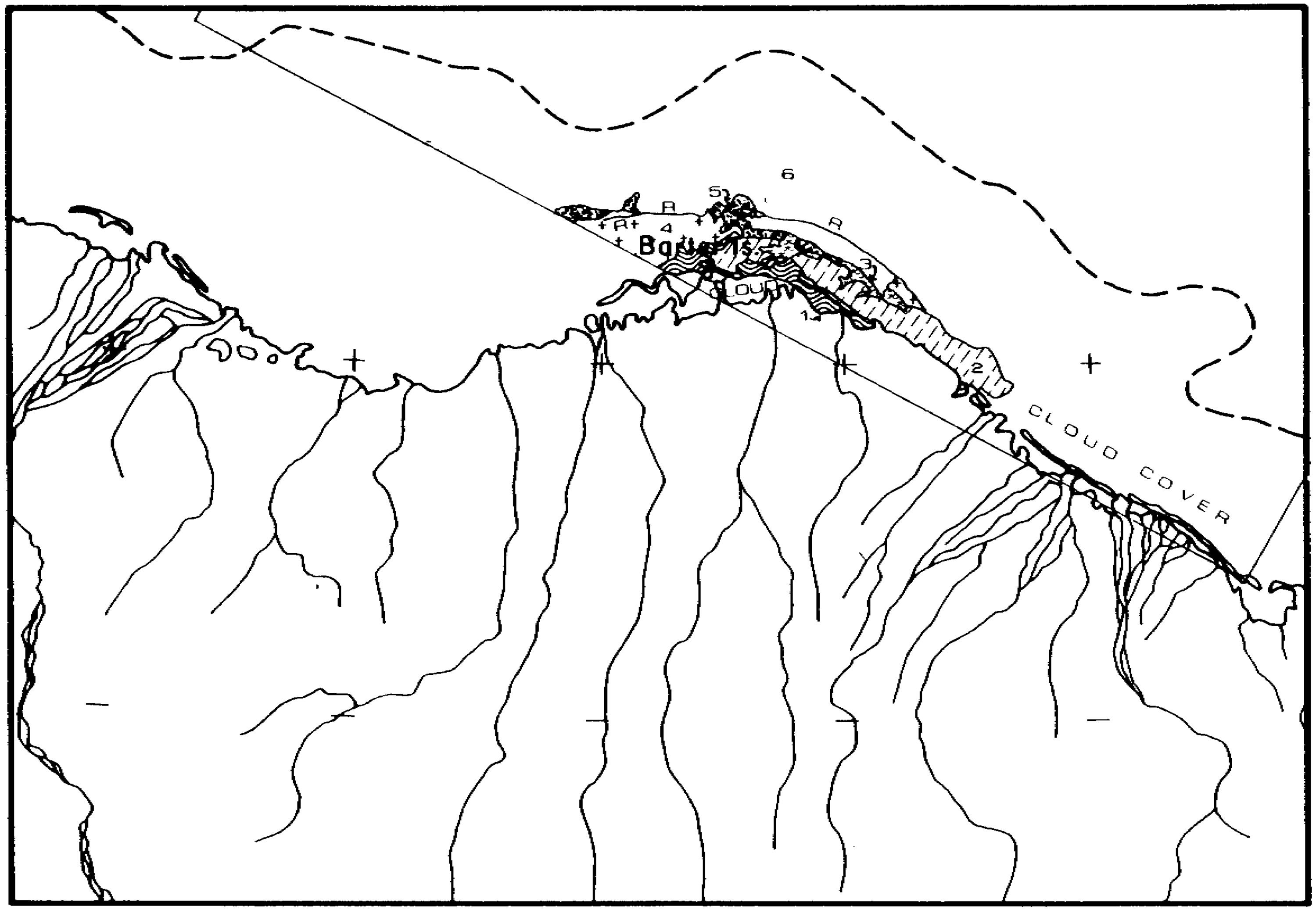
BEAUFORT SEA COAST: BARTER IS. SECTOR

28 JUNE, 1975

Figure 42

14 July 1975: Scene E-2173-20481

On this summer frame, there is cloud cover over much of the coast and the continuous ice, so it is difficult to determine boundaries based on puddling differences. In the part of the frame that overlaps with the 28 June frame (a small area around Barter Island) there does not appear to have been much change in the ice conditions. The ice is still continuous close to shore. Zone 1 is smooth-looking ice that is fairly dark toned in all bands. Zone 2 is lighter toned than zone 1, but looks very similar. Zone 3 is a very small area and is similar in tone to zone 1, but appears to be a rougher texture and has some light lineations. The ice of the lightest tone on this frame is zone 4. Overall this zone appears quite smooth but there is ridging along the seaward boundary. Zone 5, the darkest tone, appears to be open water with floating ice. This zone bisects the major ridge system which runs approximately 10 km from and parallel to the coast. The ridges seem to be present in this area on earlier frames, so it appears that they have been rafted away since 28 June. Zone 6 is pack ice which is fairly consolidated except in the southeastern corner of the frame.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

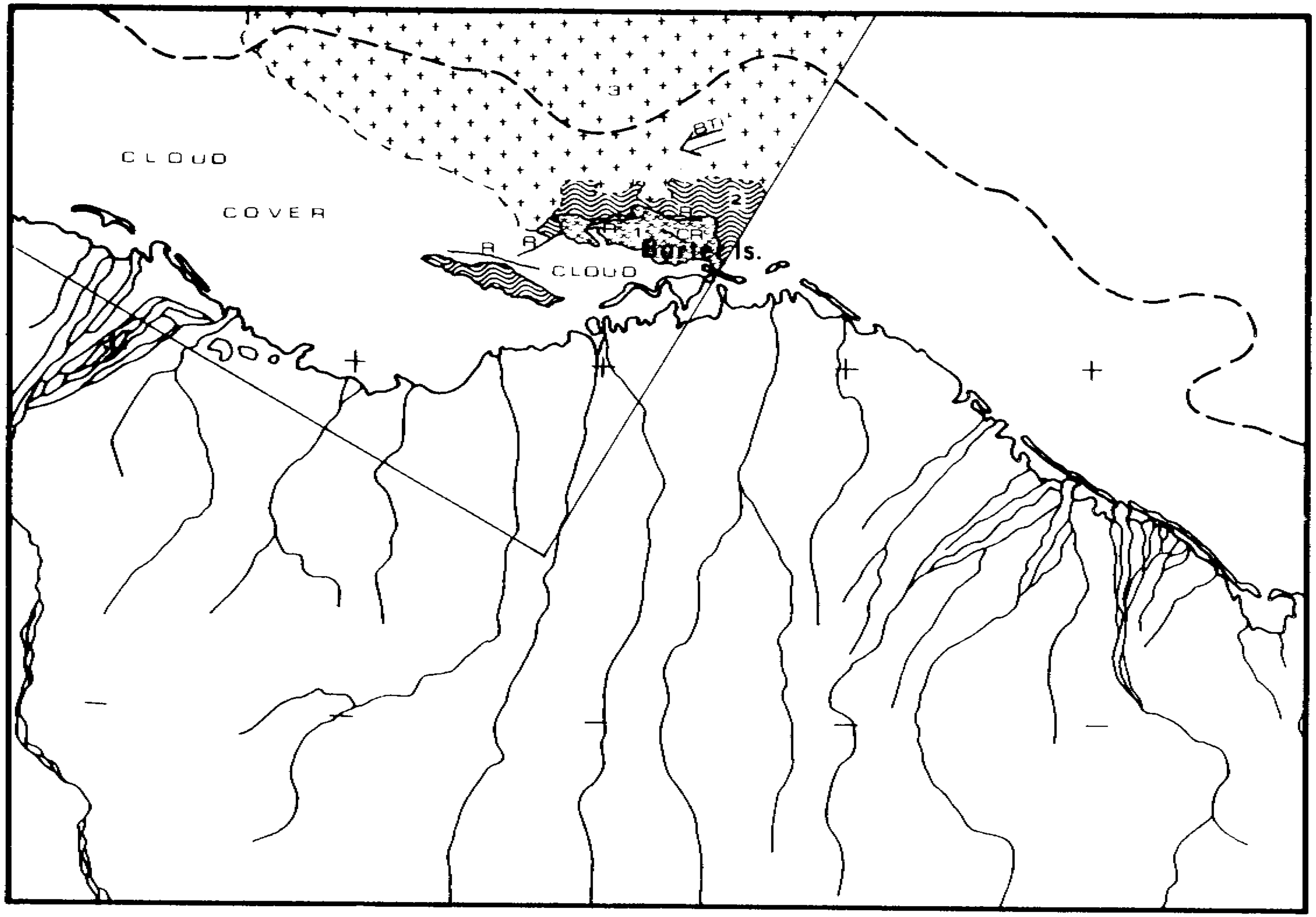
BEAUFORT SEA COAST: BARTER IS. SECTOR

14 JULY, 1975

Figure 43

16 July 1975: Scene E-2175-20594

Clouds cover much of this summer frame, making it quite difficult to distinguish ice boundaries. It is not possible to determine the nature of the ice (continuous ice, open water, or open water with floes) close to shore, due to clouds. The prominent ridge system (R) north of Barter Island appears to have remained stationary since at least 28 June. It seems to be breaking apart in several places by 16 July, however. There is an area of quite cohesive ice (1) that is attached to and extends shoreward from this ridge system. Overall this ice is a medium grey tone but is somewhat darker in the shoreward half. A large crack (CR) has developed in the center of the zone since 14 July. Zone 2 appears to be mainly open water with floating ice. The boundary is dashed where uncertain, due to a gradually changing ice concentration. In much of this area (zone 2), the ice was quite continuous on the previous frame (14 July). Winds (shown by a double arrow on the map) from 13 through 16 July were from the ENE at an average speed of 6.4 m/sec at Barter Island, and this may have been part of the cause of the ice deterioration north of Barter Island. The pack ice (3) is quite consolidated on this date.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

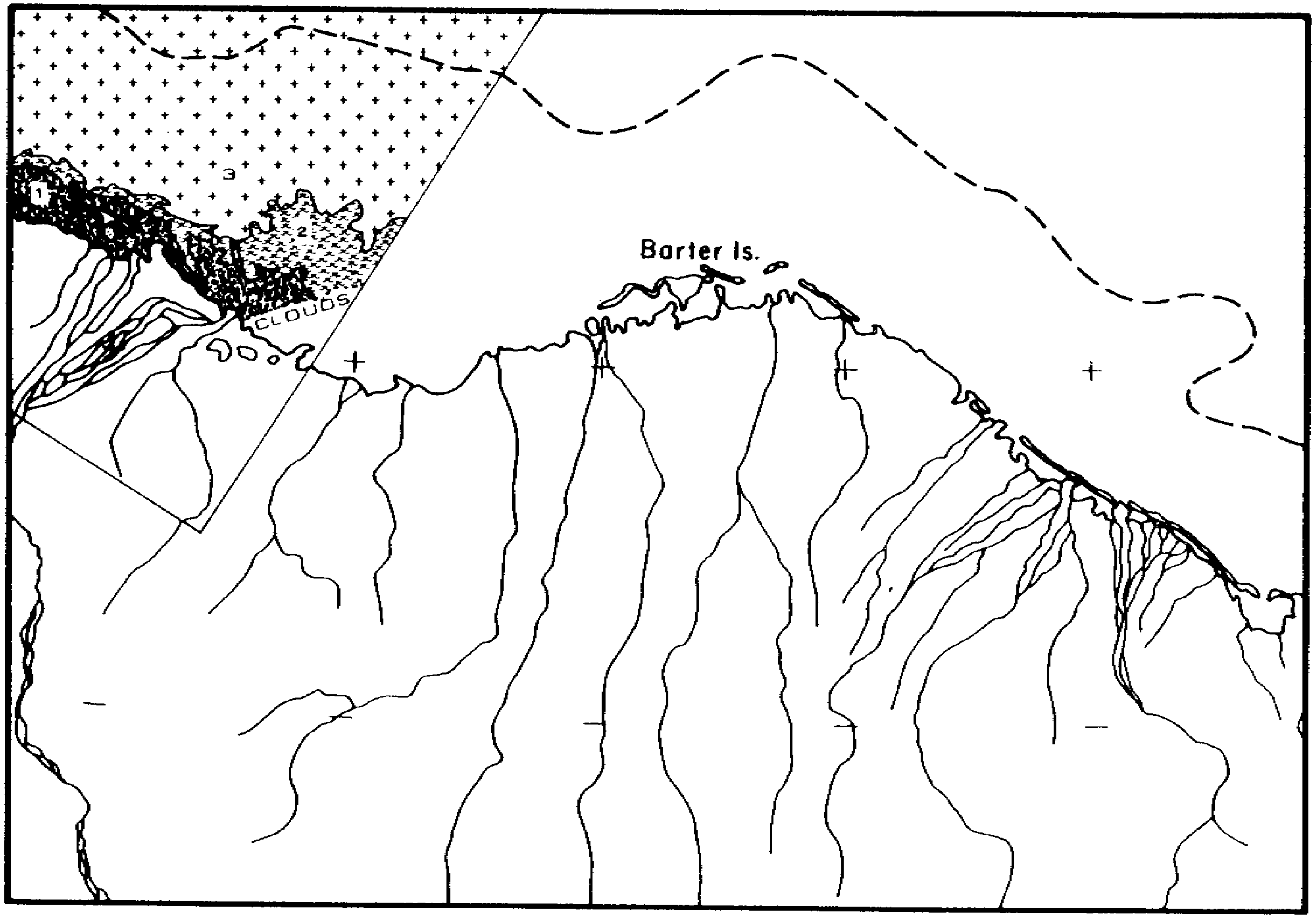
BEAUFORT SEA COAST: BARTER IS. SECTOR

16 JULY, 1975

Figure 44

4 August 1975: Scene E-2194-21050

By this date, most of the nearshore ice is gone. There is some cloud obstruction, mainly along the eastern edge of the frame. Zone 1 is mainly open water with a small amount of floating ice. Zone 2, on the edge of the pack ice, is quite dark toned ice. There is some cloud obstruction in the eastern part of the zone, which makes identification somewhat difficult. Zone 3, fairly light toned pack ice, is quite consolidated. No similar ice features can be seen when comparing the 4 August frame with that of 28 June, which is the only previous frame that covers the same area.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

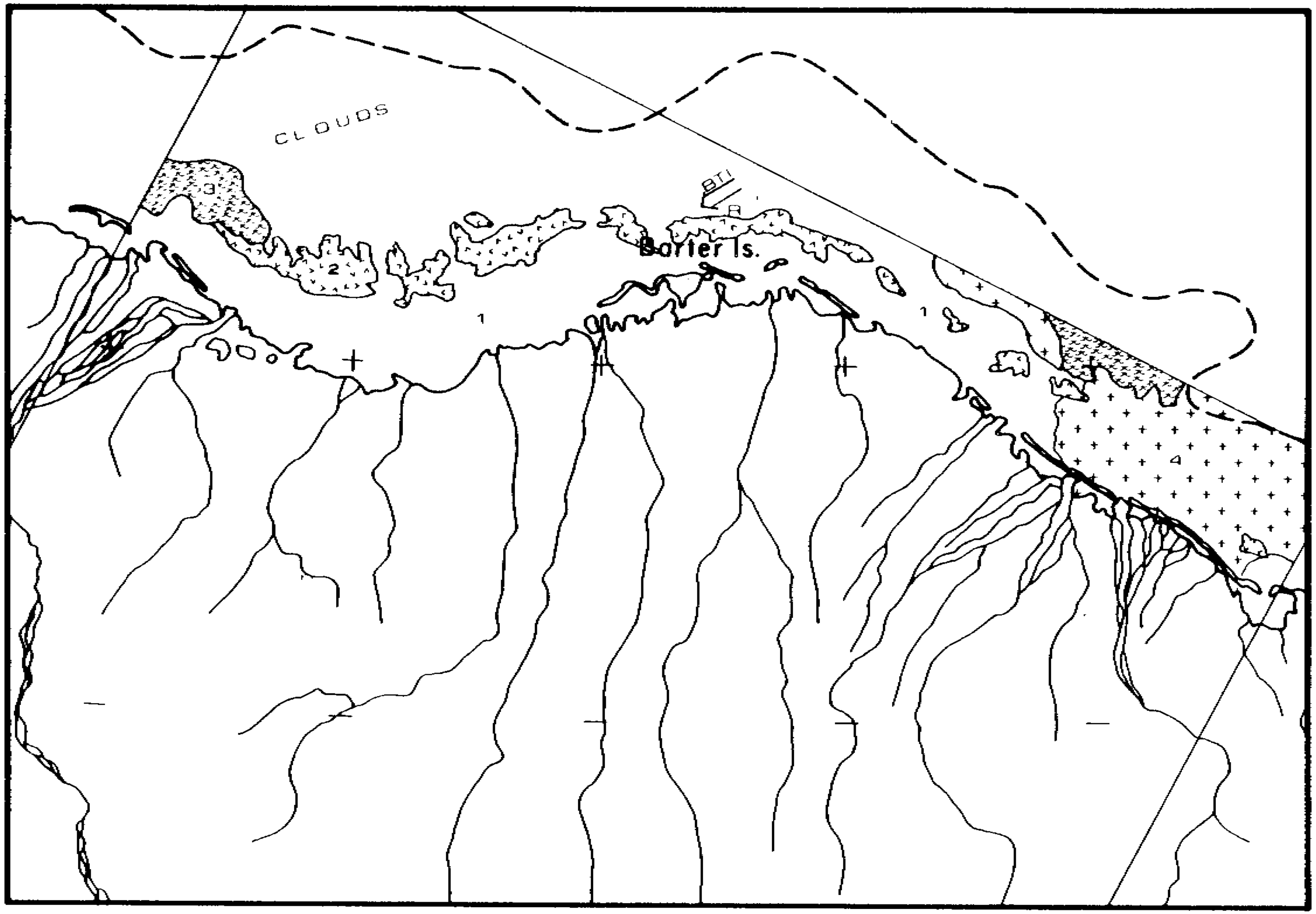
BEAUFORT SEA COAST: BARTER IS. SECTOR

4 AUGUST, 1975

Figure 45

19 August 1975: Scene E-2209-20474

This late summer frame has much cloud cover over the coast and some clouds over the ice. Several zones of ice concentration were distinguishable, however. Zone 1 is mainly open water with scattered medium to big-sized floes. Much of the ice in the seaward part of the zone cannot be seen due to cloud cover. Zone 2 is characterized by very light toned areas of consolidated ice located 5 to 15 km offshore, approximately on the 10 fm contour. Winds at Barter Island (shown by a double arrow on the map) from 17 to 19 August were from the northeast at an average speed of 5.7 m/sec. This may have caused some of the zone 2 ice build-up. The large ridged area (R) north of Barter Island appears to have been stationary since 28 February. Zone 3 is a slightly darker tone than zone 2 and consists of somewhat less consolidated ice. Zone 4 consists of less consolidated pack ice than zone 3. It is difficult to determine the ice to water ratio in zone 4 due to cloud cover, but it may be as high as 8/10 ice.



SHOREFAST SEA ICE

SURFACE MORPHOLOGICAL CHARACTERISTICS

BEAUFORT SEA COAST: BARTER IS. SECTOR

19 AUGUST, 1975

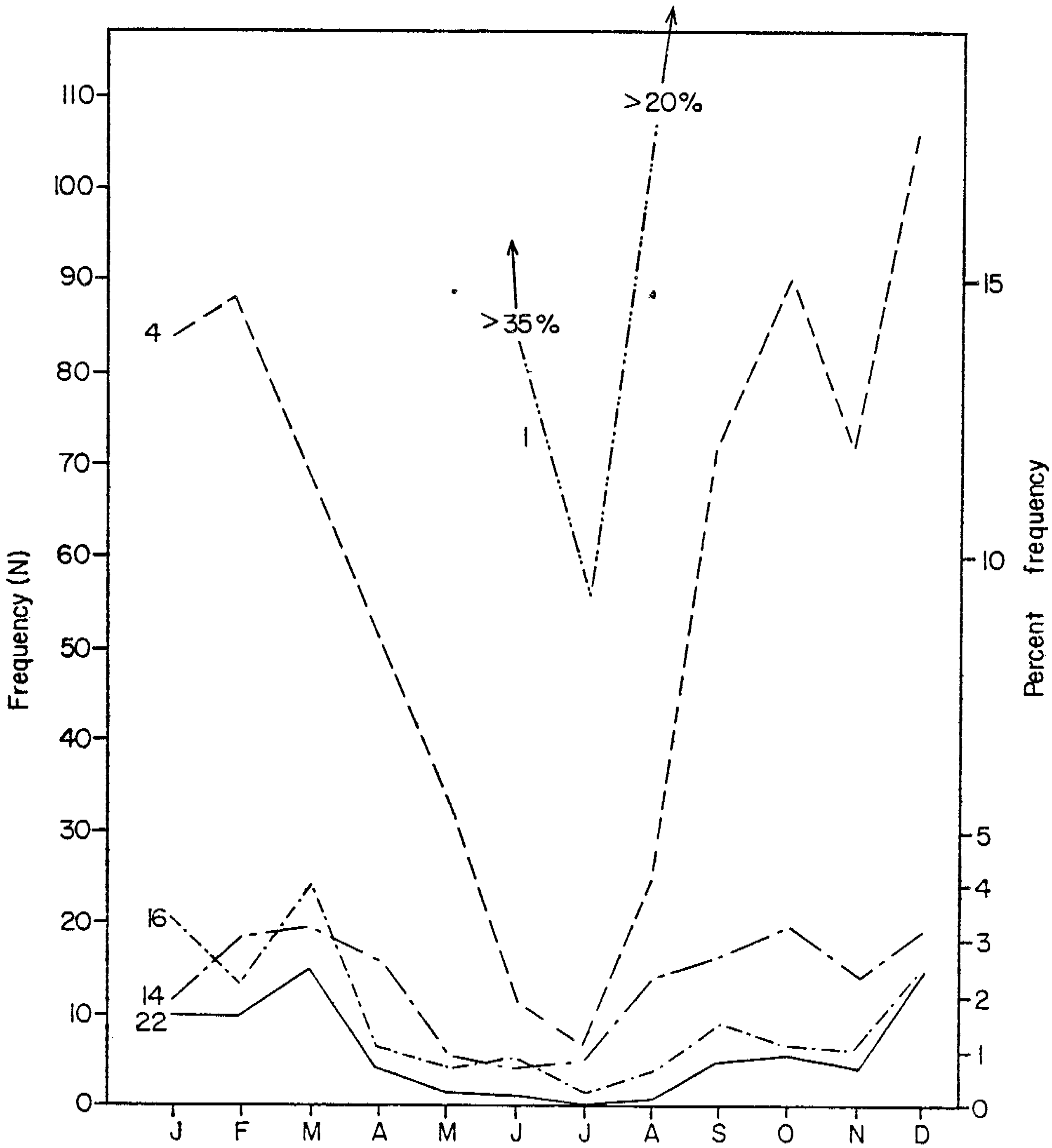


Figure 46. Seasonal frequency of types with a characteristic winter maximum frequency.

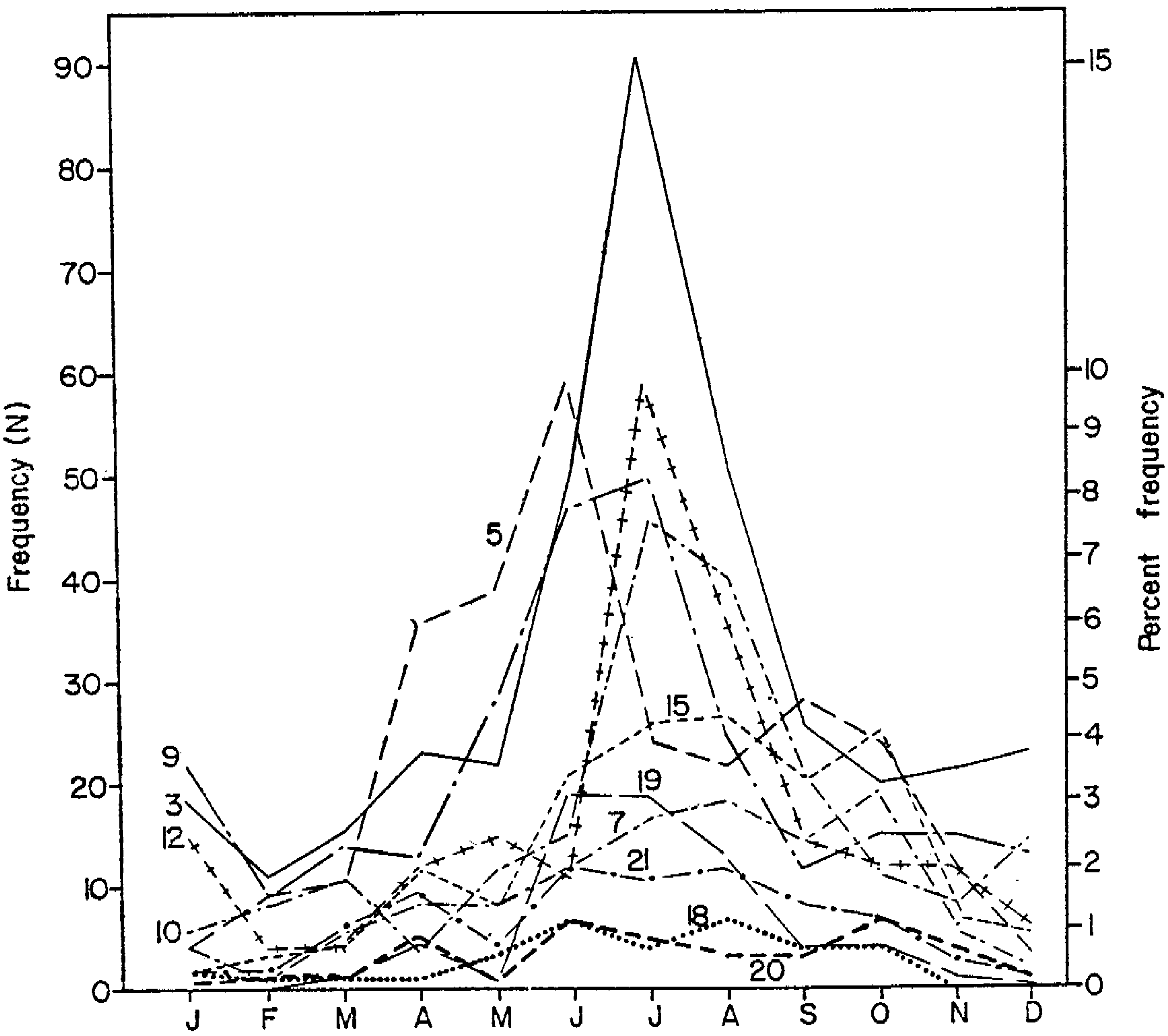


Figure 47. Seasonal type frequency of patterns with a characteristic summer maximum of frequency.

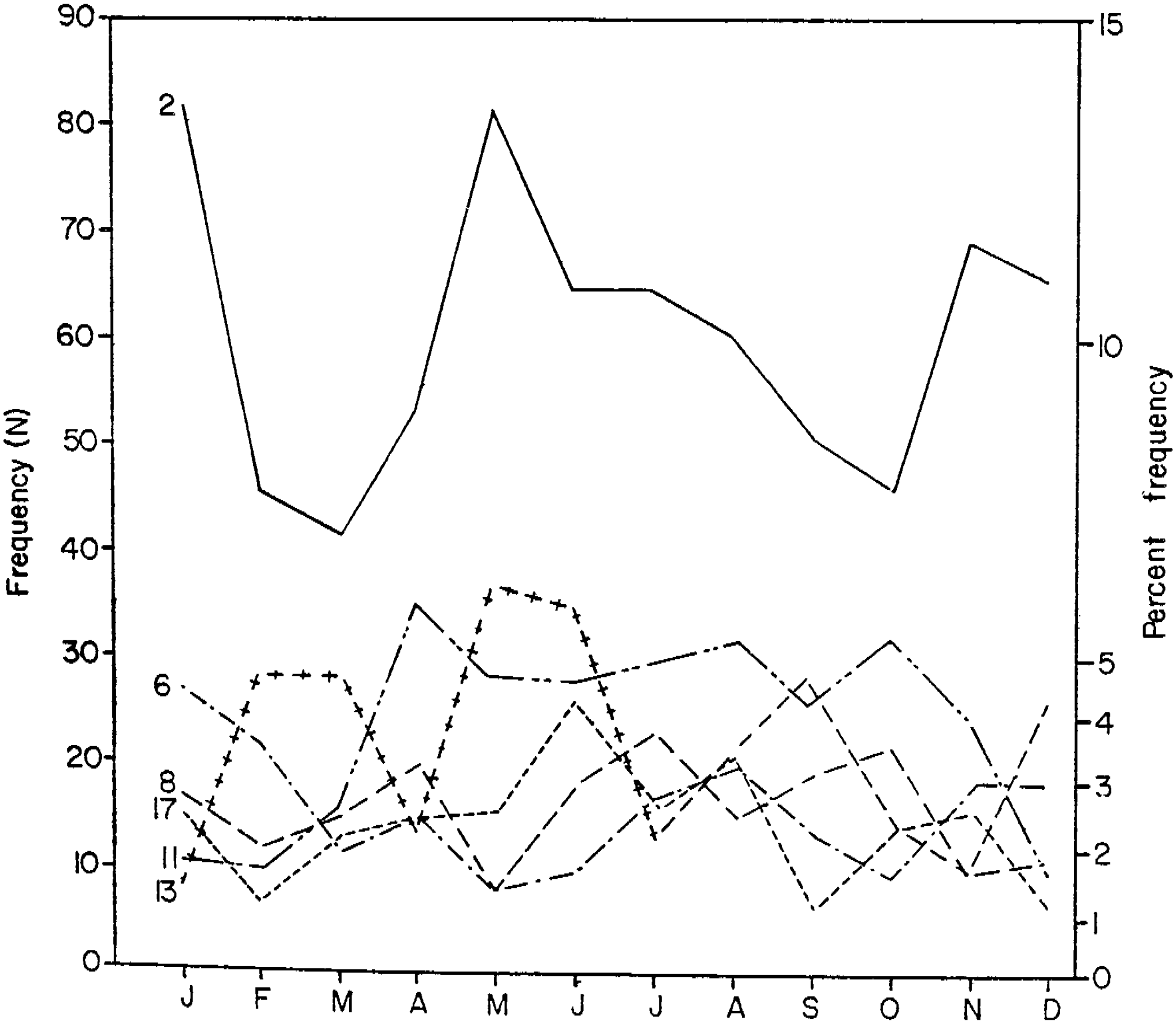
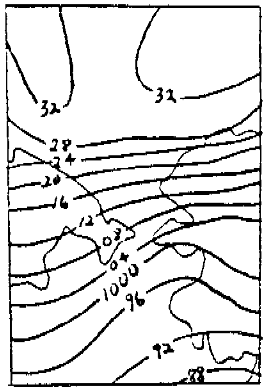
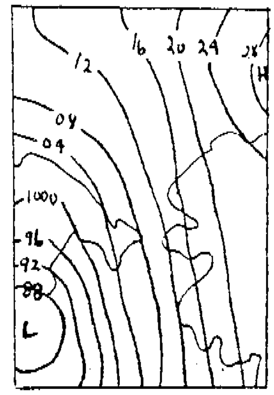


Figure 48. Seasonal frequency of types with no characteristic seasonal maximum of frequency.

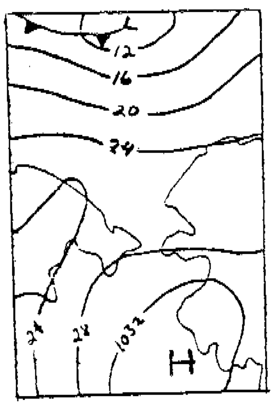
Figure 49. Number of types with at least 3% frequency in a given month.



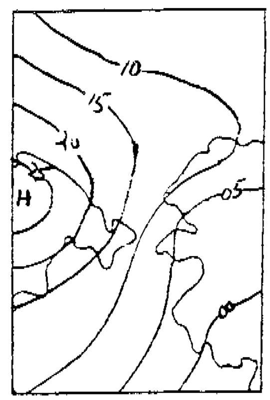
Type 1. 14 March 1970



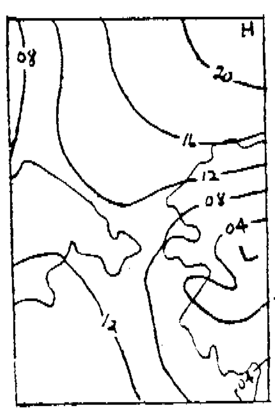
Type 2. 7 August 1968



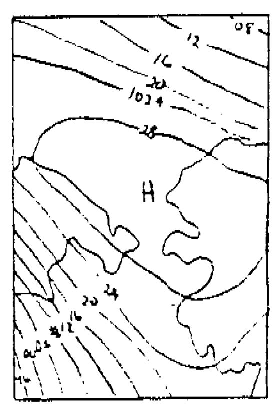
Type 3. 20 March 1967



Type 4. 2 February 1961

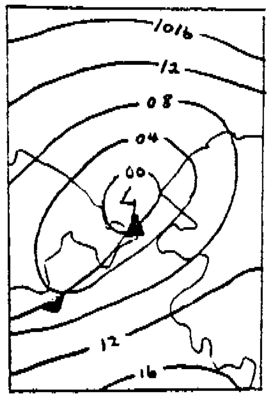


Type 5. 23 June 1969

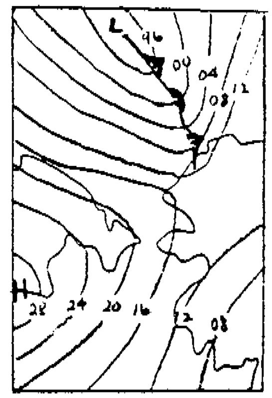


Type 6. 12 March 1955

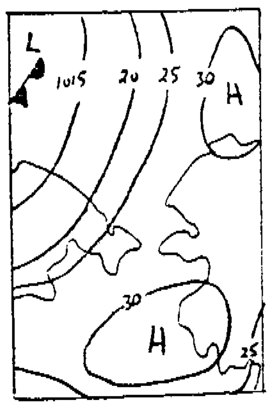
Figure 50. Chukchi Synoptic Types 1 - 6 (isobars in mb, omitting 1000 or 900)



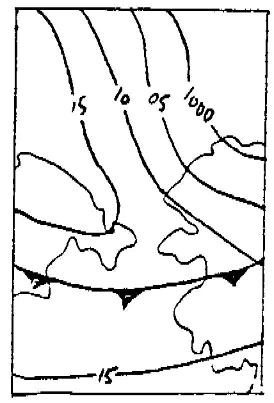
Type 7. 16 July 1966



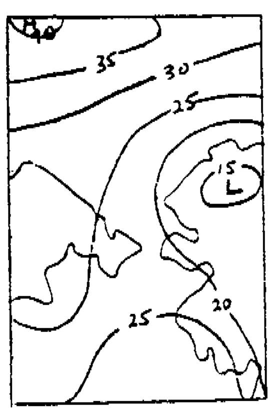
Type 8. 26 September 1957



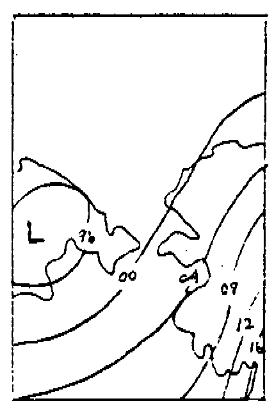
Type 9. 17 April 1948



Type 10. 28 August 1948

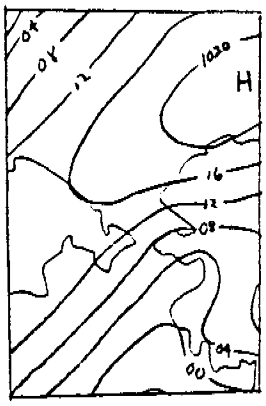


Type 11. 4 February 1955

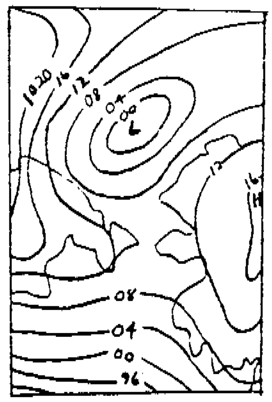


Type 12. 8 September 1946

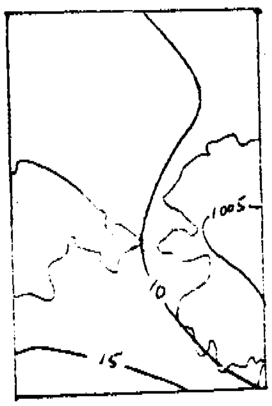
Figure 51. Chukchi Synoptic Types 7 - 12 (isobars in mb, omitting 1000 or 900)



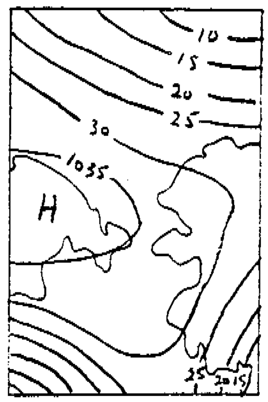
Type 13. 16 June 1969



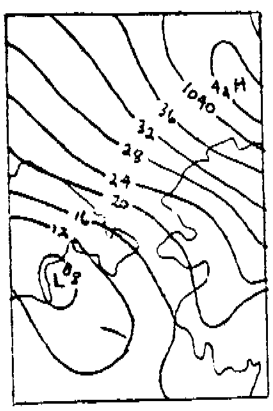
Type 14. 19 December 1966



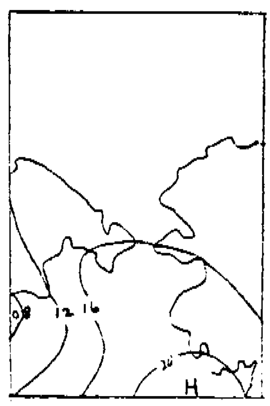
Type 15. 16 June 1960



Type 16. 4 March 1956

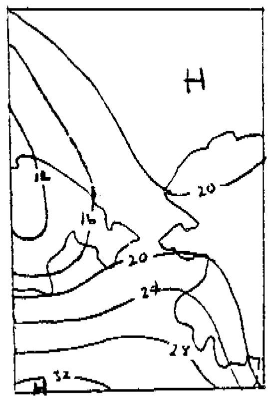


Type 17. 26 December 1968

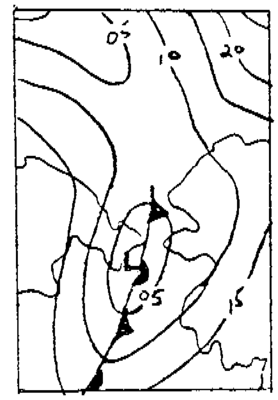


Type 18. 19 July 1963

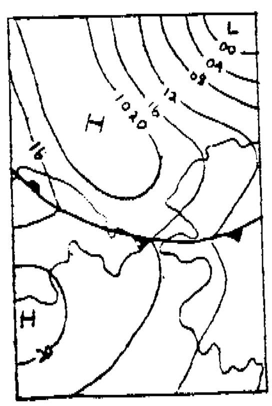
Figure 52. Chukchi Synoptic Types 13 - 18 (isobars in mb, omitting 1000 or 900)



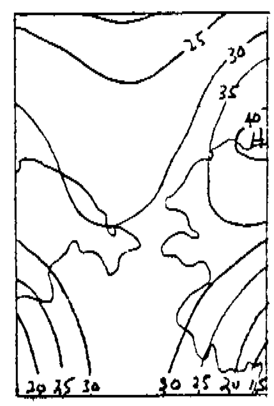
Type 19. 17 October 1964



Type 20. 24 April 1959



Type 21. 7 June 1970



Type 22. 1 January 1956

Figure 53. Chukchi Synoptic Types 19 - 22 (isobars in mb, omitting 1000 or 900)

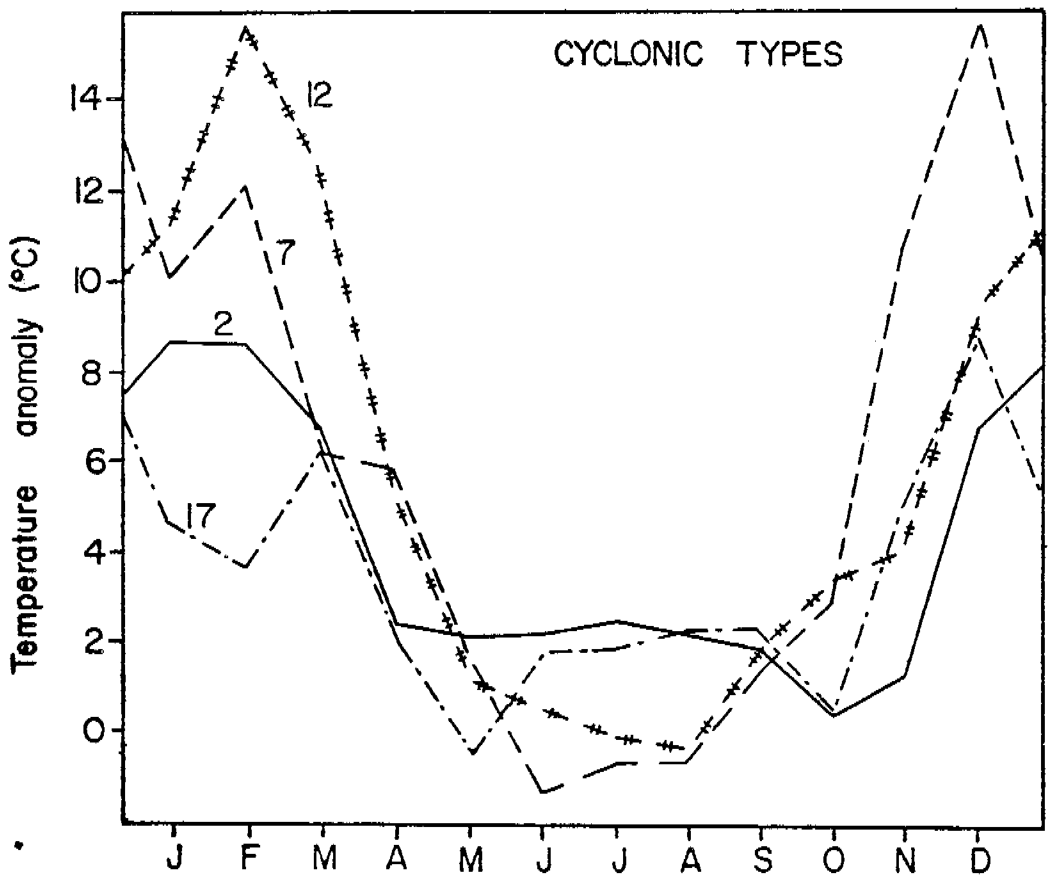


Figure 54a. Temperature departure characteristics of the major cyclonic types, at Kotzebue, 1955-1974.

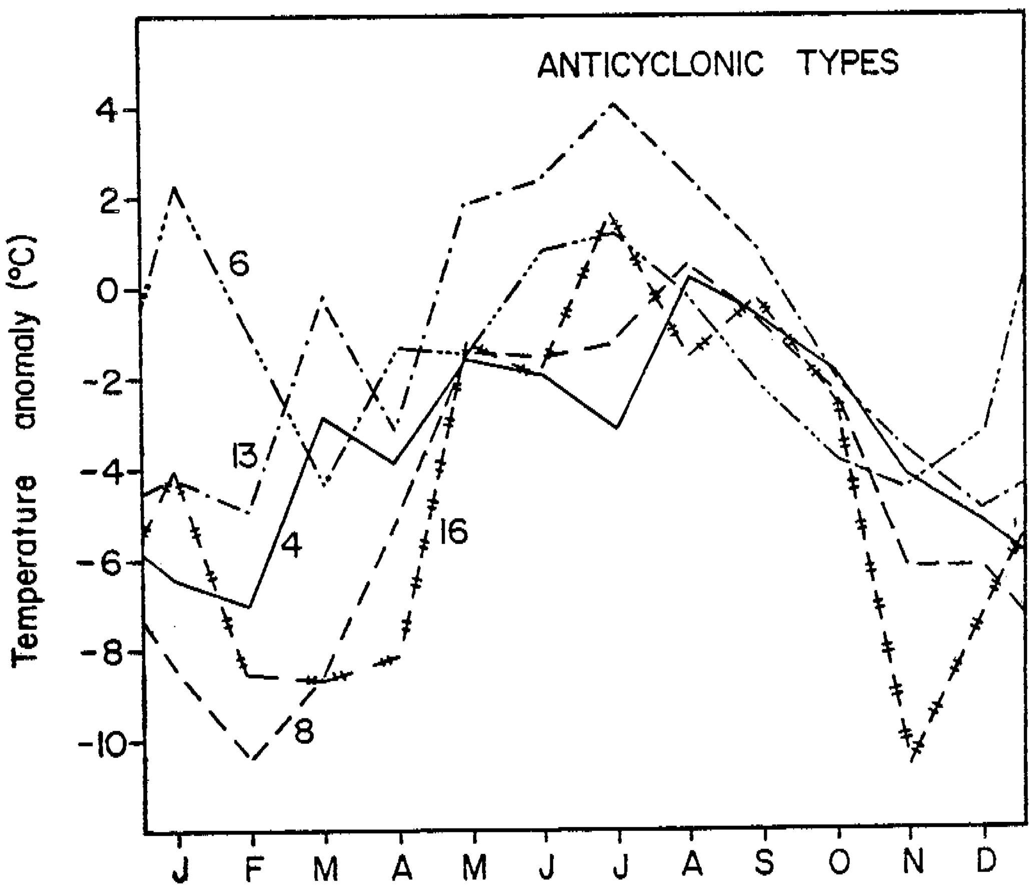


Figure 54b. Temperature characteristics of the major anticyclonic types, at Kotzebue, 1955-1974.

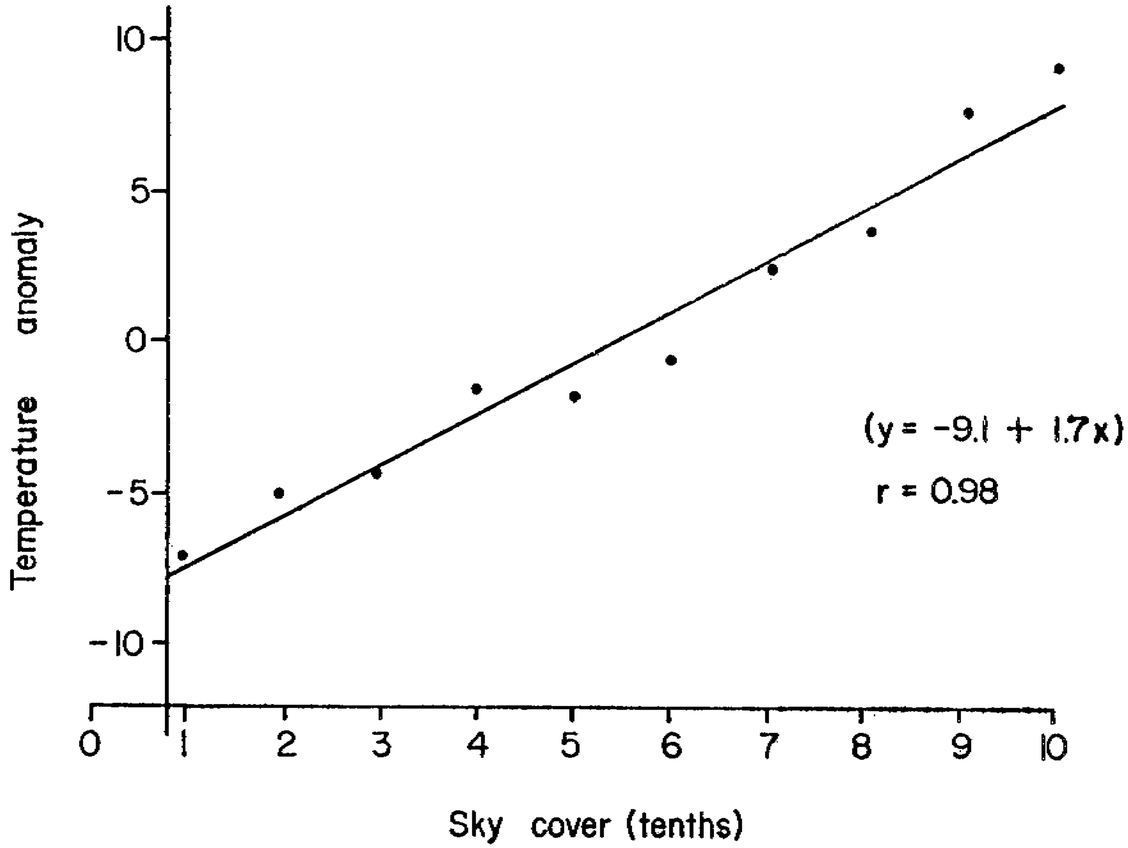


Figure 55. Cover amount and Associated Mean Temperature Departure from normal at Kotzebue in December.

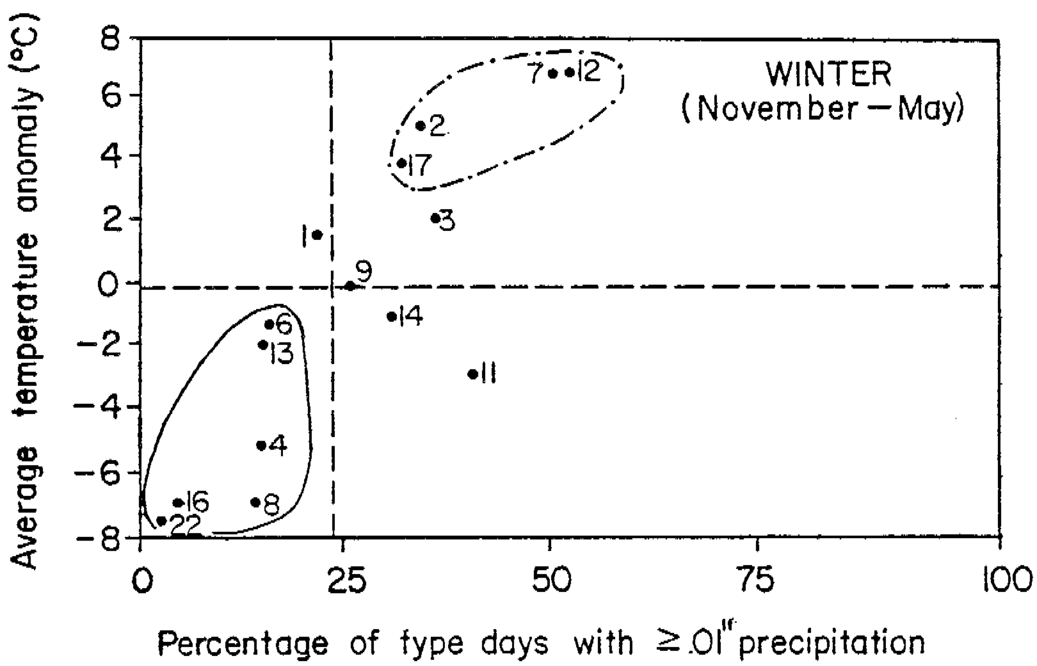


Figure 56a. Temperature and precipitation characteristics of winter types.

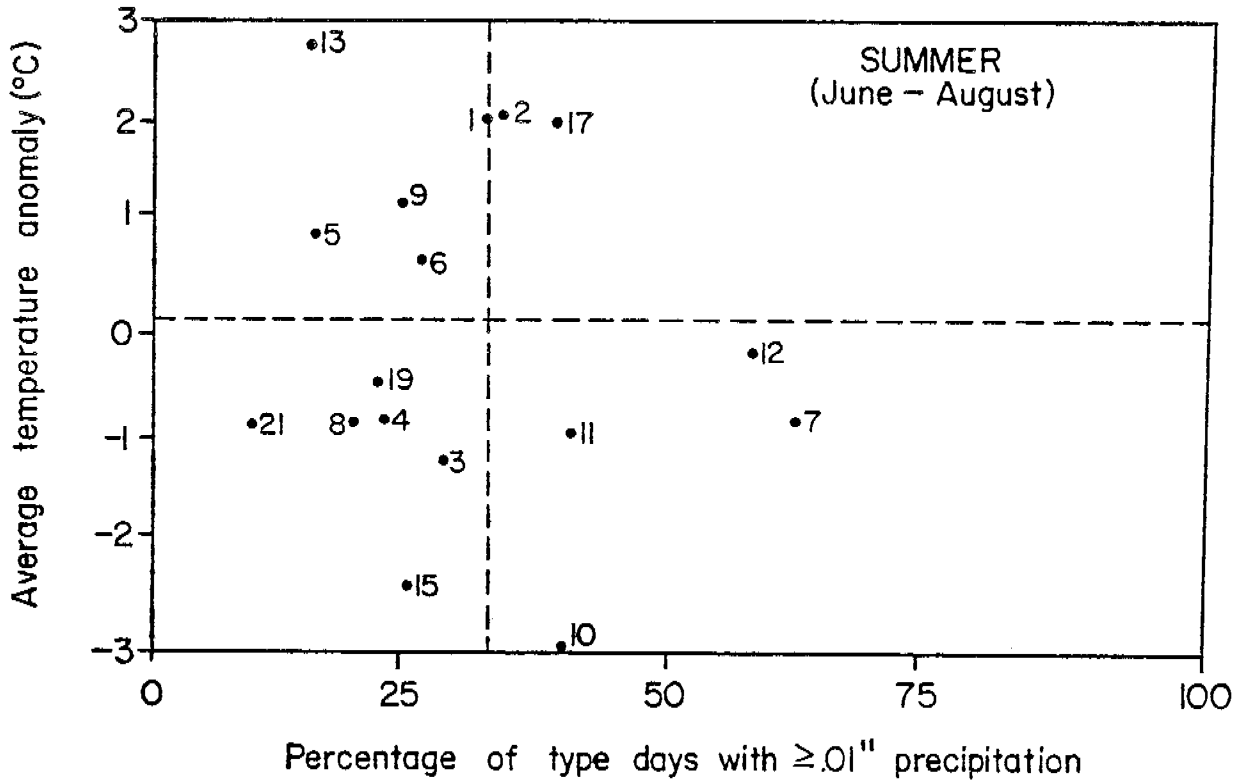
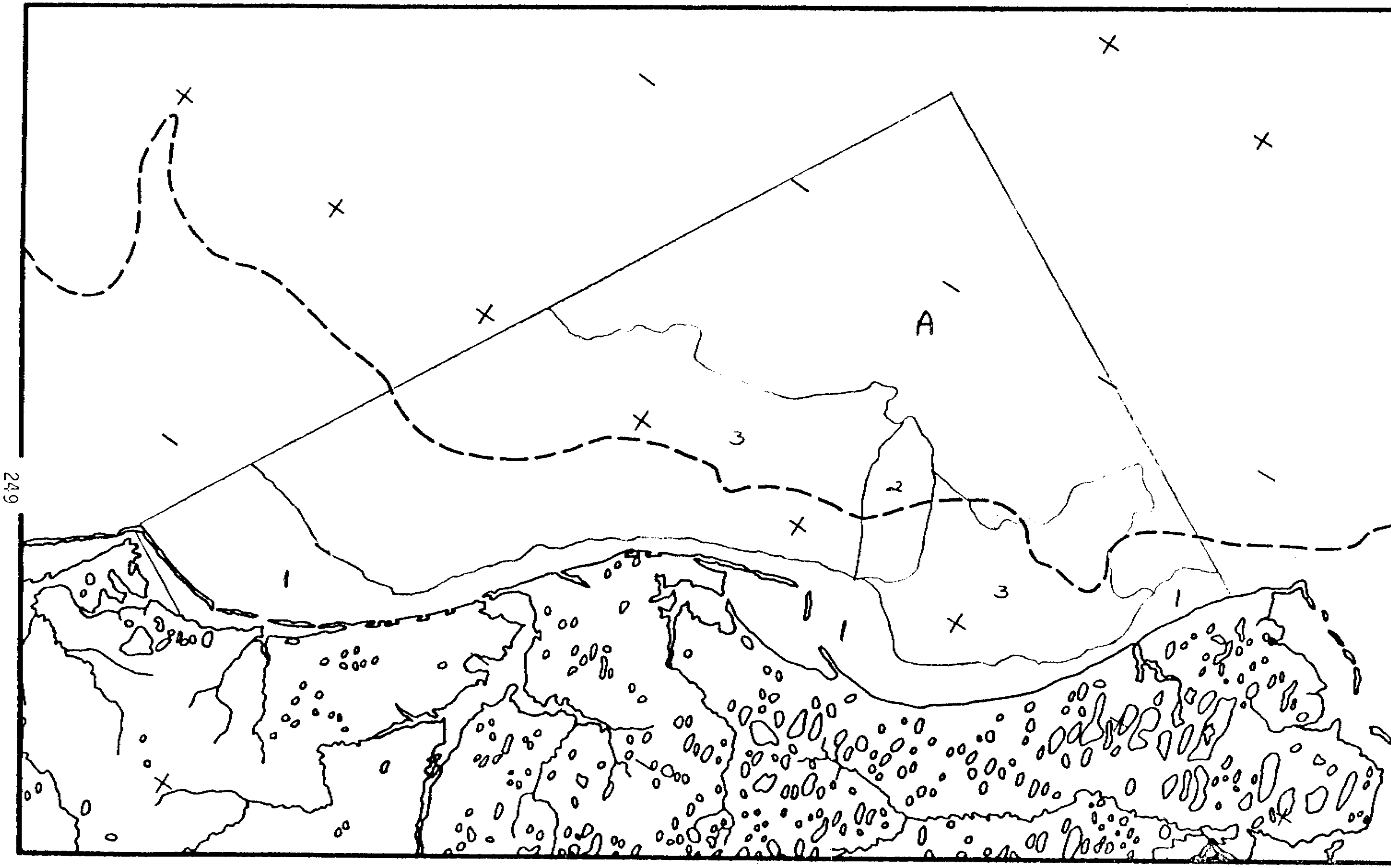


Figure 56b. Temperature and precipitation characteristics of summer types.

Figure 57

15 March 1976: Scene E-2418-21473

1 Shorefast ice.
2 Light toned, homogeneous ice. Appears to have broken away from the shorefast ice and moved seaward.
3 Thinner, refreezing ice. Darker toned than other ice types; generally slightly lighter tone in seaward part of this ice type.
A Pack ice, generally less consolidated along shoreward edges.



SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: BARROW SECTOR

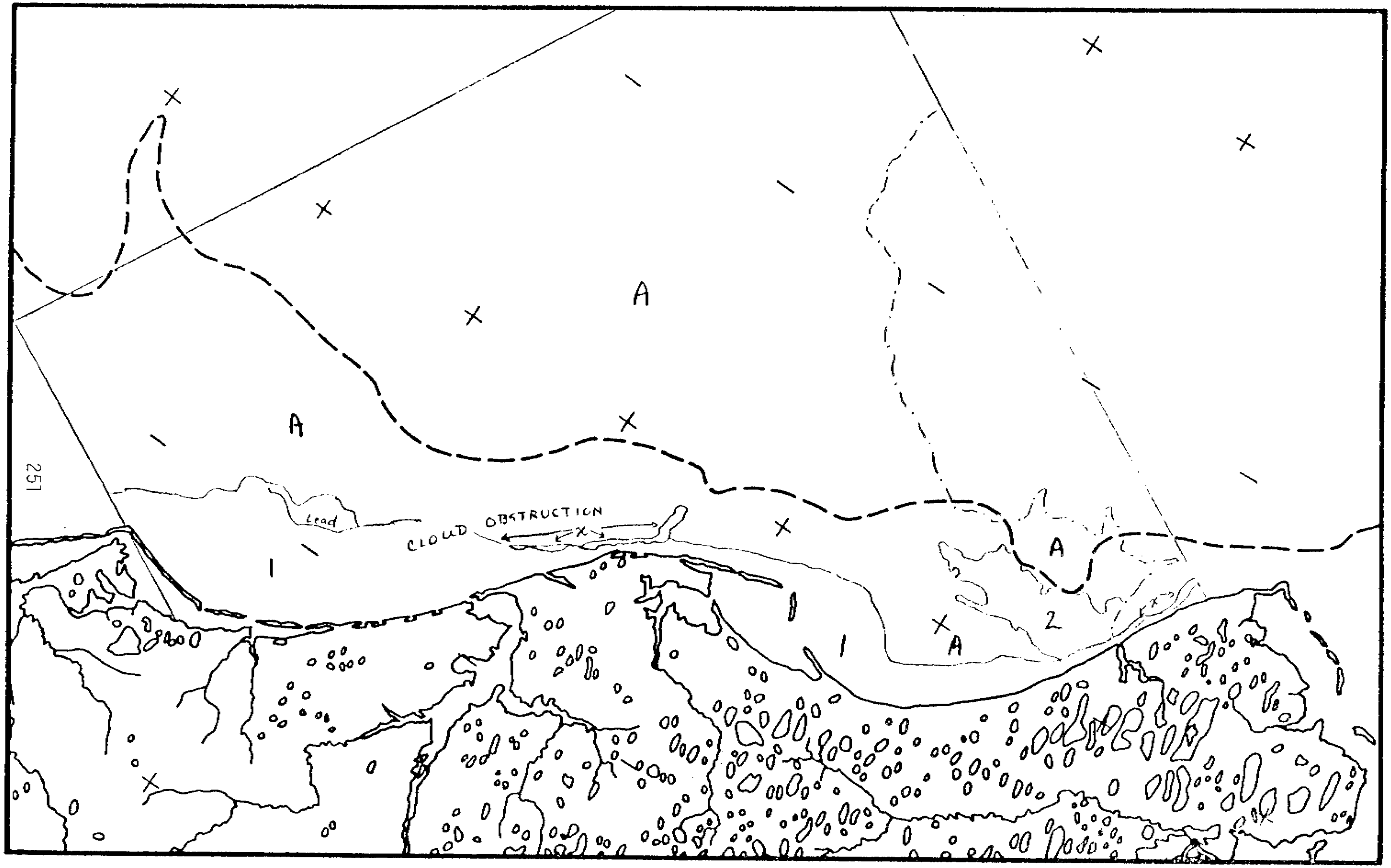
15 MARCH 1976

Figure 58

3 April 1976: Scene E-2437-21524

1 Shorefast ice; homogeneous near shore, but appears to be some darker, newer ice along the seaward edge. It is difficult to locate the seaward boundary due to cloud obstruction, especially in the Pt. Franklin area.
2 Darker, homogeneous, newer ice.
x Areas of open water and/or new ice.
A Pack ice.
.-.- Pack ice is more consolidated east of this line, although there has been some fracturing of the ice.

Note: There is a fairly light cloud cover over much of this frame, mainly in the western part, that prevents a clear view of the ice.



SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: BARROW SECTOR

3 APRIL 1976

Figure 59

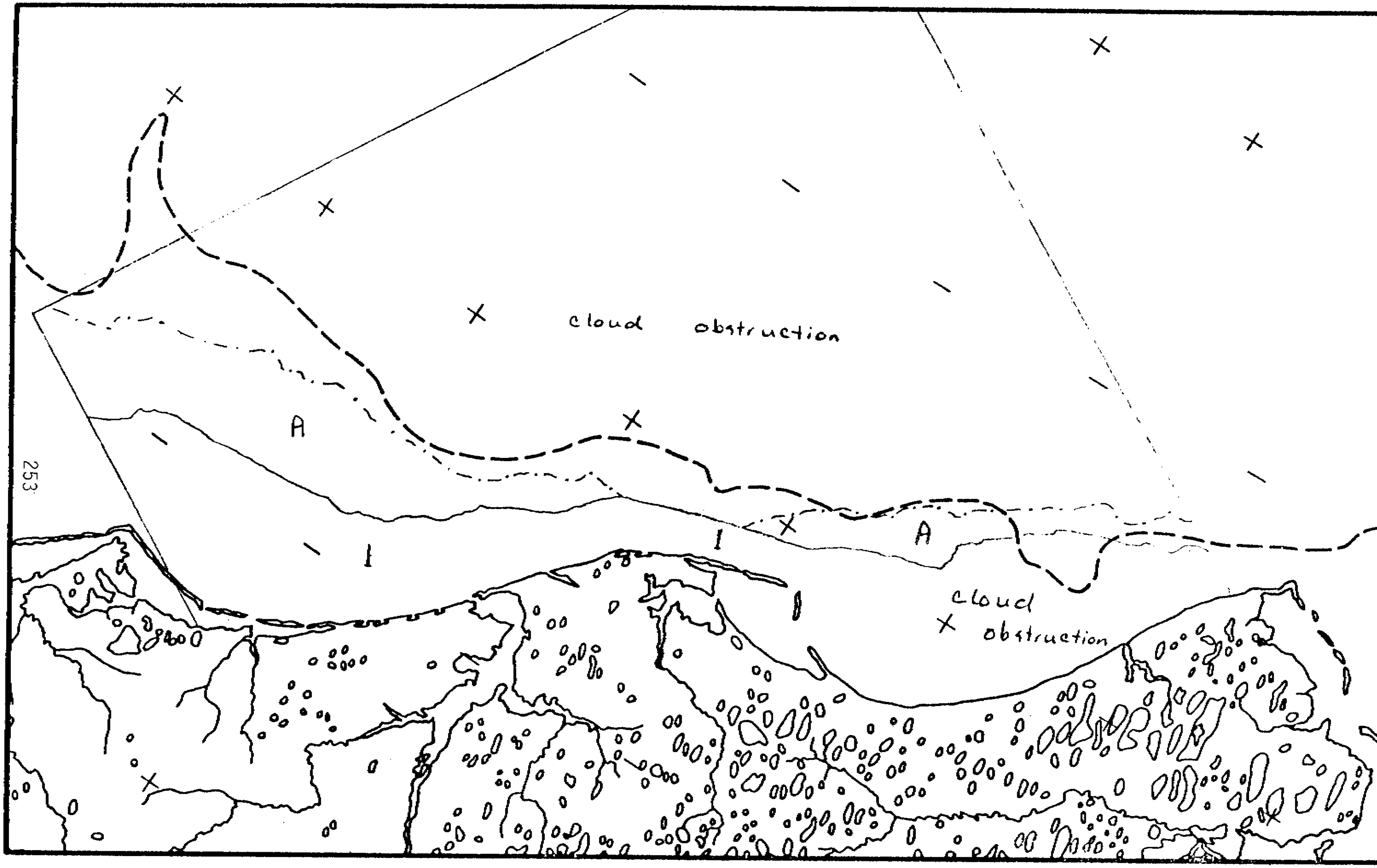
21 April 1976: Scene E-2455-21521

1 Shorefast ice. Fairly homogeneous light tone near the shore and slightly darker, newer ice along the seaward boundary.

A Broken pack ice with dark, newer ice between floes. Little open water, if any, in this zone.

.-.- Cloud obstruction to seaward of this line.

Note: There is quite a lot of cloud cover over the ice, however the boundary of the shorefast ice appears clear.

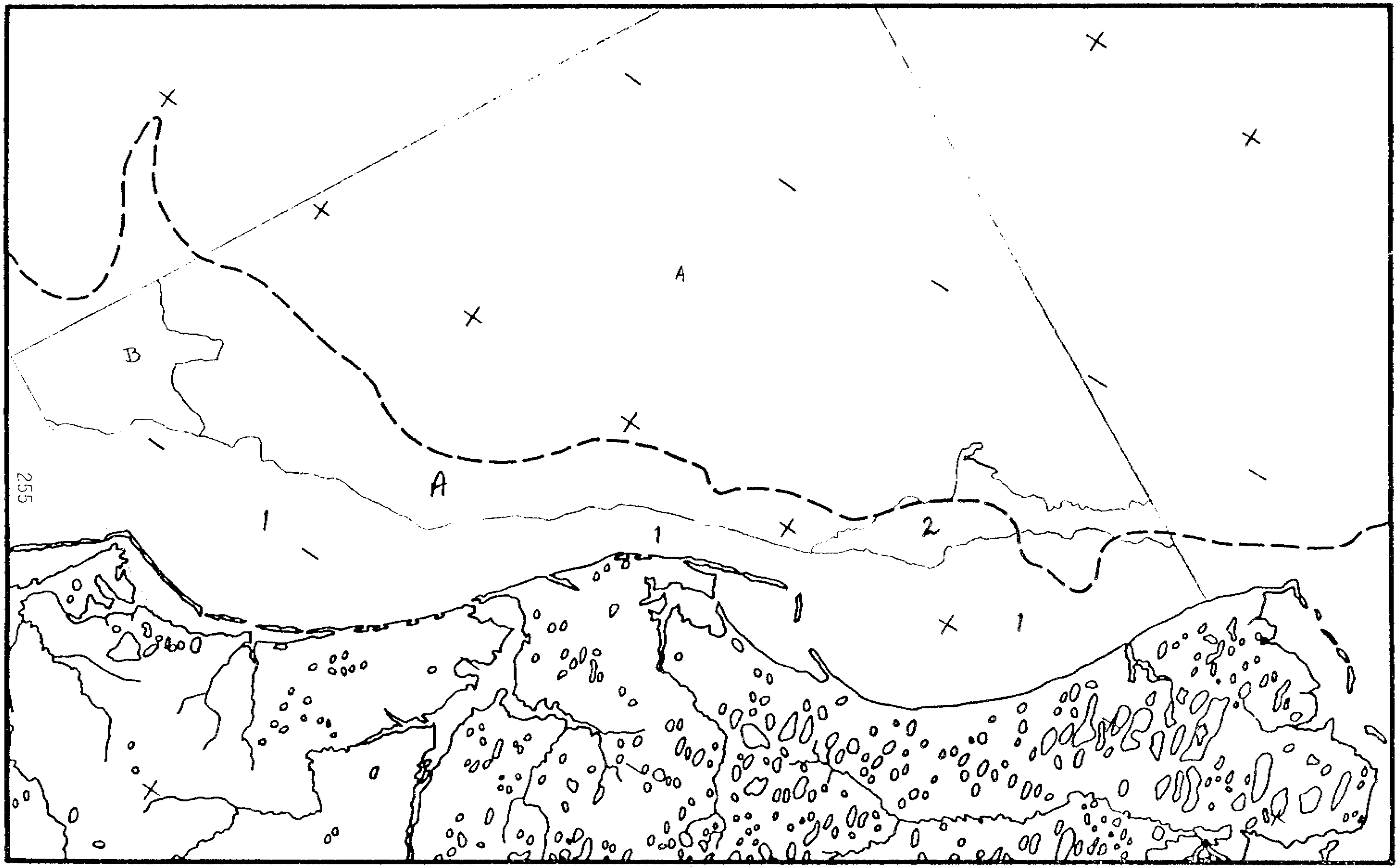


SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: BARROW SECTOR
21 APRIL 1976

Figure 60

9 May 1976: Scene E-2473-21514

1 Homogeneous shorefast ice.
2 Mainly dark toned, newer ice with a small amount of open water. Several older, lighter toned floes are also included.
A Pack ice.
B Unconsolidated pack ice; approximately 50% ice.



SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: BARROW SECTOR

9 MAY 1976

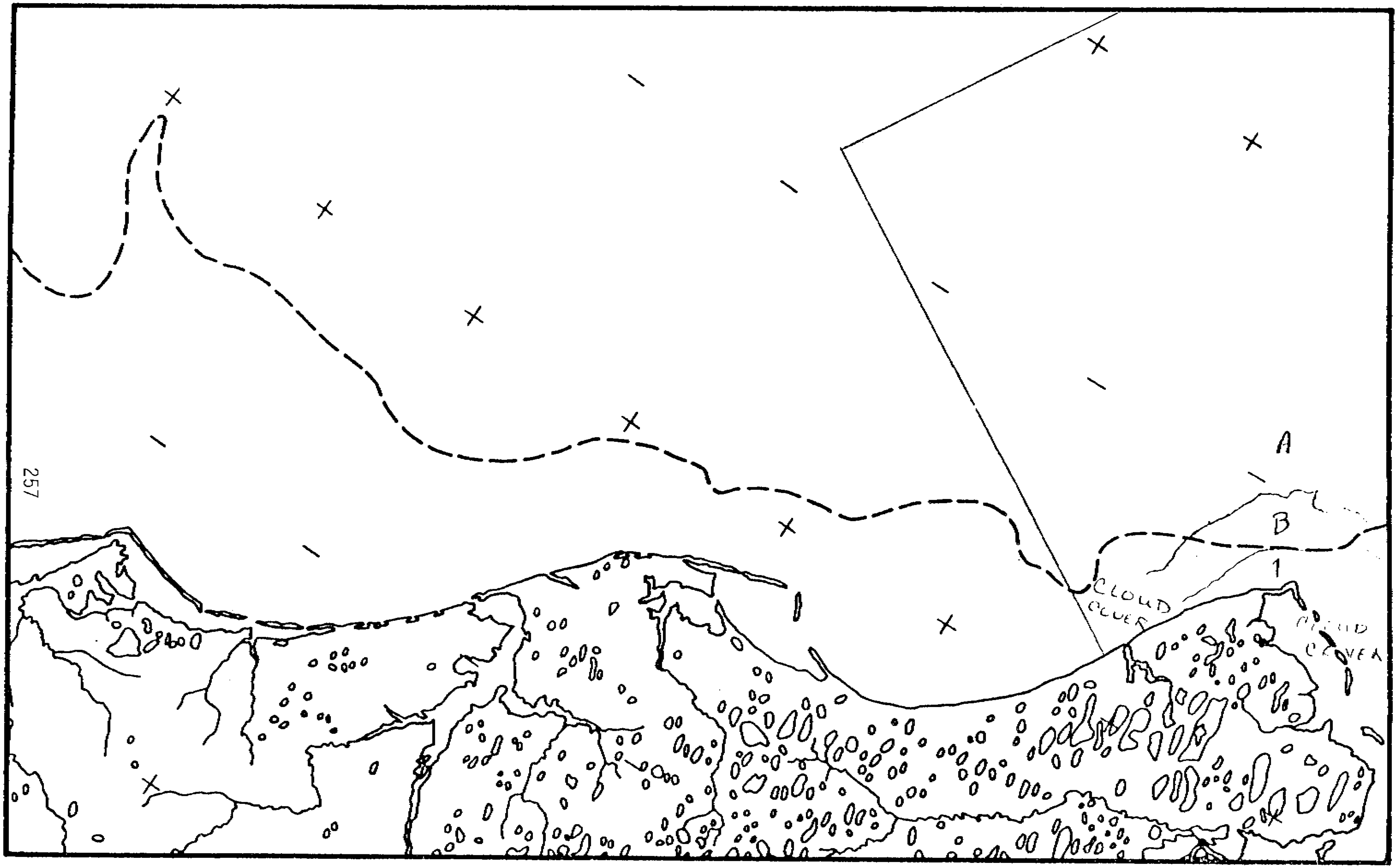
Figure 61

13 June 1976: Scene E-2508-21444

1 Shorefast ice. There is a darker area northwest of Pt. Barrow, but this appears to be due to cloud cover. Overall the ice is a darker, more mottled tone than in previous images.

A Pack ice.

B Less consolidated pack ice; approximately 35% open water.



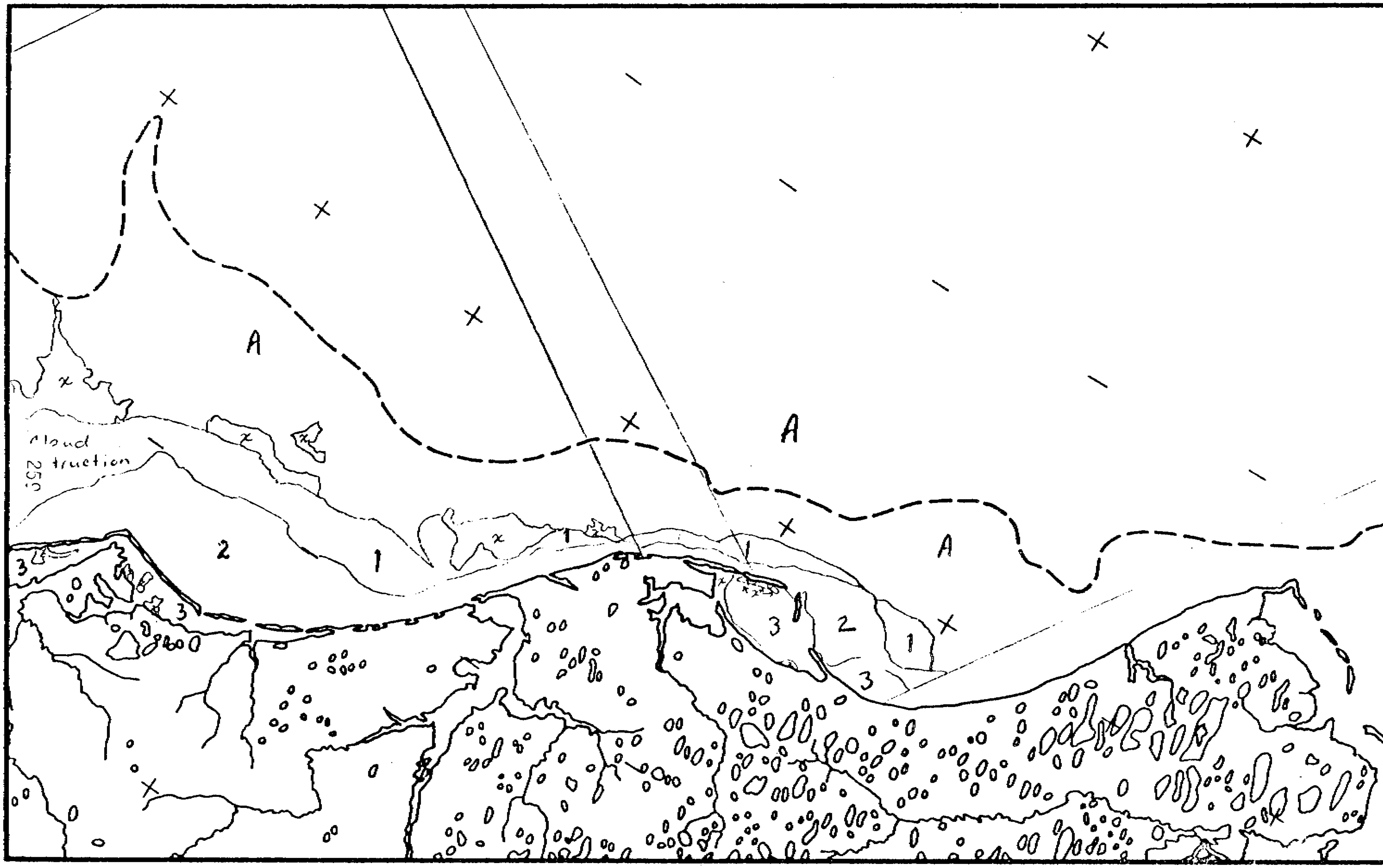
SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: BARROW SECTOR

13 JUNE 1976

Figure 62

15 June 1976: Scene E-2510-21561, E-2510-21563

1 Light toned ice along the seaward edge of the fast ice.
2 Generally dark toned ice with many light lineations and lighter toned areas.
3 Darker toned than type 2, with fewer lineations and more surface meltwater.
x Mainly open water, but with some small areas of dark toned ice along the coast. Along the shoreward edge of the pack ice, the open water areas contain approximately 25% ice.
A Pack ice.



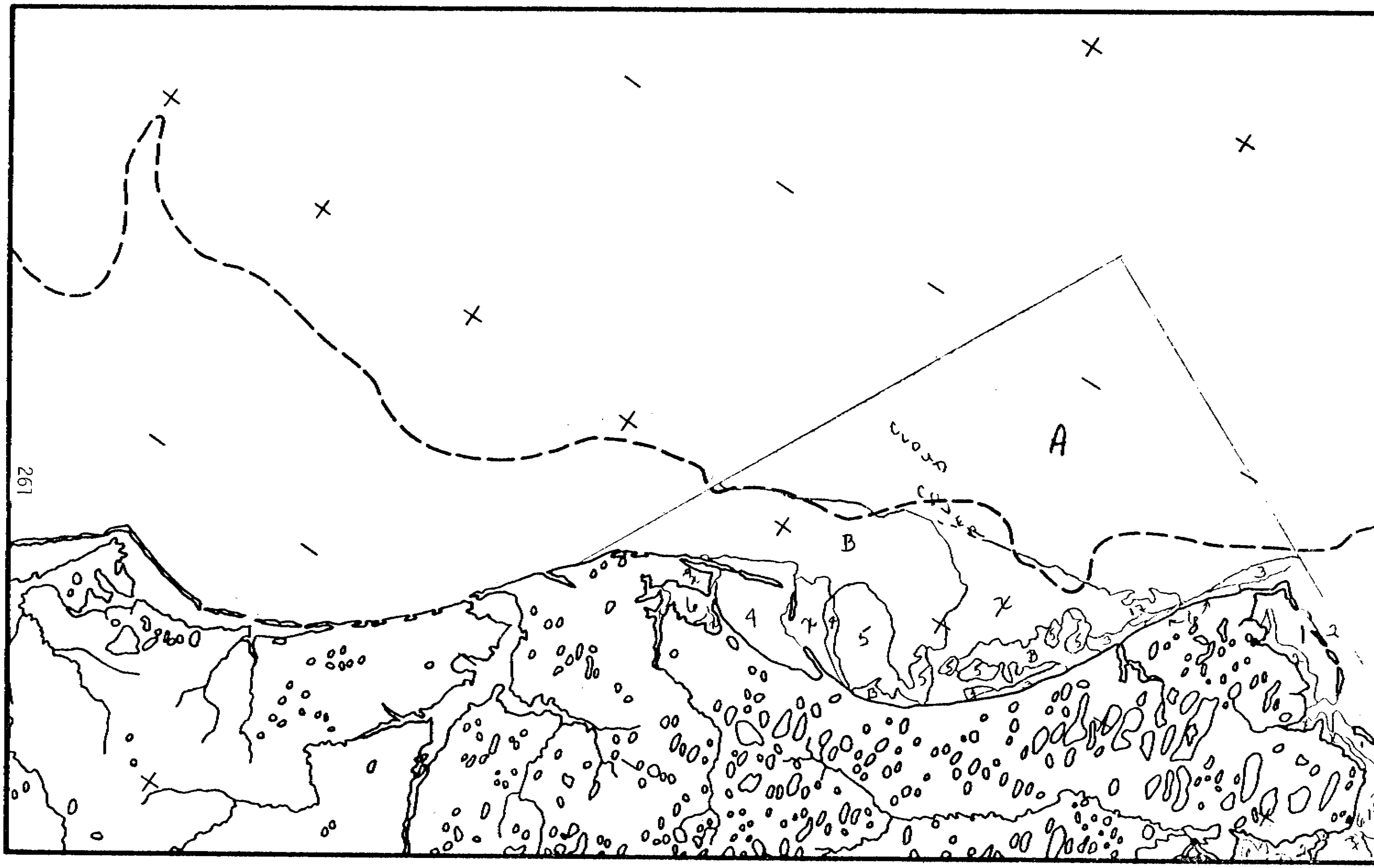
SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: BARROW SECTOR

15 JUNE 1976

Figure 63

18 July 1976: Scene E-2543-21382

1 Light toned, homogeneous shorefast ice.
2 More surface water on the ice than type 1. The ice also appears somewhat mottled, with many small darker areas.
3 Fairly dark toned overall and slightly mottled ice.
4 Similar in tone to type 3, but this ice appears quite smooth.
5 This ice appears similar to type 3, but it has larger light toned areas and many light toned linear features. The ice has either broken away from shore or is only narrowly attached.
6 Very dark toned ice located along the shore. Some small areas of open water are included in this zone. The ice appears to be close to breaking up.
X Open water with very small amounts of ice (approximately 5%).
A Pack ice.
B Open water with approximately 60% floating ice.



SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: BARROW SECTOR

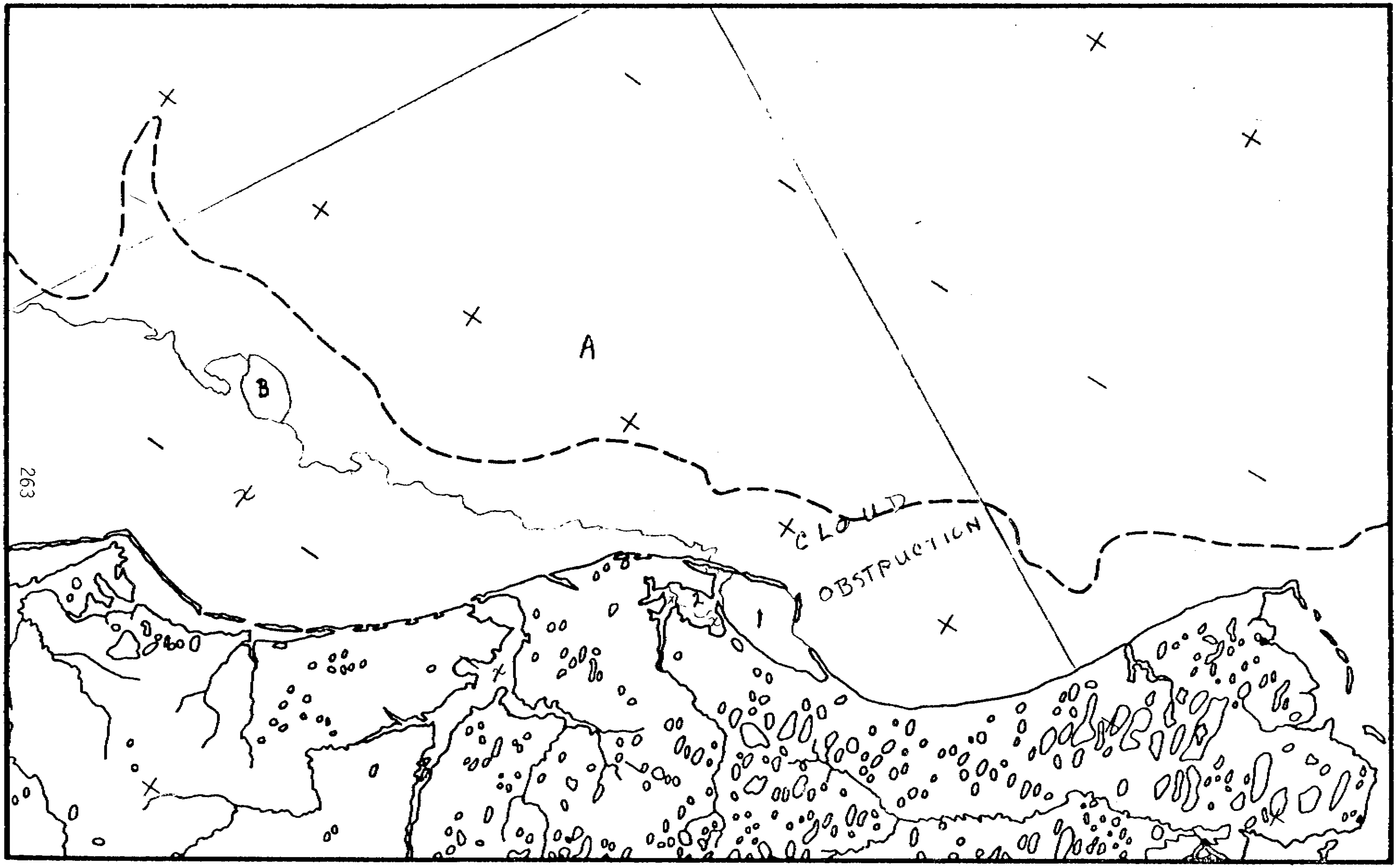
18 JULY 1976

Figure 64

20 July 1976: Scene E-2545-21495

1 Fairly light toned shorefast ice.
2 Much surface water on the ice; very dark toned. Some small areas of open water. This ice is in advanced stages of decay.
X Open water with very small amounts of floating ice.
A Continuous pack ice.
B This vast floe appears to have been a part of the shorfast ice before it broke up.

Note: Cloud obstructs most of the ice north of Pt. Franklin.



263

SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: BARROW SECTOR

20 JULY 1976

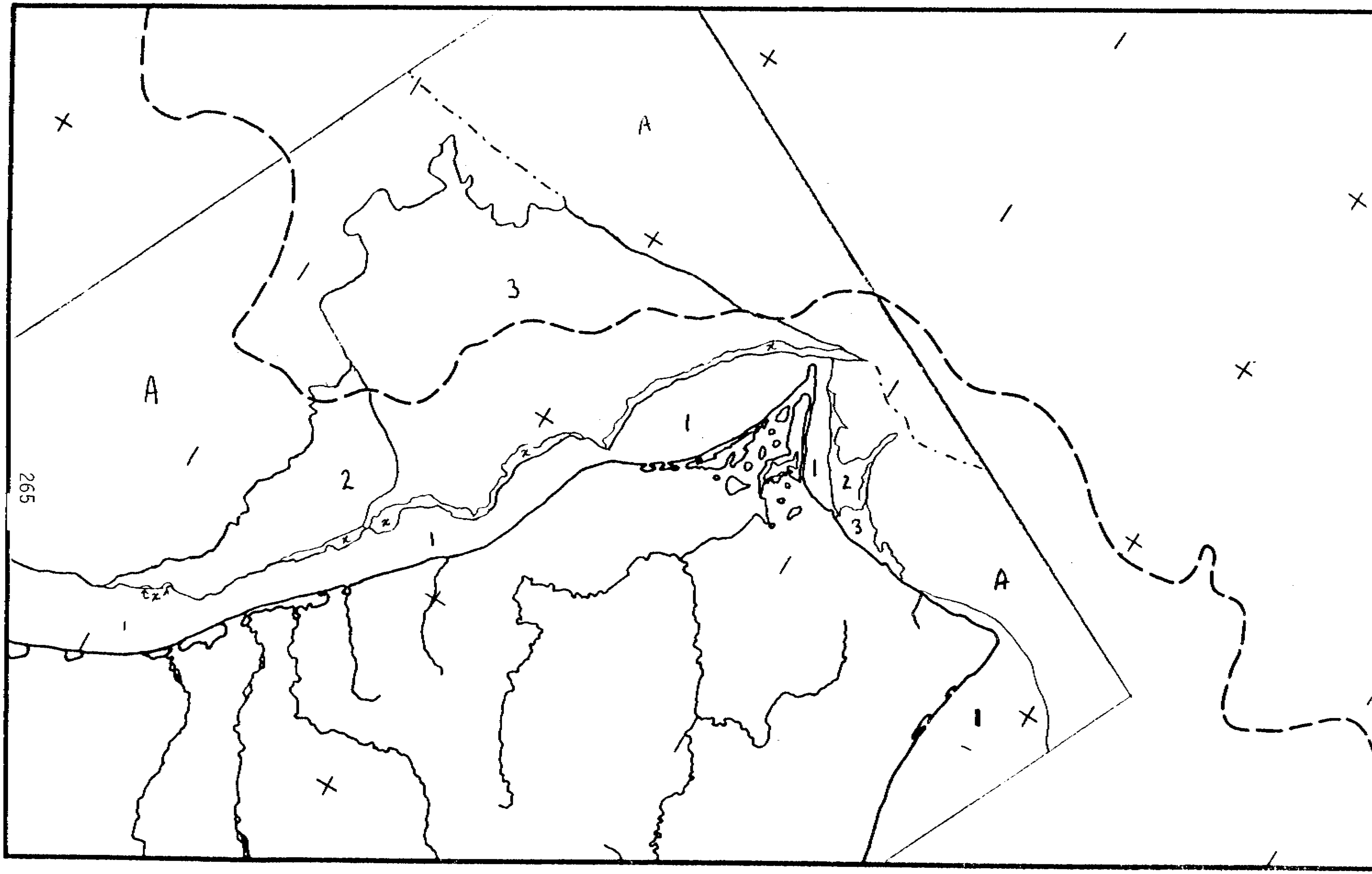
6 August 1976: Scene E-2562-21443

No map. The fast ice is no longer present, but pack ice has moved in along the coast between Barrow and Pt. Franklin.

Figure 65

17 March 1976: Scene E-2420-21595

1 Shorefast ice
2 New ice; darker than type 1
3 New ice; darker than type 2. Ice is quite "ragged" along boundary with type X. Some small areas of open water are present.
x Mainly open water, but with some thin, refreezing ice.
A Pack ice.
.-.- Shoreward of this line, the pack ice is more consolidated - the closer to shore the more consolidated.



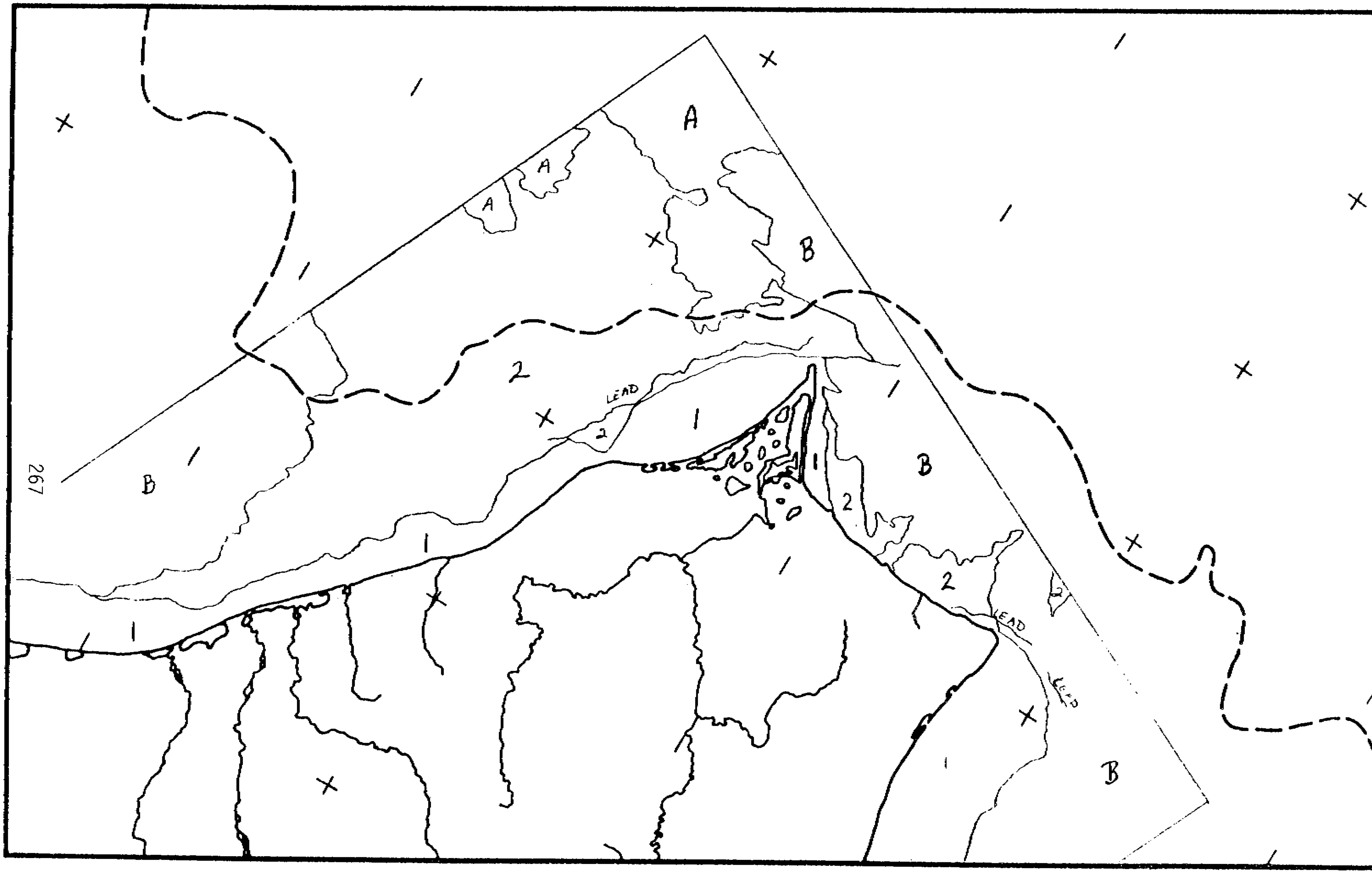
SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: POINT HOPE SECTOR

17 MARCH 1976

Figure 66

4 April 1976: Scene E-2438-21591

1 Shorefast ice, mostly homogeneous but with some darker areas.
2 Darker, new ice. Some tonal variation within this type, but all the ice is quite dark.
A Pack ice; composed of variously-sized floes, newer ice comprises about 25%.
B More consolidated pack ice.



SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: POINT HOPE SECTOR
4 APRIL 1976

Figure 67

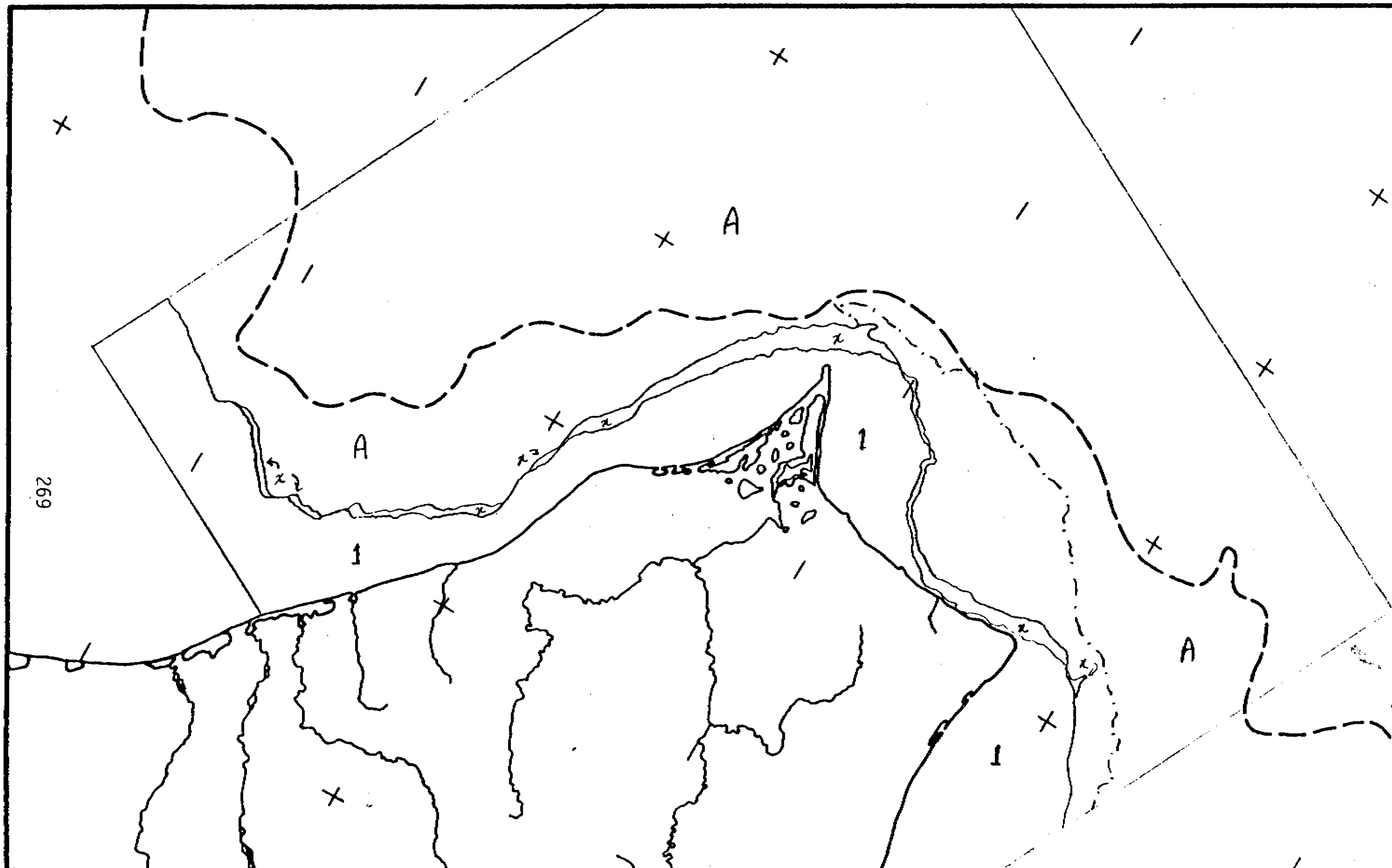
23 April 1976: Scene E-2457-22042

1 Shorefast ice. Light toned overall, but some darker areas within this zone.

x Mainly open water, with some areas of refreezing ice.

A Consolidated pack ice.

.-.- Shoreward of this boundary, the pack ice is quite broken up, newer ice, 20%.



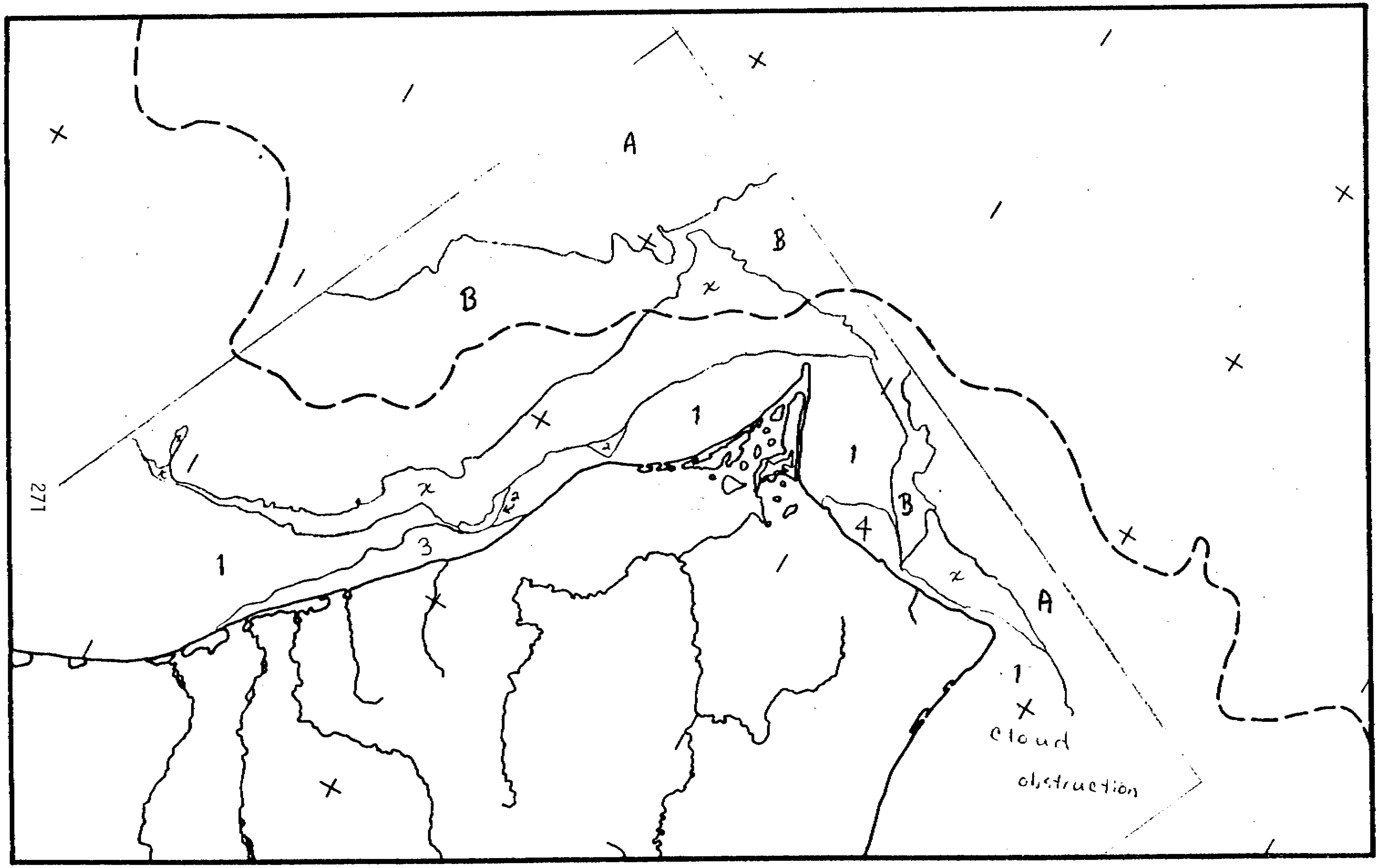
SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: POINT HOPE SECTOR
23 APRIL 1976

Figure 68

10 May 1976: Scene E-2474-21581

1 Shorefast ice. This ice has started to darken slightly since the April frames.
2 Areas of markedly darker shorefast ice.
3 Shows linear features and areas of more rapid melt especially near shore.
4 Darker than type 1 but not as dark as type 2.
A Fairly consolidated, light toned pack ice.
B Darker toned pack ice than type A.

Note: There is some cloud cover northeast of Cape Lisburne, so parts of the shorefast and pack ice are obstructed.



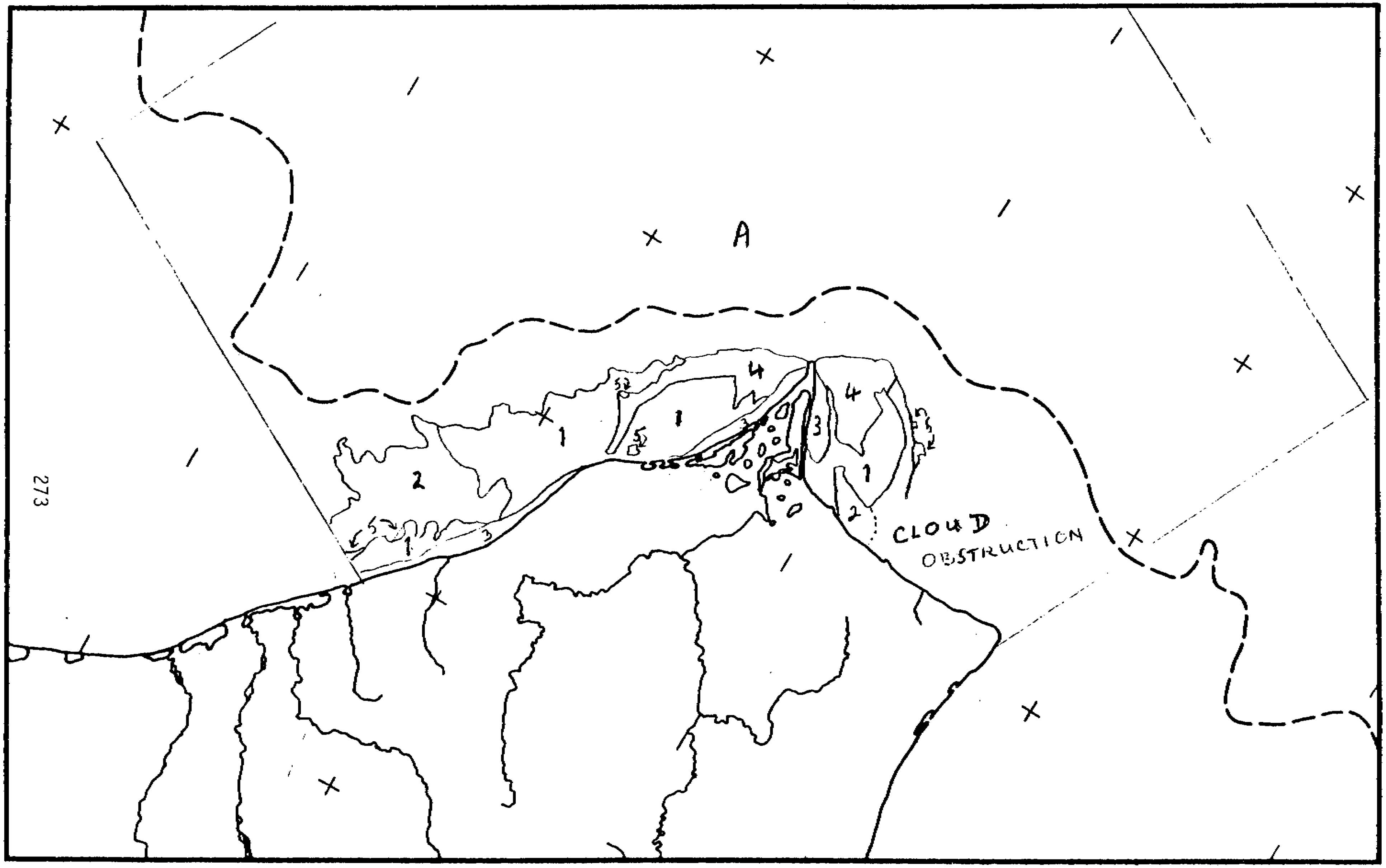
SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: POINT HOPE SECTOR

10 MAY 1976

Figure 69

7 June 1976: Scene E-5415-21361

1 Light toned, homogeneous shorefast ice.
2 Similar to type 1, but with more water on the ice, so it appears darker.
3 Overall this ice is darker than the above types, and it is a mottled tone.
4 This ice is similar to type 3, but there are larger areas of light and dark mottling that in type 3.
5 The darkest toned ice. There may be some open water, but overall the ice appears to be very thin or heavily puddled.
A Consolidated pack ice.



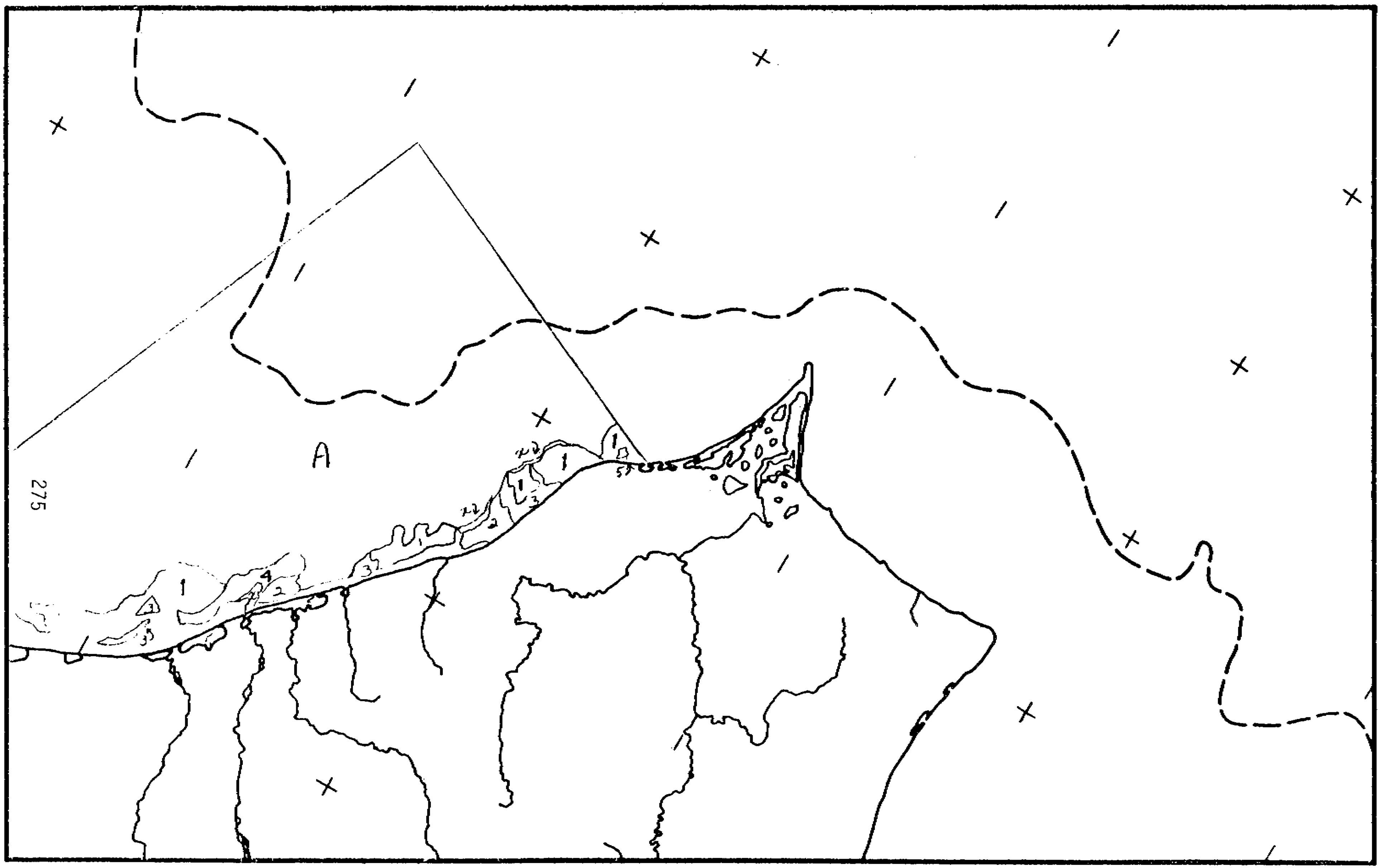
SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: POINT HOPE SECTOR

7 JUNE 1976

Figure 70

14 June 1976: Scene E-2509-21514

1 Fairly homogeneously light toned shorefast ice.
2 Ice appears similar to type 1, but is darker toned due to more surface meltwater.
3 Slightly darker tone than type 1 and the ice appears rougher due to its non-homogeneous character.
4 Ice appears similar to type 2, but is darker toned.
5 Ice with much meltwater on the surface, so it appears very dark.
x Open water. A small amount of ice is also present, mainly along the coast.
A Consolidated pack ice.



SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: POINT HOPE SECTOR

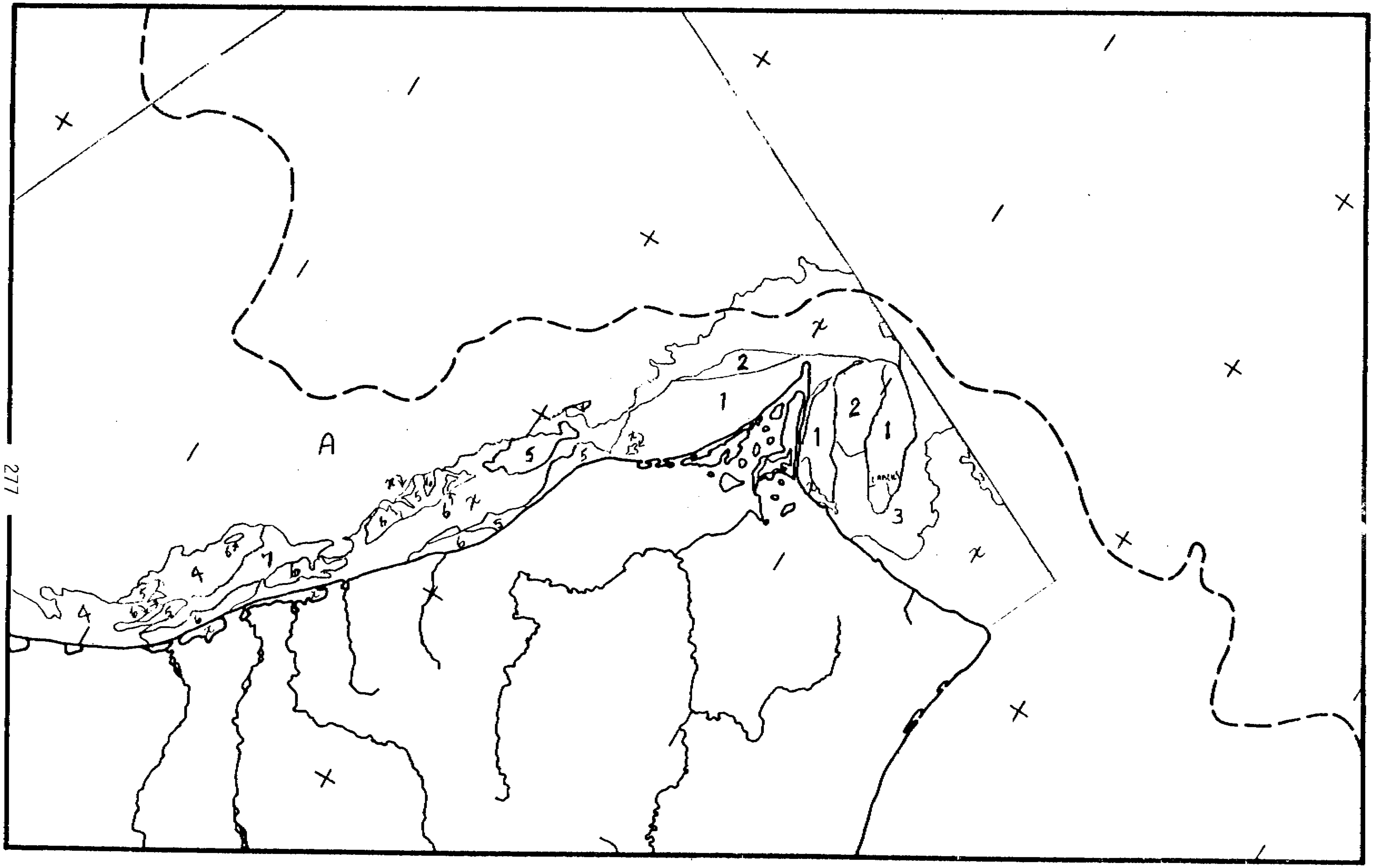
14 JUNE 1976

Figure 71

15 June 1976: E-2510-21572

1 Light toned, generally homogeneous shorefast ice.
2 Similar to type 1, but with slightly more puddling.
3 Similar to type 2, but with markedly greater puddling. Some open water is present in the seaward part of this type.
4 Light toned shorefast ice; similar in tone to type 1, but appears more mottled and less homogeneous.
5 Fairly dark toned, smooth-looking ice.
6 Similar to type 5, but with more water on the ice.
7 Very dark toned ice that appears close to breaking up.
x Open water with small amounts (less than 10%) of floating ice.
A Discontinuous pack ice.

Note: In the southern third of sector the pack is indistinguishable from any fast ice that may be present.



SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: POINT HOPE SECTOR

15 JUNE 1976

23 July 1976: Scene E-2548-22072

No map. No shorefast ice is visible on this frame, however, discontinous pack ice (20-50% ice) is present along the coast near Cape Lisborne.

20 April 1976: Scene E-2454-21474

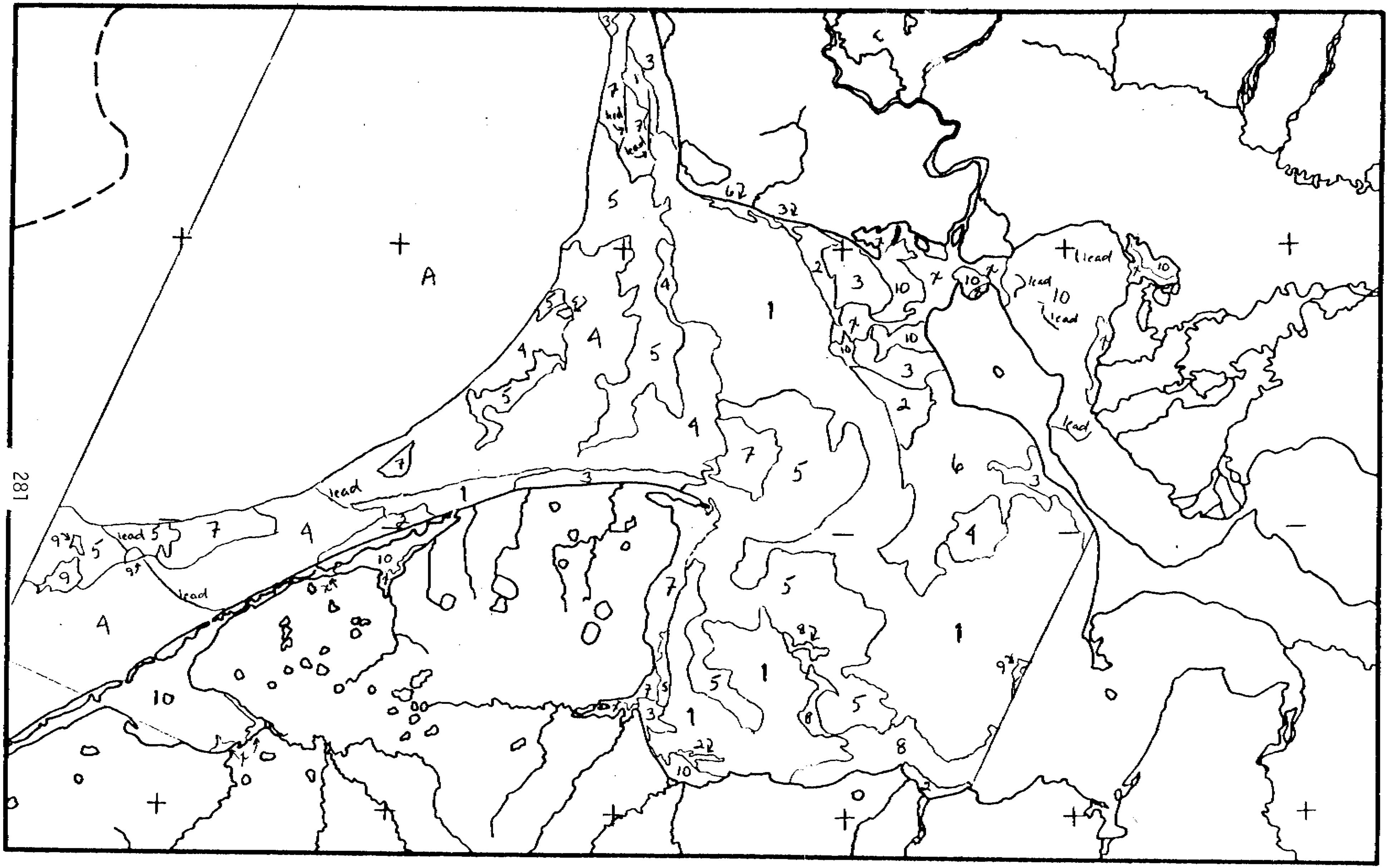
No map. Mainly cloud covered in Kotzebue Sound. Several leads visible seaward of Cape Krusenstern, extending southward across the mouth of the sound.

Figure 72

13 June 1976: Scene E-2508-21462

Types 1-10 are shorefast ice with type 1 being the lightest tone and type 10 being the darkest.

1 Fairly homogeneous ice, including some darker toned areas and some fractured areas.
2 Smooth-looking homogeneous ice.
3 This ice appears very similar to type 2 but with more water present on the ice.
4 Similar in tone to type 2, but somewhat mottled and rougher-looking.
5 Similar-looking ice to type 4, but more water is present overall on the ice.
6 Similar to type 5, but overall greater contrast between the light and dark areas.
7 Ice appears dark (much water on the ice) with some light areas.
8 Dark, fairly smooth-looking ice with a few light areas, mainly lineations.
9 Very dark, smooth-looking ice.
10 Nearshore ice, overall fairly dark toned, that appears ready to break up or melt.
x Open water.
A Pack ice.



SHOREFAST SEA ICE
SURFACE MORPHOLOGICAL CHARACTERISTICS
CHUKCHI SEA COAST: KOTZEBUE SOUND SECTOR

13 JUNE 1976

6 August 1976: Scene E-2562-21445

No map. No ice is visible on this frame of Kotzebue Sound.

Photo 1 Kotzebue (right center) and adjacent channel of rapidly moving open water, looking north. 4 June 1977.

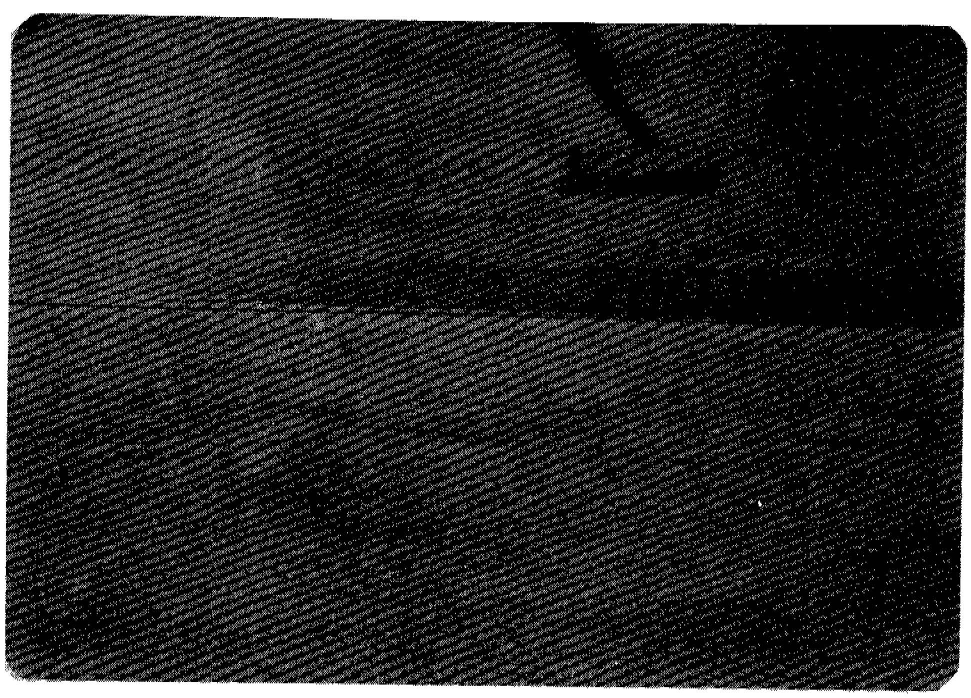


Photo 2 Flat winter ice in Kotzebue Sound looking north.

Photo 3 Ice floes and leads immediately west of Kozebue Sound. Ridging is present only along the edges of the floes.

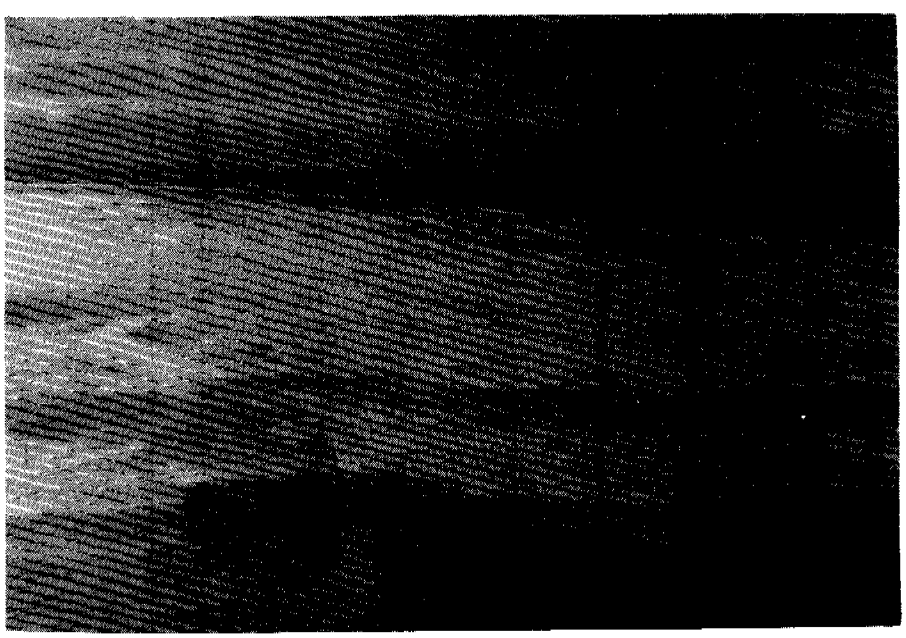


Photo 4 Two types of ice in Kotzebue Sound (demarcation line upper left to lower right). View to east, Baldwin Peninsula.

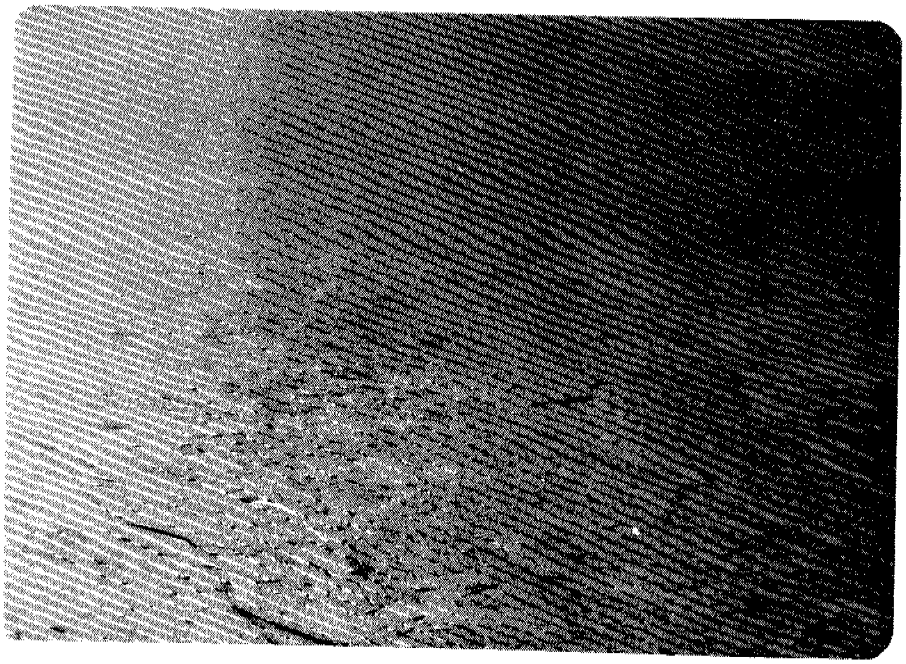


Photo 5 Wide ridged area at end of Barter Island transect. View east, 18 June 1977.

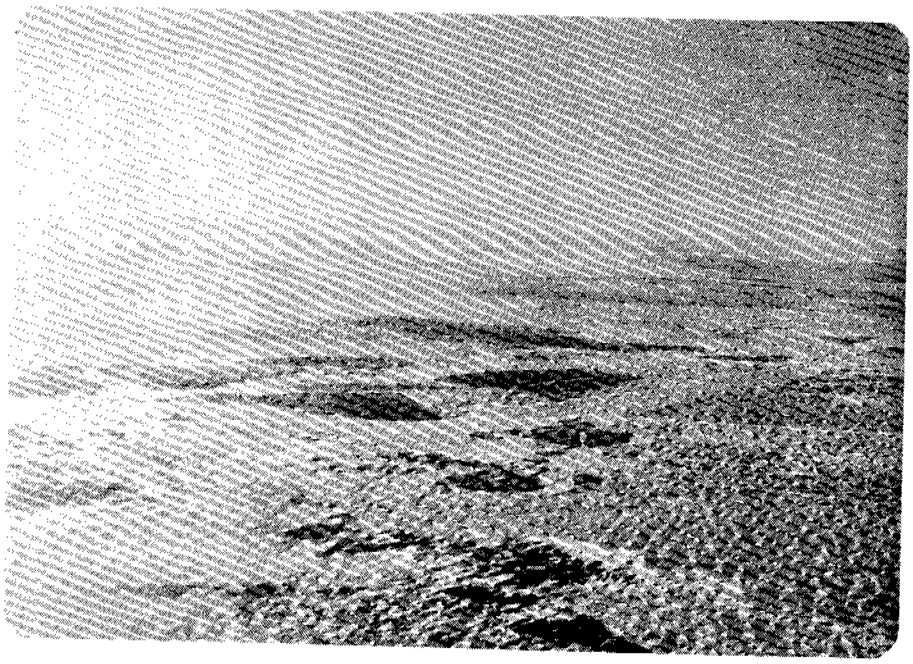


Photo 6 Flat winter shorefast ice with intervening darker floes frozen in place. Harrison Bay transect just east of Atigaru Point, 13 June 1977.

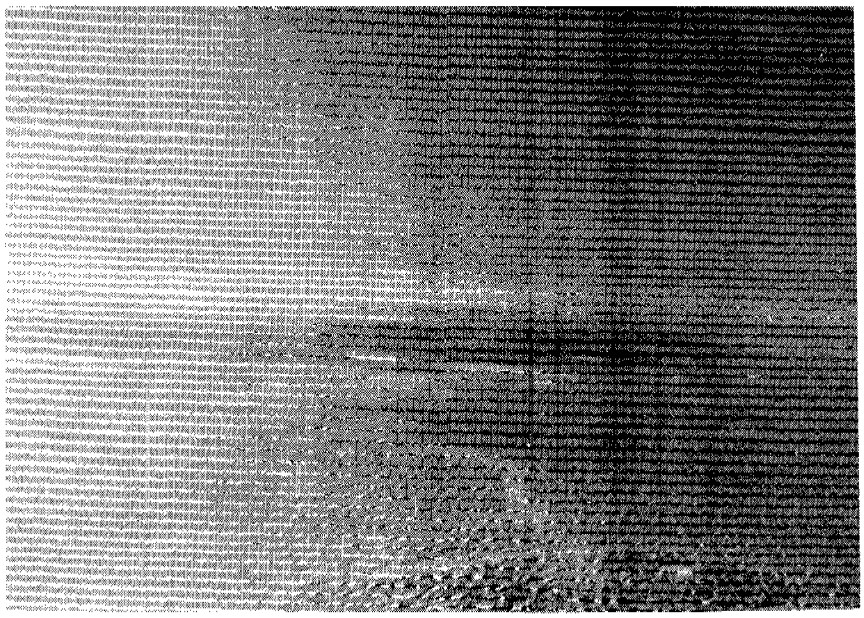


Photo 9 Flat shorefast ice beyond hummock fields along Harrison Bay transect. View to the NE. Ridges and pack ice visible in background.

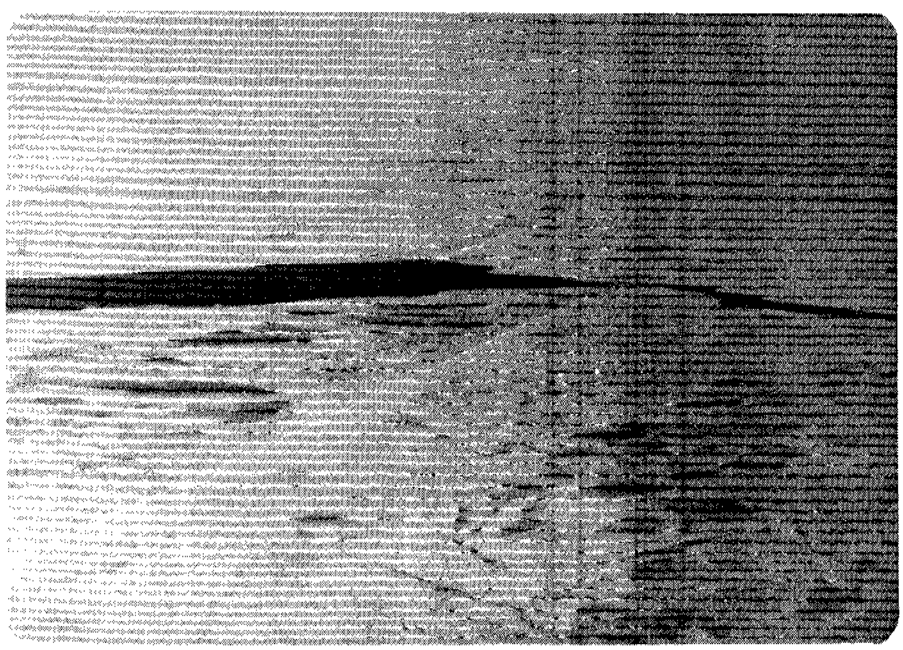


Photo 10 Fast ice - Pack ice boundary in Harrison Bay, 13 June 1977. Note breaking of fast ice and seaward movement (to the left) in the upper right.

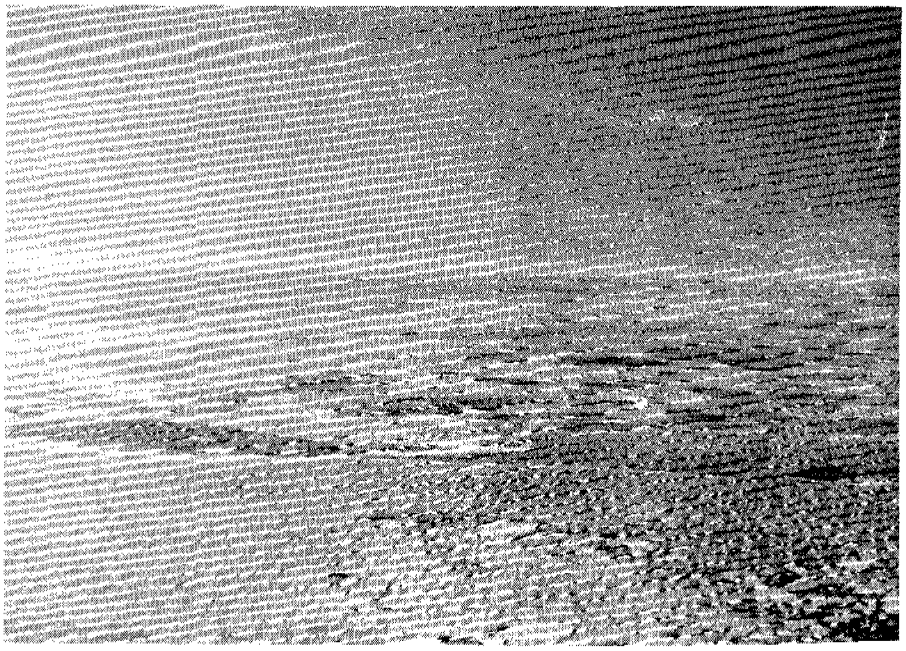


Photo 7 Rough ice and hummock fields along the Harrison Bay transect, view to the NE, 13 June 1977.

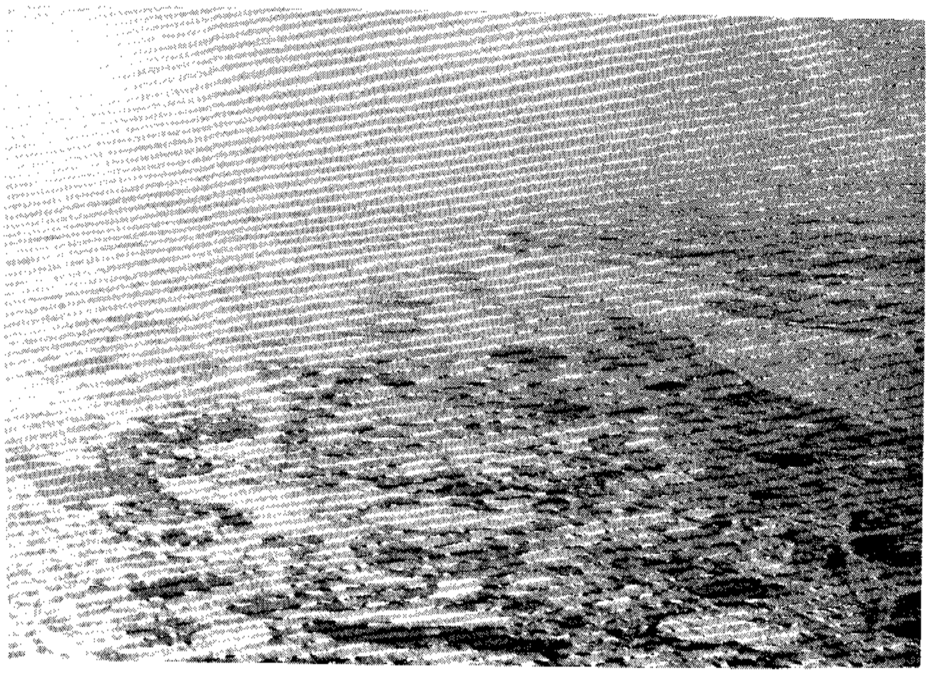


Photo 8 Rough, dirty, hummocked ice in Harrison Bay, 13 June 1977.

APPENDIX 1.

Paper submitted to Fourth POAC Conference, 1977.

A METEOROLOGICAL BASIS FOR LONG-RANGE FORECASTING OF SUMMER AND EARLY AUTUMN SEA ICE CONDITIONS IN THE BEAUFORT SEA

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INTRODUCTION

The beginning of drilling operations and the movement of supplies and resources between Point Barrow and Prudhoe Bay, Alaska, has made an assessment of the Beaufort Sea ice regime imperative. Under the Offshore Continental Shelf Environment Assessment Program (OCSEAP) of NOAA/BLM one such appraisal is underway (Barry et.al., 1977). The Beaufort Sea is ice covered approximately nine months of the year. Only between late July and early October (in favorable ice summers) is it possible to safely ship supplies along the coast. In more severe ice summers such as those of 1955 (Winchester and Bates, 1958) and 1975 shipping can be delayed or halted. Using meteorological data as the predictor, the purpose of this paper is to develop possible long-range forecasting techniques of the expected summer-time ice severity along the Beaufort Sea Coast between Pt. Barrow and Prudhoe Bay.

There are two primary procedures used in developing a meteorologically based sea ice forecasting scheme. The first is to discover the important meteorological parameters which are associated with sea ice breakup and the second is to develop a suitable forecasting scheme which employs those parameters. Historically the most useful meteorological parameter in both breakup and freezeup forecasting has been air temperature from land based stations (Lee and Simpson, 1954; Wittmann, 1958; Bilello,1961). Considerable variability occurs when one reviews the actual forecasting schemes developed by these authors. Lee and Simpson determined the ice potential of an area from heat budget analysis and then used air temperature as a final predictor of the time of freezeup. Wittmann converted air temperatures into accumulated thawing degree days (TDD's), which were in turn associated with different phases of breakup, and then predicted future TDD accumulations and ice conditions using conventional meteorological forecasts. A TDD is the negative departure of 1C^{o} from 0^{o}C. Bilello showed that regression equations, with air temperature as the independent variable, can be used to predict the growth and decay of sea ice. This paper will develop long-range forecasting schemes by using both persistence in monthly anomalies of air temperature and long term periodicities in summertime monthly air temperatures. Preceding that is a discussion of the interrelated meteorological parameters which affect sea ice conditions between Pt. Barrow and Prudhoe Bay.

DATA

The data used for this study consisted of:

1. Barrow, Alaska, monthly mean temperatures from January 1921 through December 1976, and daily mean temperatures (usually converted to accumulated TDD's during

summer months) since 1953.

2. The distance northward from Pt. Barrow to the southernmost limit of 4/8 concentration of pack ice on Sept. 15 between 1953 and 1975. These data were taken from Barnett (1976) who ranked each summer in order of its ice severity. Severe summers are those during which the ice is closest to Pt. Barrow and during which there are relatively few ice free days along the sea route to Prudhoe Bay. Ranked in Barnett's order of increasing severity these unfavorable summers are those of 1967, 1966, 1965, 1953, 1971, 1960, 1964, 1970, 1956, 1969, 1955, and 1975.

3. Surface prevailing and resultant (after 1964) wind directions for Barrow taken from the NOAA publication Local Climatological Data. Data were tabulated from July 1 through Sept. 15 from 1953 through 1975.

4. Monthly sea level pressure values (at each $5^\circ x 5^\circ$ grid point interval) from May to October from 1939 to 1975 and made available by the National Center for Atmospheric Research at Boulder and originally derived from historic weather maps.

5. LANDSAT imagery of the Beaufort Sea Coast between 1972-76.

METEOROLOGICAL PARAMETERS ASSOCIATED WITH BEAUFORT SEA ICE BREAKUP

As discussed in the Introduction, the primary parameter used in long and extended-range forecasts of sea ice decay and breakup has been air temperature. Although these data are usually collected from a nearby (to the ice) land station, a high degree of relationship has been established (Wittmann, 1958) between such data and stages of breakup. In the Beaufort Sea the breakup process begins with thawing and ponding of landfast ice which approximately extends to the 20 m. isobath. The landfast ice then breaks and clears from that zone and thawing and thinning of the areal concentration of the adjacent polar pack ice begins. Although the southernmost boundary of the pack ice may vary with winds, the pack ice will normally retreat northward about 150 km. by mid-September (based on Barnett's data).

Recent studies (Barnett, 1976; Walsh, 1977) have suggested the importance of sea level pressure distribution as an important forecasting parameter. In addition, Wittmann (1958) noted that the Beaufort Sea near Pt. Barrow is geographically situated such that ice may become trapped in the area and offshore and onshore winds play very important roles in determining the characteristics of breakup.

In view of the importance of other meteorological parameters beside air temperature an attempt was made (Rogers, 1977) to determine the interrelationship between such parameters and Beaufort Sea breakup. The primary meteorological parameters which emerged from that analysis are shown in Table 1. Table 1 shows that summertime accumulated TDD's, the number of days with southerly and northerly winds, and the Sept. 15 distance to the pack ice are highly intercorrelated. These factors were affected by the sea level pressure distribution which was best represented by the grid point pressure values at 80°N120°W and 75°N170°E. A mild ice summer was characterized by high pressure near 80°N120°W, lower pressure northwest of Point Barrow (75°N170°E) and the resultant southerly (overland) winds and higher temperatures. The opposite pattern (northerly winds) occurred during severe ice summers.

Despite the interrelationship between these parameters it appears that air temperature remains the primary factor associated with breakup. The ease with which air temperature forecasts can be applied or obtained from other sources as compared to wind direction and pressure data has resulted in it being the primary parameter of interest here. Nonetheless forecasts based upon the pressure at the grid points given in Table 1 were also considered.

TABLE 1 - Correlation matrix of meteorological parameters associated with the distance to the pack ice margin on Sept. 15 since 1953 (after Rogers, 1977). Statistically significant coefficients are underlined (95%).

	Dist.	TDD	140	350	80N	75N
Sept. 15 dist. to ice margin	1.000					
TDD's	0.815	1.000				
# of days winds from 140-190°	0.760	0.606	1.000			
# of days winds from 350-040°	-0.718	-0.623	-0.524	1.000		
Pressure at 80°N120°W	0.598	0.612	0.326	-0.582	1.000	
Pressure at 75°N170°E	-0.225	-0.416	-0.197	-0.025	0.195	1.000

As a prediction guide the number of accumulated TDD's associated with the stages of Beaufort Sea breakup and pack ice retreat were tabulated. Based upon LANDSAT images of ice conditions along the Beaufort Sea Coast from 1972-76 the ranges of TDD accumulations associated with breakup stages are given in Table 2. Wittmann (1958) found that 170-180 TDD's (average) accumulate when the ice is removed near Pt. Barrow (stage 3 below).

TABLE 2 - Accumulated TDD's associated with stages of sea ice breakup and retreat in the Beaufort Sea.

		TDD (°C) accumulation
1.	Initiation of ponding and thawing	0 to 55
2.	Fast ice breakup, open water appears	56 to 140
3.	Fast ice removed to 20 m. isobath, pack melting	141 to 225
4.	Pack ice retreat, possibly up to 80 km.	226 to 305
5.	Pack ice retreat greater than 80 km.	306 or more

PERSISTENCE OF MONTHLY AIR TEMPERATURE ANOMALIES AT BARROW

The monthly temperatures at Barrow for May through October from 1921 to 1976 were divided into three categories, above normal (AN), below normal (BN), and normal. A monthly mean temperature was characterized as normal if it was within $\pm$ 0.5 standard deviations of the 56 year (long term) monthly mean temperature. AN and BN months lay outside those limits of normal. This method of determining the monthly temperature anomaly categories resulted in approximately 40% of all months being normal and about 30% each being AN or BN during the 56 year period for any given month. Table 3 shows the 56 year mean and the range of normal monthly temperatures for May through October. Persistence between any two months occurs if they have the same temperature anomaly category, and it was assumed when developing the forecasting technique that persistence always occurs between any pair of months.

The first of the two months in a persistence (or non-persistence if the above assumption is incorrect) pair is the predictor month and the second is the predictand month. The predictor month must always occur earlier in the year than the predictand month, therefore May is always a predictor while October is always a predictand in the data set analyzed here.

A test of the persistence assumption was made to determine if persistence could be further considered as a forecasting technique. If persistence between any pair of months occurred in more than 33.3% to 40% of the past 56 years then it was assumed

TABLE 3 - Long term (56 year) mean temperature, range of normal temperatures, and range of mean monthly TDD accumulation for May through October.

MONTH	MEAN Temp. (°C)	Temperature range of normal category	Range of TDD accumulation during normal cat. months
May	-7.3	-8.1 to -6.6	0*
June	0.9	0.3 to 1.3	28 to 56
July	4.1	3.4 to 4.8	107 to 150
Aug.	3.3	2.4 to 4.3	74 to 135
Sept.	-0.9	-1.7 to 0.1	0 to 22
Oct.	-9.1	-10.6 to -7.6	0*

* TDD's do not accumulate during AN category months either.

that it occurred with a frequency greater than chance and that it could be used as an air temperature forecasting technique between those months. If persistence between any pair of months occurred in about 33.3% to 40% or fewer of the past 56 years then there is no persistence occurring other than what might be expected by chance. The 33.3% to 40% chance limit is a result of there being one chance in three that the anomaly category of the predictand month is the same as that which occurred in the predictor month, and as a result of there being a slightly better chance of a normal month occurring (about 40% of the months).

Starting with a one month lag between predictor and predictand months (May to June,... etc.... Sept. to Oct.) the number of month pairs with the same anomaly categories since 1921 were tabulated and are shown in Table 4. The percentage of these persistent month pairs is given in the lower right corner of each part of Table 4. The results show that all months except the June-July pair exhibit persistence to a greater degree than would be expected by chance. The persistence indicated in the one month lags of Table 4 is even better when considering that AN and BN category predictor months are very seldom followed by BN or AN (respectively) predictand months. For example,from Table 4C an AN July was followed by a BN August only once.

Whether or not persistence also existed for lags of two or more months was also tested. May-July, June-Aug., July-Sept., and Aug.-Oct. persistence existed in 36%, 39%, 50%, and 48% of the last 56 years. Generally only about one-half of the months intervening between the predictor and predictand months had the same anomaly category when persistence occurred between them. This frequent dissimilarity in the anomaly category of the intervening months implies that the useful degree of persistence in the July-Sept., and Aug.-Oct. pairs is more statistically sound than physically sound. The persistence at three months lag (May-Aug. = 32%; June-Sept. =36%; and July-Oct. = 45%) occurred during even fewer years.

Table 5 further shows the degree of persistence (correlation) between the various predictor-predictand month pairs. In particular Table 5 shows that May and June are statistically significantly correlated with each other but not with any of the other months. This can be seen from Table 4 where May-June persistence occurs during 54% of the years, however when either May or June are predictors for other month pairs on any time lag scale there is little persistence. Table 5 also shows that there should be a good degree of persistence between most month pairs from July through November (which hasn't been considered in the analysis up to this point). This suggests that persistence may be successfully applied to freezeup forecasts as well as toward late summer breakup forecasts.

TABLE 4 — One month lag persistence and non-persistence occurrences between temperature anomaly categories since 1921 for May through October. The percentage of persistent years for each pair of months appears on the lower right.

	Cat.	JUNE AN	JUNE N	JUNE BN	Total
MAY	AN	7	7	2	16
MAY	N	5	13	5	23
MAY	BN	4	3	10	17
	Total	16	23	17	54%

TABLE 4A. May vs. June

	Cat.	JULY AN	JULY N	JULY BN	Total
JUNE	AN	7	6	3	16
JUNE	N	4	9	10	23
JUNE	BN	4	8	5	17
	Total	15	23	18	38%

TABLE 4B. June vs. July

	Cat.	AUGUST AN	AUGUST N	AUGUST BN	Total
JULY	AN	8	6	1	15
JULY	N	6	10	7	23
JULY	BN	1	8	9	18
	Total	15	24	17	48%

TABLE 4C. July vs. August

	Cat.	SEPTEMBER AN	SEPTEMBER N	SEPTEMBER BN	Total
AUGUST	AN	8	5	2	15
AUGUST	N	8	11	5	24
AUGUST	BN	1	7	9	17
	Total	17	23	16	50%

TABLE 4D. August vs. September

	Cat.	OCTOBER AN	OCTOBER N	OCTOBER BN	Total
SEPT	AN	11	5	1	17
SEPT	N	9	9	7	25
SEPT	BN	1	3	10	14
	Total	21	17	18	54%

TABLE 4E. September vs. October

TABLE 5 - Correlations between mean monthly temperatures at Barrow, 1921-76. Underlined coefficients are significant at the 99% level.

MONTHS	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER
MAY	1.000						
JUNE	0.347	1.000					
JULY	0.132	0.307	1.000				
AUGUST	-0.086	0.138	0.383	1.000			
SEPTEMBER	0.159	0.180	0.251	0.445	1.000		
OCTOBER	0.146	0.292	0.387	0.481	0.666	1.000	
NOVEMBER	0.083	0.188	0.386	0.434	0.384	0.501	1.000

The remaining months, January through April, and December, were not significantly correlated to any of the months May through November or with each other. This would suggest that useful air temperature anomaly predictions using persistence could only be made between May and June and during combinations of months from July through November. The May-June discontinuity with the remainder of the warm season not only hinders the chance for reliable early long-range temperature anomaly forecasts, it is also difficult to explain physically. Perhaps the explanation depends upon surface feature changes such as in albedo when the land and sea ice snow cover decreases in May and June and/or in atmospheric circulation changes at this time of year such as those described by Barry et.al. (1977).

An analysis of possible seasonal persistence in temperature anomalies was done in the same manner as the monthly analysis and revealed that persistence greater than that which would be expected by chance does not exist between winter and spring (29%), or winter and summer (36%, see Table 6F), or between spring and summer (25%, see Table 6E). There is however, persistence between summer and September (54%, see Table 6C), and summer and October (55%, see Table 6D). This further suggests that air temperature anomaly forecasts might also be applied to freezeup forecasting in this area. Warmer summers are associated with warmer water and more ice free area in the Beaufort Sea, and this in turn takes longer to freeze in the autumn and modifies otherwise cold air masses in the area during those months. The persistence tables of Table 6 show that AN or BN summers are seldom followed by BN or AN (respectively) categories in either September or October.

The persistence of anomalies of sea level pressure at 80°N120°W and 75°N170°E was also tabulated using data since 1939. The results showed that the persistence between predictor and predictand month pairs is slightly greater than that which would be expected by chance at 80°N120°W but not at 75°N170°E for a one month lag. The May to June,...etc... September to October one month lags showed persistence in 43%, 46%, 30%, 43%, and 38% of the years since 1939 at 80°N120°W and in 31%, 31%, 32%, 41%, and 38% of the years since 1939 at 75°N170°E. Lags of two or more months showed no persistence. Since these results are poorer than those obtained using air temperatures, sea level pressure was not considered further as a predictor of summertime pressure or ice conditions.

Table 6 includes additional air temperature persistence tables between two month lag pairs described above especially July-Sept., Aug.-Oct., May-July and June-Aug.

PERIODICITIES IN THE BARROW MONTHLY TEMPERATURE TIME SERIES

Predictability based upon periodicities in monthly air temperature was also considered. Spectrum analysis of monthly normalized Barrow temperatures from January 1948 through December 1974 (324 months) showed that a periodicity of about 50 to 66 months (frequencies between 0.015 and 0.020 cycles per month) occurred in the low frequency variance (Figure 1). The spectral estimates at these frequencies were the only ones to be statistically significant at the 99% confidence limit in the entire spectrum. Spectrum analysis of the 56 year time series for each month showed that several, primarily summer months, had spectral estimates which peaked above their white noise continuum at frequencies between 0.20 and 0.25 cycles per year which corresponds to a periodicity between four and five years. Further testing of these data showed that these spectral estimates were not statistically significant.

Cospectrum analysis of the 56 years of data for adjacent months also revealed a four to five year periodicity along with one of slightly more than two years. Cospectrum analysis is a statistical technique in which the relationship or

TABLE 6 - Two month lag persistence and non-persistence occurrences and seasonal persistence between temperature anomaly categories since 1921. The percentage of persistent years for each pair appears on the lower right.

	SEPTEMBER				
Cat.	AN	N	BN	Total	
AN	7	6	2	15	
N	7	12	4	23	JULY
BN	3	6	9	18	
Total	17	24	15	50%	

TABLE 6A- July vs. September

		OCTOBER			
	Cat.	AN	N	BN	Total
	AN	10	3	2	15
AUGUST	N	9	8	7	24
	BN	2	6	9	17
	Total	21	17	18	48%

TABLE 6B - August vs. October

	SEPTEMBER				
Cat.	AN	N	BN	Total	
AN	8	5	3	16	
N	9	11	2	22	SUMMER
BN	0	7	11	18	
Total	17	23	16	54%	

TABLE 6C - Summer vs. September

		OCTOBER			
	Cat.	AN	N	BN	Total
	AN	9	5	2	16
SUMMER	N	12	8	2	22
	BN	0	4	14	18
	Total	21	17	18	55%

TABLE 6D - Summer vs. October

	SUMMER				
Cat.	AN	N	BN	Total	
AN	3	7	6	16	
N	9	6	7	22	SPRING
BN	4	9	5	18	
Total	16	22	18	25%	

TABLE 6E - Spring vs. Summer

		SUMMER			
	Cat.	AN	N	BN	Total
	AN	4	8	5	17
WINTER	N	7	9	6	22
	BN	5	5	7	17
	Total	16	22	18	36%

Table 6F - Winter vs. Summer

	JULY				
Cat.	AN	N	BN	Total	
AN	6	4	6	16	
N	6	9	8	23	MAY
BN	3	10	4	17	
Total	15	23	18	36%	

TABLE 6G - May vs. July

		AUGUST			
	Cat.	AN	N	BN	Total
	AN	5	6	5	16
JUNE	N	6	11	6	23
	BN	4	7	6	17
	Total	15	24	17	39%

TABLE 6H - June vs. August

correlation between two time series is separated into individual contributing frequencies or periodicities. Therefore taking the cospectrum between the August and September and September and October time series (which are correlated by r=0.445 and r=0.666 respectively from Table 5) as an example shows that the primary contribution to those correlations comes from periodicities in the four to five year range. Even some of the winter and early spring months had spectra with larger than expected estimates in this period range even though their correlations were low and insignificant.(In general however, many of the cospectrum between adjacent months did not have any statistically significant estimates despite the apparent peaks above the white noise continuum between four and five years period. The fact that this periodicity recurs in most months suggests that it should be investigated further.

Barnett (1976) found a five year periodicity in his Beaufort Sea ice data between 1953 and 1975. He cited the fact that severe ice summers had occurred in 1955, 1960, 1965, 1970, and 1975 as one piece of evidence for this. Severe ice summers also occurred in 1956, 1964, and 1969 and mild summers have occurred in 1954, 1958, 1962, 1968, and 1972 which suggests that there are elements of a four year periodicity also. A subjective analysis of Barrow mean summer temperatures indicated as expected from the above results (Table 1 and the spectrum analysis) that there is a four to five year gap between very mild summers and very cold summers. Analysis of the pre-1953 temperature record in a similar manner seemed to indicate that such a periodicity may have been less pronounced or even nonexistant before the late 1940's. This was the rationale for choosing the 1948 to 1974 time series for the spectrum analysis of Figure 1. Comparison of the low frequency portion of that spectrum to another of the equal length period 1921 to 1947 in Figure 2 shows that the 50 to 66 month periodicity does not exist. This earlier period time series is characterized by significant long term periodicities between 100 and 200 months and one at about 25 months (nonsignificant). In view of this additional fact that the nature of the spectrum of the Barrow temperature time series changes then the significance of any of the periodicities should be doubted. The existence of this periodicity is more a function of statistics than physics of the atmosphere.

CONCLUSIONS AND APPLICATION OF MONTHLY TEMPERATURE PERSISTENCE AND PERIODICITIES TO BEAUFORT SEA ICE FORECASTING

The results have shown a high correlation between air temperature (TDD's) at Barrow, Alaska, and the extent of ice breakup in the Beaufort Sea from Point Barrow to Prudhoe Bay (Tables 1 and 2). Analysis of the temperature time series at Barrow showed persistence between anomalies during about 50% of all month pairs for one month lags (Table 4). This represents 30% to 50% more cases of persistence than might be expected by chance. Two month lag forecasts would only be successful using July, August, or summer temperature anomalies as predictors of September and October anomalies (see Table 6). May is a good predictor of June anomalies but neither of these months could be used directly as predictors of the remaining warm season months (Table 5). In addition it was found that a four to five year periodicity which has been noted since about 1950 in the Beaufort Sea ice (Barnett, 1976) and temperature record is a statistical manifestation, indicating that it must be applied with caution in sea ice forecasting.

Despite the problems indicated above the desired long-range sea ice forecast is relatively simple; only a determination of whether the ice summer will be severe or mild is required. Table 3 shows that during a summer in which only normal months would occur, anywhere from 209 to 363 TDD's (computed by summing the ranges of monthly TDD accumulations in the fourth column of Table 3) can be expected.

These ranges of normal category month TDD accumulations were based upon actual accumulations since 1953. Comparing this range of net accumulated TDD's to the results of Table 2 shows that such a normal summer would generally favor shipping and mild ice conditions. Since only four severe ice summers (1971, 1967, 1966, and 1965) as defined in the data section had TDD accumulations of more than 209 TDD's (and none of them exceeded 256 TDD's) it can be assumed that summers predominated by BN months with some normal months will become severe ice summers. While it is possible that a summer with all normal months could become severe the monthly temperature anomaly data shows that the BN category always occurs during some or most of the severe ice summer months.

It is therefore necessary to discern only between summers which will have a combination of AN and normal months (which will result in mild ice summers) and those which will have a combination of BN and normal months (becoming severe ice summers). Based upon the results of one (Table 4) and two (Table 6) month lags starting in July there is a high degree of persistence when AN or BN months occur. If July is AN or BN one can be relatively assured that that anomaly category will recur, or at least that a normal month will follow.

Waiting until the end of July to make a relatively useful high persistence forecast may be too late to be of operational value to shippers and others. As a result two questions emerge:

1) How can one make a useful early sea ice forecast around the May-June discontinuity with the remainder of the summer and around the possibility that July may become a normal category month which would prolong the indecision of the forecast of the nature of the ice summer since AN or BN categories could follow with approximately equal probability?

2) How can a forecaster distinguish a severe ice summer which will seriously delay or halt shipping from one that will not greatly hamper shipping? As mentioned above the summers of 1955 and 1975 were in the former category.

The answer to the first question derives from information which persistence tables (Tables 4 and 6) indicate does <u>not</u> have a high probability of occurring. Since the primary concern is whether one or more of the months July, August, and September will be either AN or BN and we are confident from Table 4 that they will almost never mix, there are two possible approaches:

1) Generally there is approximately a 60% chance or more that the anomaly category for one of these three primary summer months will be normal or opposite (in terms of AN and BN) the category in May or June (see Tables 6G and 6H).

2) Similarly there is a good chance that the temperature anomaly category for the summer will be normal or opposite (in terms of AN and BN) the anomaly category of the preceding winter or spring (see Tables 6E and 6F for example).

The answer to the second question posed above is more difficult. Persistence of categories such as BN cannot separate extremely severe ice summers from those during which a modest amount of shipping can take place. Perhaps the best possible answer lies in applying the four to five year periodicity observed in the ice and temperature record despite the lack of a physically sound basis for it. Assuming that this periodicity will continue to exist in the near future it is possible to suggest that after the severe summer of 1975 three summers of gradually improving ice conditions will follow with 1978 being the most favorable. This in turn will be followed by a rapid decline in ice conditions with the summer of 1980 being the most likely to be very severe. During the summer of 1976 sufficient melting and retreat of the pack ice occurred to permit shipping although the ice margin was well south of its normal position. It appears from June 1977 field work done by the author that melt and decay of the fast ice was about two weeks ahead of that which occurred in 1976.

The overall results suggest that persistence of monthly air temperature anomalies at Barrow in conjunction with cautious application of periodicities in those temperatures can be successfully used as predictors of the severity or mildness of summertime Beaufort Sea ice conditions. Depending upon user needs these meteorologically based prediction techniques could feasibly be used in other aspects of sea ice forecasting, particularly the time of freezeup.

ACKNOWLEDGMENTS

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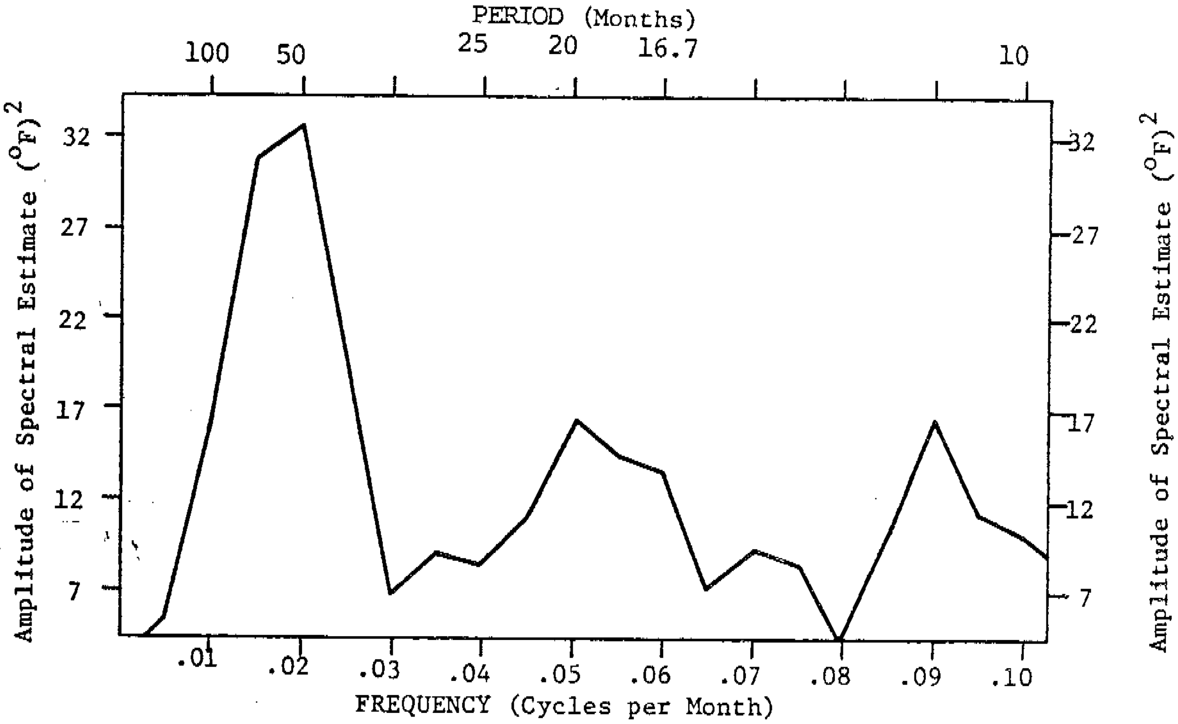

FIGURE 1 - The spectrum at low frequencies of monthly normalized air temperatures at Barrow, Alaska, from January 1948 through December 1974.

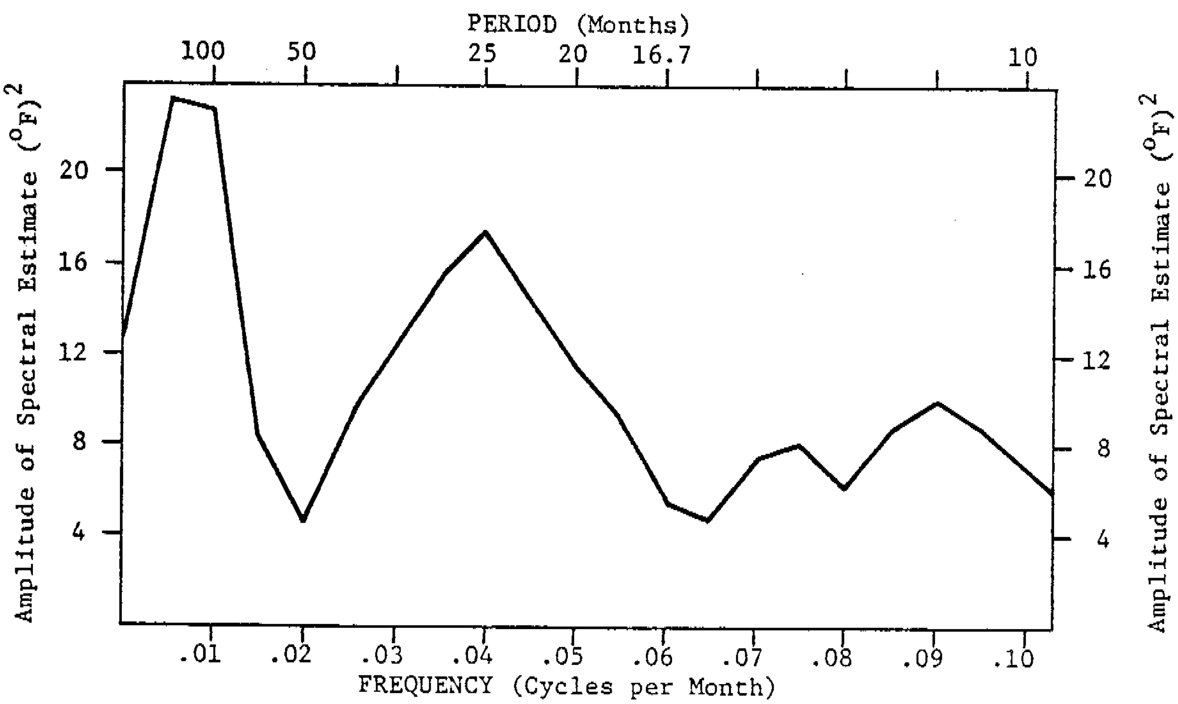

FIGURE 2 - The spectrum at low frequencies of monthly normalized air temperatures at Barrow, Alaska, from January 1921 through December 1947.

Quarterly Report

Contract # 03-5-022-55
Research Unit # 250
Task Order # 11
Reporting Period: 7/1/77-9/30/77
Number of Pages: 1

MECHANICS OF ORIGIN OF PRESSURE RIDGES, SHEAR RIDGES AND HUMMOCK FIELDS IN LANDFAST ICE

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September 30, 1977

OCS COORDINATION OFFICE

Univeristy of Alaska

Quarterly Report for Quarter Ending September 30, 1977

Project Title:	Mechanics of Origin of Pressure Ridges, Shear Ridges and Hummock Fields in Landfast Ice.
Contract Number:	03-5-022-55
Task Order Number:	11
Principal Investigators:	Lewis H. Shapiro, William D. Harrison, and Howard F. Bates.

I. Task Objectives:

To determine the mechanics of origin of pressure ridges, shear ridges and hummock fields in landfast ice.

II. Schedule:

Field work and analysis.

III. Results:

1. During the past quarter we collaborated with Dr. Peter Barnes of the U. S. Geological Survey on a side-scan sonar survey of the sea floor off the Naval Arctic Research Laboratory at Barrow. Approximately 50 kilometers of track line was surveyed within the field-of-view of the University of Alaska sea ice radar system. The path of the survey vessel was monitored by the radar and the data acquired are currently being processed.

2. A series of experiments were conducted at Barrow to determine the coefficient of friction between an ice sheet and typical beach gravels. The field work was done during June, and the data reduction has been completed. The results of 51 separate measurements, in which a large block of ice was dragged over the beach by a bulldozer, gave a value .67 for the coefficient of static friction and .56 for the coefficient of kinetic friction. The standard derivation for both data sets was .04.

IV. Problems Encountered:

Vacations reduced the number of man-hours available for this project by almost 50% during the past quarter.

V. Esimtated Funds Expended: $10,000.

Quarterly Report

Contract #03-5-022-55
Research Unit # 257
Task Order # 5/8
Reporting Period: 6/30/77 - 9/30/77
Number of Pages: 3

MORPHOLOGY OF BEAUFORT, CHUKCHI AND BERING SEAS NEAR SHORE ICE CONDITIONS BY MEANS OF SATELLITE AND AERIAL REMOTE SENSING

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September 30, 1977

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending September 30, 1977

Project Title:	Morphology of Beaufort, Chukchi and Bering Seas Near Shore Ice Conditions by Means of Satellite and Aerial Remote Sensing.
Contract Number:	03-5-022-55
Task Order Number:	8
Principal Investigator:	W. J. Stringer

I. Task Objectives:

The objective of this study is to develop a comprehensive morphology of near shore ice conditions along the ice-frequented portions of the Beaufort, Chukchi and Bering Sea coasts of Alaska. This comprehensive morphology will include a synoptic picture of the development and decay of fast ice and related features, and in the absence of fast ice, the nature of other ice (pack ice, ice islands, hummock fields, etc.) which may occasion the near shore areas in other seasons. Special emphasis will be given to consideration of potential hazards to offshore facilities and operations created by dynamic ice events. Based on satellite observations available since 1972, a historical perspective of near shore ice dynamics will be developed to aid in determining the statistical rate of occurrence of ice hazards.

II. Field and Laboratory Schedule:

This project has no field schedule. All remote sensing aircraft data is to be provided by project management. Occasional field reconnaissance flights will be carried out on an unscheduled basis. The work does not involve laboratory activities. No field work was performed during this quarter.

III. Results:

Using maps summarizing ice conditions for the ice years 1972-73, 1973-74, 1974-75, and 1975-76, maps describing near shore morphological conditions in the Chukchi and Beaufort Seas were constructed. Based on these morphology maps, the next generation maps: Chukchi and Beaufort ice hazard maps have been completed to draft form. These maps are approximately 20 x 50" in size and will be submitted in final form in one volume as part of our next annual report unless we are directed otherwise by project management. This is a change in plans from our original intention to include these maps with this quarterly report. The chief reason for this change in plans is the large format of the maps and our desire to avoid needless duplication, since these maps will necessarily be part of this year's annual report in any case.

IV. Preliminary Interpretations:

The Beaufort and Chukchi sea ice morphology maps have been used to identify regions of reasonably common morphology. These areas have been delineated for use in near shore ice hazard maps. The near shore ice hazard maps have interpreted these areas along the Chukchi and Beaufort coasts with various degrees and periods of hazard to surface exploration activities and similar analyses of degrees and periods of hazards to structures placed in these areas resulting from ice behavior. In addition, the areas identified have been evaluated in terms of the fate of underwater petroleum spills.

In general, many large areas of stable ice suitable for prolonged surface activities have been identified. However, several other areas have been identified which, although often well inshore of flaw leads, are extremely hazardous for surface operations. Similarly, areas have been identified where ice is formed early in the winter and remains until late spring providing little danger to temporary structures during that time. Other areas have been identified where the probability of ridging activity is great at all times resulting in constant danger to temporary structures.

Each hazard area has been described separately and although each area description is brief, the hazard area descriptions for the Chukchi Sea ice hazard map require 30 typewritten pages. As further considerations are formulated it is possible that these area descriptions will be expanded.

V. Plans for Next Reporting Period:

We expect to complete our analysis of ice hazard based on the data examined to date. Also during this time we expect to begin analysis of the Landsat data of the 1976-77 ice season.

VI. Problems Encountered/Recommended Changes: None

VII. Estimate of Funds Expended: 95%

VIII. Appendices: None

Quarterly Report

Contract # 03-5-022-55
Research Unit # 259
Task Order # 7
Reporting Period: 7/1/77-9/30/77
Number of Pages: 2

EXPERIMENTAL MEASUREMENTS OF SEA ICE FAILURE STRESSES NEAR GROUNDED STRUCTURES

W. M. Sackinger
R. D. Nelson
Geophysical Institute
University of Alaska
Fairbanks, Alaska, 99701

September 30, 1977

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending September 30, 1977

Project Title: Experimental Measurements of Sea Ice Failure Stresses Near Grounded Structures.

Contract No.: 03-5-022-55

Task Order No.: 7

Principal Investigators: W. M. Sackinger, R. D. Nelson

I. Task Objectives:

The objectives of this study are to measure, in-situ, the stresses generated in a sea ice sheet as it fails in the vicinity of a static obstacle, and the rate of movement of the ice sheet during this process.

II. Field or Laboratory Activities:

None this quarter.

III. Results:

During the spring quarter, the array of three transducers which was deployed on March 12, 1977, near Barrow, continued to transmit ice stress data reliably to the recorders on the shoreline. No technial problems with the telemetry link, the data acquisition equipment, or the recording equipment were encountered. A reconnaissance visit to the site was made on April 13, 1977, and the direction and location of the tension cracks which formed on March 16-18, 1977, (described in the 1977 Annual Report) were confirmed. A more complete description of the crack pattern was made during that visit. An additional reconnaissance was made on May 29, 1977, to check for possible thawing near the site. No evidence of thaw was noted, and no recent crack patterns were observed. It was decided to continue to acquire data throughout the beginning of breakup, until the transducers had clearly decoupled from the ice.

Throughout April, May, and the first half of June, ice stress events occurred every few days, depending upon the intensity and direction of the wind. The open lead was generally located approximately three miles offshore, as indicated by radar and aerial reconnaissance, so there was very little relative ice motion near the site of ice stress transducer emplacement. All three transducers generally indicated each ice stress event, but at different magnitudes because of their location relative to the grounded ice ridge. Most of the events were tension events, because of the wind direction, and the site location. Ice tension seemed generally to increase with time constants occasionally as short as one hour, but more commonly over several hours, followed by decay over several hours or even days. On June 11, a massive movement of the pack ice towards the shoreline produced extensive ice thrusting, buckling, and ridgebuilding. The telemetry system recorded this event up to the moment of damage of each transducer, as was expected. Data collection then terminated.

IV. Preliminary Interpretation of Results:

It appears that a tensile stress is the most common condition, and that tensile stresses greater than 100 psi can be sustained under some conditions without crack formation. Stresses occur frequently near grounded obstacles. The many stress events must be examined in more detail, in conjunction with the wind records, the ice movement data from the ice dynamics radar, and related SLAR and satellite imagery, before additional conclusions can be drawn.

Because of the substantial quantity of useful data on tensile and compressive stresses near the grounded pressure ridge obtained the spring quarter it was recommended that this project be extended until December 31, 1977 with an additional funding of $5K to allow analysis of this fortuitious data. This extension has been granted.

V. Problems Encountered/Recommended Changes:

None.

VI. Estimate of Funds Expended:

$102,296.54 out of an extended total of $109,200.00.

Quarterly Report

Contract # 03-5-022-55
Research Unit # 261
Task Order # 4
Reporting Period: 7/1/77-9/30/77
Number of Pages: 3

BEAUFORT SEA, CHUKCHI SEA AND BERING STRAIT BASELINE ICE STUDY

W. R. Hunt, C. M. Naske
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending September 30, 1977

Research Unit #261

Project Title: Beaufo't Sea, Chukchi, Sea and Bering Strait Baseline Ice Study.

Contract Number: 03-5-022-55

Task Order Number: 4

Principal Investigator: W. R. Hunt and C. M. Naske

I. Task Objectives:

The objective of this study is to perform a baseline analysis of historical records relative to ice conditons and movements in the Bering Sea. A documentation of past location and behavior of coastal fast ice and of shear zone ice movements, leads, and thicknesses will supplement satellite studies of present ice conditions to provide considerable additonal data. Through careful analysis of this historical data, the probability of occurrence of fast ice at any location and at particular times of the year can ultimately be derived. From such data, it may be possible to predict, to some extent, the character of the edge of the ice pack, expected floe movements, leads, and other occurrences in that zone.

II. Field Activities:

No field activities were performed this quarter.

III. Results:

This will be the last quarterly report by this research unit. The major activity this quarter has been compilation of our final report which we anticipate submitting shortly. In additon, the following activities have been performed this quarter.

In the past, the investigators completed a number of maps showing the historic variatons in ice conditions over a 100 year period. These maps were presented at the Beaufort Sea Synthesis meeting held in Barrow during February, 1977. Additional pertinent ice data has been sought to update these maps.

In addition to historical ice maps, additional data lending itself to chronological narrative rather than cartographic representation has been compiled.

IV. Preliminary Interpretations:

Our preliminary interpretations indicate significant long term changes in the extent of summer ice, with more open water in August and September since about 1940 than between 1860-1919. This trend is especially apparent if the post-1940 observations are compared with the more tentative line representing the edge of the pack during 1860-1879.

V. Problems Encountered/Recommedned Changes: None

VI. Estimate of Funds Expended:

Approximately 90% of budgeted amount.

Quarterly Report

Contract # 03-5-022-55
Research Unit # 265
Task Order # 6
Reporting Period: 7/1/77-9/30/77
Number of Pages: 3

IN SITU MEASUREMENTS OF THE MECHANICAL PROPERTIES OF SEA ICE

Lewis H. Shapiro
Richard D. Nelson
Geophysical Institue
University of Alaska
Fairbanks, Alaska 99701

OCS COORDINATION OFFICE

University of Alaska

September 30, 1977

Quarterly Report for Quarter Ending September 30, 1977

Project Title: *In-Situ* Measurements of the Mechanical Properties of Sea Ice.

Contract Number: 03-5-022-55

Task Order Number: 6

Principal Investigators: Lewis H. Shapiro and Richard D. Nelson

I. Task Objectives:

To develop hardware and procedures for conducting *in-situ* measurements of the mechanical properties of sea ice.

II. Schedule:

Laboratory work and data reduction.

III. Results & Interpretation:

The following work was accomplished during the past quarter:

1. A small loading frame was constructed for use in a series of experiments to evaluate the performance of various methods of embedding strain gauges in sea ice samples. The experiments were delayed while modifications were being made to the data recording system. However, these have been completed and the program will begin shortly.

2. Evaluation of Peyton's (1966) "constant load-rate" experiments was begun. Curves of stress vs. strain and stress and strain vs. time have been plotted for about 200 of the tests. These indicate that the tests were not conducted at constant loading rates but instead, were probably run at constant crosshead speed. In addition, strain rates were generally not constant through the peak stresses so that the reported strength values are probably lower than those which would have been reached if the strain-rates had been controlled. These results are preliminary, but, if true of the entire test series, they indicate the need for further work.

3. The one-dimensional, non-linear viscoelastic model for sea ice, described in the last annual report of this project, has been extended to include the case of deformation at constant strain-rate. In addition, work is in progress to examine the applicability of the law to post-yield behavior.

IV. Problems Encountered:

Vacations and leaves of absence absorbed almost one-half of the man-hours available to this project during the past quarter.

V. Estimated Funds Expended: ($10,000)

QUARTERLY REPORT

Contract # 03-5-022-55, task 10
Research Unit #267
Reporting Period: July 1, 1977 to
September 30, 1977
Number of Pages: 4

OPERATION OF AN ALASKAN FACILITY FOR APPLICATIONS OF REMOTE-SENSING DATA TO OCS STUDIES

Albert E. Belon
Geophysical Institute
University of Alaska

September 30, 1977

OPERATION OF AN ALASKAN FACILITY
FOR APPLICATIONS OF REMOTE-SENSING DATA TO OCS STUDIES

Principal Investigator: Albert E. Belon
Affiliation: Geophysical Institute, University of Alaska
Contract: NOAA # 03-5-022-55, Task 10
Research Unit: #267
Reporting Period: July 1 to September 30, 1977

I. TASK OBJECTIVES

The primary objective of the project is to assemble available remote-sensing data of the Alaskan outer continental shelf and to assist other OCS investigators in the analysis and interpretation of these data to provide a comprehensive assessment of the development and decay of fast ice, coastal geomorphology, sediment plumes and offshore suspended sediment patterns along the Alaskan coast from Yakutat to Demarcation Bay.

II. LABORATORY ACTIVITIES

A. Operation of the Remote-Sensing Data Library

We continued to search periodically for new Landsat imagery of the Alaskan coastal zone entered into the EROS Data Center(EDC) data base. As a result 536 cloud-free Landsat scenes were selected and ordered from EDC at a total cost of $8406. These data products, which are gradually received from EDC, complete our files of Landsat data from the launch of the first satellite, July 26, 1972. Until March 1977 we had purchased the selected Landsat scenes in the following formats, commonly used by OCS principal investigators:

- 70mm positive transparencies of multispectral scanner (MSS) spectral band 4, 5 and 7
- 70mm negative transparency of MSS, spectral band 5
- 9½ inch print of MSS, spectral band 6

After March 1977, the EDC price for Landsat data products having increased by an average of 166%, we reduced our routine purchase of selected Landsat scenes to two formats:

- 70mm positive transparency of MSS, spectral band 5
- 9½ inch print of MSS, spectral band 7

Other formats are ordered on a case-by-case basis and at the request of individual OCS investigators.

We continued to receive and catalog daily copies of NOAA satellite imagery of Alaska in both the visible and infrared spectral bands under a standing order with the NOAA/NESS Fairbanks Satellite Data Acquisition Station. 270 NOAA scenes at a total cost of $3609 were acquired in 10" positive transparency format during the reporting period.

The high altitude (65,000 ft) aerial photography acquired in June 1977 by the NASA U-2 aircraft was received and catalogued. Owing to heavy cloud cover the only photographic coverage of the Alaskan coast was of the Prudhoe Bay area, but this imagery is excellent and allows an evaluation of the substantial changes which have occurred since the U-2 photographed the same area in 1974.

We received and catalogued 14 flight lines (543 frames) of natural color and color-infrared aerial photography of the Alaskan coast from Cape Sabine on the Chukchi Sea coast to Harrison Bay in the Beaufort Sea. This medium altitude (18,400 ft) aerial photography was acquired in July 1977 by the National Ocean Survey's Buffalo aircraft at the request of the OCSEAP Arctic Project Office. Like the aerial photography acquired by the same aircraft last year, from the Yukon Delta to Point Lay, it is of superb quality and fills a void in color aerial coverage of the arctic coast.

A catalog of remote-sensing data acquired during 1977 has been prepared and will be distributed to OCSEAP investigators in early October, as a special issue of the OCSEAP Arctic Project Bulletin.

B. Operation and Maintenance of Data Processing Facilities

Consolidation of the Geophysical Institute's remote-sensing data library with the geophysical archives was completed during the quarter. This consolidation has fulfilled our expectations of enhanced effectiveness and significant benefits to the OCSEAP program, as discussed in the previous quarterly report. In particular the increased work space and individually controlled illumination for the several items of analysis equipment now allows several investigators to use the facility simultaneously.

Following the move of the remote-sensing data library to the fifth floor of the Institute, its previous quarters were partitioned and remodeled for use as a photographic laboratory for wide-film processing of remote-sensing data acquired by the NARL/OCSEAP remote-sensing program. Equipment for this laboratory was received during the reporting period on loan from government laboratories in Alaska, Nevada and Mississippi and consists of:

A versamat continuous processor (5" to 9.5" film or paper)
A LogEtronic SP1070B strip printer (5" to 9.5" film)
A LogEtronic Mark III step and repeat printer (5" to 9.5" film)
An Omega B+W and color enlarger (10"x10" film)

Installation and check-out of the equipment will occur during next quarter when this additional task under the contract becomes effective.

In addition to the above film processing equipment, we have also received on loan various aerial cameras (KC-6, KC-1B, KS-72 and I^2S) which will be checked out during the winter prior to installation in the NARL remote-sensing aircraft in March. Until then, there will be insufficient solar illumination on the arctic coast for acquisition of aerial photography. Therefore, the emphasis will be placed on acquisition of SLAR imagery.

C. Development of Data Analysis and Interpretation Techniques

Work continued, within the available financial resources of the project, on the conversion of existing computer programs for the digital analysis of Landsat data. It is now possible to analyse and classify a small portion (10x10 mi.) of a Landsat scene on the University of Alaska's Honeywell 66/40 time-sharing computer, but processing of large areas must still be done using computing facilities in California.

We are experimenting with the digital superimposition of two Landsat scenes of the same area acquired at different times, in the expectation that the resulting 8-channel digital tape (4 spectral images per scene times 2 scenes) would allow substantially improved discrimination and, therefore, identification of coastal vegetation classes. The results, so far, are promising.

A visit of Mr. James McCord, chief of the photographic laboratories of the EROS Data Center, has been postponed to the next quarter. As mentionned in our last quarterly report, the purpose of this visit was to evaluate the usefulness to OCSEAP of new photographic enhancement techniques developed by Mr. McCord, and to train our photographers in the use of these techniques.

D. Assistance to OCS Investigators

Despite the heavy commitment of OCSEAP investigators to field activities during the reporting period, 35 of them made extensive use of our facilities and services ranging from data searches and orders to utilization of data analysis equipment.

Data purchases by OCS investigators totalled $2536 for orders placed to the EROS Data Center, $138 for orders placed to NOAA/NESS, $90 for orders placed to the National Ocean Survey, and several hundred dollars in work orders for urgent or custom reproduction of selected data in our photographic laboratories. In addition 30 OCSEAP investigators performed analyses of library copies of data archived in our facility.

Dr. William Stringer (RU #257), Dr. Jan Cannon (RU #99), Drs. Burns and Lewis Shapiro (RU #230, 232, 248 and 249), Dr. Wilford Weeks (RU #88) and Dr. Thomas Royer (RU #289) continued to be the most frequent and heavy users of our data and facilities. Additional substantial users during the quarter were: Dag Nummedal (U. of South Carolina), David Drake (USGS, Menlo Park), Carleton Ray (Johns Hopkins U.), Erk Reimnitz (USGS, Menlo Park), Peter Myers (U. of California), Thomas Eley (Alaska Dept. Fish & Game), F.I. Gonzales (NOAA/PMEL), Gary Searing (LGL, Ltd.), Asbury Sallenger (USGS, Menlo Park) and several oil companies.

III. RESULTS

A major catalog of all remote-sensing data (satellite and aircraft) acquired during 1977 has been prepared as an update of previous catalogs. It will be distributed to all OCSEAP investigators in October 1977, as a special issue of the Arctic Project Bulletin.

Completion of the consolidation of remote-sensing and geophysical data archives has been effected, thus providing better facilities and services to OCSEAP investigators.

Equipment, including aerial cameras and wide-film photographic processing systems, have been acquired and a new photographic processing laboratory is being established in support of the OCSEAP/NARL airborne remote-sensing data acquisition program.

IV. PRELIMINARY INTERPRETATION OF RESULTS

The project's function is to provide remote-sensing data and technical support to the other OCSEAP projects. Therefore disciplinary data interpretations are normally reported by the individual user projects.

V. PROBLEMS ENCOUNTERED/RECOMMENDED CHANGES

Substantial increases in the price of remote-sensing data products by the EROS Data Center of USGS and NOAA/NESS have caused us to restrict the acquisition of certain formats of Landsat data (see section II-A). Still, our FY77 budget for acquisition of remote-sensing data will be exceeded and will require a transfer of funds from the salary portion of the budget which still has a positive balance. A similar transfer may be required for the FY1978 budget.

VI. ESTIMATE OF FUNDS EXPENDED

The estimated expenses of the project during the reporting period were approximately $30,000, of which about $12,000 was for the purchase of remote-sensing data.

Quarterly Report

Contract #03-5-022-56
Research Unit #289
Task Order #19
Reporting Period 7/1 - 9/30/77

CIRCULATION AND WATER MASSES IN THE GULF OF ALASKA

Dr. Thomas C. Royer
Institue of Marine Science
University of Alaska
Fairbanks, Alaska 99701

October 1, 1977

OCSEAP Quarterly Report - 1 July - 30 September 1977

RU 289

Thomas C. Royer
Institute of Marine Science
University of Alaska

I. Task Objectives

To gather and analyze hydrographic and current data in the northern Gulf of Alaska for the purpose of describing possible flow trajectories, describing the physical environment and understanding its driving mechanisms. To continue to monitor the NOAA satellite data for use by this project and other OCSEAP investigators.

II. Field Activities

A. R/V ACONA Cruise 248, 8-15 August 1977

B. Scientific Party

- D. Nebert, IMS, Chief Scientist
- C. Hansen, IMS, Programmer/Analyst
- T. Cashen, IMS, Data Control Clerk
- B. Hood, IMS, Technician
- D. Livingston, IMS, Graduate Student
- K. Nam, IMS, Graduate Student

C. Methods - STD Sampling

D. Sample Localities - Kodiak Island Shelf

E. Data Collected

Twenty STD Stations (see enclosed station listing)

III. Results

Data reports with vertical profiles and horizontal cross-sections are being prepared for FY 1976 and FY 1977. After numerous delays due to funding problems we have now acquired the equipment necessary to carry out these data displays. Coastal sea level observations for Yakutat and Seward for 1970 - 1976 have been acquired and corrected for barometric pressure effect. They have also been meshed with sea level records from before 1970. We are forwarding the current meter data in OCSEAP format for GASS9C; others will follow shortly. Some processing delays were encountered with the tapes processed by PMEL including some delays in excess of a year in the early stages. The addition of N and W designation to those CTD data returned from the Juneau Project Office will be completed and returned. Statistical analysis is continuing on the Middleton Island wind data. The satellite imagery is being monitored and a copy of our photo collection is now being sent to PMEL for their use as per the request at the last physical oceanographers meeting. Satellite imagery has been provided to other investigators; in particular IR enhancements were provided to G. L. Hunt for the detection of upwelled areas in the Pribilofs. Work is also continuing on the numerical model of the Seward line and the IMS 9 current meter data. Assembly of the current meter arrays for November deployment near Prince William Sound has begun. A. D. Kirwan indicates that three of his drifters released last year south of 45°N are in the Gulf of Alaska between Icy Bay and Kodiak.

IV. Preliminary Interpretation of Results

Analysis of sea level, dynamic topography upwelling index (wind stress) and weather records for the northern Gulf of Alaska indicate that the role of wind stress in controlling circulation has been overstated. Coastal sea level and nearby dynamic topography have an excellent correlation at Seward but not as good at Yakutat. The system might respond in a different manner at these two points. Further details are not clear at this point.

The treatment of the Middleton Island wind data will produce wind estimates for our circulation analysis. This work indicates that Bakun's wind transports are acceptable only for the summer months. These winter estimates are 3-5 times too large.

V. Problems Encountered

As stated in a letter to the OCSEAP Juneau Office last month, there is concern about the lack of coordination between PI's. It appears that we might be doing the same grid at the same time without the other person knowing it. We are attempting to correct this among ourselves, but we require cooperation from the administration.

The problem concerning the accuracy of CTD aboard NOAA vessels, which was reported last quarter, has not been corrected to my knowledge. It must be corrected prior to the use of NOAA ships by this project, but should have been done immediately.

The ship schedule for next year does not reflect the requested ship time or location. The Kodiak grid is to be done three times with seven days each from NOAA vessels. The Northern Gulf of Alaska-Prince William Sound is to be done four times with ten days each and ACONA is to be used. These times do not include transit-time.

QUARTERLY REPORT

Contract No. 03-5-022-56
Research Unit No. 347
Reporting Period: July 1, 1977
through Sept. 30, 1977
Number of Pages: 1

MARINE CLIMATOLOGY OF THE GULF OF ALASKA AND THE BERING AND BEAUFORT SEAS

James L. Wise

Arctic Environmental Information and Data Center
University of Alaska

Sept. 26, 1977

QUARTERLY REPORT

For the Period Ending Sept. 26, 1977

I. Task Objectives:

To determine and publish the knowledge of the climatological conditions of that portion of Alaska that is important to OCS development.

II. Field and Laboratory Activities:

This portion of the project has no field or laboratory activities. It is a joint project with the National Climatic Center (NCC) in Asheville, North Carolina. AEIDC responsibilities are to provide extremes of all weather elements, information on coastal damage resulting from wind generated storm flooding, check analysis work done at NCC, and through our graphics department, prepare materials for publication.

III. Results:

The final product of this research project is the publication of the "Climatic Atlas of the Outer Continental Shelf Waters and Coastal Regions of Alaska." The atlas has three volumes, Volume I, Gulf of Alaska; Volume II, Bering Sea; and Volume III, Chukchi and Beaufort Seas. The table of contents and areas covered in each of the three volumes is as shown in the annual report of March 1977.

Preparation of all three volumes for printing is complete and the material was turned over to the Government Printing Office in Boulder, Colorado for printing on Sept. 12, 1977. Selection of the printer and schedule for printing are not known at this time.

IV. N/A

V. N/A

Quarterly Report

Contract #03-5-022-56
Research Unit #351
Task Order #23
Reporting Period 7/1/77 - 9/30/77

LOGISTICS I

Ms. E. R. Dieter
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

October 1, 1977

I. Task Objectives

This project provides logistics and vessel time support for portions of the NOAA/OCS program.

II. Field and Laboratory Activities

Not applicable.

III. Results

A. Marine Technician Support

The two marine technicians employed under this project continue to support all University of Alaska OCS projects. This support is provided by either work at sea or on shore equipment maintenance and travel in support of general logistics.

B. R/V Acona

During this quarter the R/V Acona was dedicated to NOAA/OCS work for 30 days. These days were used for three cruises; Feely/Cline 17 days, Cook Inlet; D. C. Burrell 6 days, Gulf of Alaska; and T. Royer 7 days, Kodiak.

IV. Preliminary Interpretation of Results

Not applicable

V. Problems Encountered

None.

RU #367

NO REPORT WAS RECEIVED

QUARTERLY REPORT

RESEARCH UNIT #435
REPORTING PERIOD: July 1, to
September 30, 1977
NUMBER OF PAGES: 93

THE BRISTOL BAY AND NORTON SOUND MODELS-- A PROGRESS REPORT

J. J. Leendertse and Shiao-Kung Liu
RAND
Sanata Monica, California 90406

MODELING OF TIDES AND CIRCULATIONS OF THE BERING SEA (RU 435)

National Oceanic and Atmospheric Administration

July 1, 1977 - September 30, 1977

Jan J. Leendertse and Shiao-Kung Liu

During the reporting period we finished all three tasks of the first phase of the study.

Task 1 - Model Extension

We finished the conversion of both models to use the most recent computational method developed under the sponsorship of the Department of the Interior. For both models we are now able to describe the tide at the boundaries at certain locations and use linear interpolation of amplitudes and phases for the intermediate sections. The computational routines associated with describing the boundaries are now working well and have been tested extensively.

Task 2 - Model System

We have advanced with the model system such that inputs and outputs can be handled without much difficulty. A number of programs to plot computed data are now working satisfactorily for both models.

Task 3 - Model Setup

The Bristol Bay and Norton Sound models appear to work satisfactorily as to the computational aspects. Several simulations with the Bristol Bay model were made with homogeneous density to make rough adjustments for the energy dissipation in the system. One simulation with the Bristol Bay model with variable density field has been made, but the data have not been processed.

A Working Note, "The Bristol Bay and the Norton Sound Model--A Progress Report," has been prepared and forwarded to the sponsor. This report describes the work performed so far and presents samples of graphical representations of simulation results. We have come to the conclusion that more advantageous use could be made by a realignment of the Bristol Bay model. Sufficient data of pressure and current stations are available for continuation of the modeling work. Much more accurate results would be obtained if three simultaneous pressure records could be obtained for the duration of one month.

Similarly, the research would be more effective if the Norton Sound model could be extended to cover a larger area with the same grid size.

Presently insufficient data are available to execute a meaningful modeling effort. However, if five simultaneous pressure records can be obtained of one month duration during the already planned deployment of other recorders, data would be available for adjustment and verification.

PREFACE

This Working Note is a progress report on the development of models of sections of the Bering Sea.

This study is in support of a comprehensive Environmental Assessment of the Alaskan Continental Shelf by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce.

In this Working Note the first phase of our research and development is reported. The work performed so far can best be described as preparing the tools for our investigations. Much time was spent on writing routines for handling the boundary conditions and writing programs for displaying results. In this effort we have benefited greatly from a system development for two-dimensional simulations and from our studies for the development of the three-dimensional model prepared for another sponsor.

In the beginning of the study a three-dimensional model with fixed exchange coefficients was used. As a more sophisticated model became available in which the vertical exchange coefficients could be computed from the information in the simulation, we used that model. This newer model is also more stable because of implicit computations of the main variables in the vertical direction.

The progress report will be somewhat informal. We have limited our effort, as we feel that the work has not yet advanced sufficiently to write a scientific report, and our time could be more effectiely used in the actual investigation.

ACKNOWLEDGMENT

This study was supported by the Bureau of Land Management through interagency agreement with the National Oceanic and Atmospheric Administration, under which a multi-year program responding to needs of petroleum development of the Alaskan continental shelf is managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) Office.

CONTENTS

I. INTRODUCTION

The long-range objectives of the modeling studies are to provide risk planning data for the Outer Continental Shelf Petroleum Development of the Bristol Bay Area, St. George Basin and Norton Sound. In addition, the modeling work should lead to a method for computing contaminant trajectories for selected locations from wind and tide data. This method should make possible the determination of the landfall location of certain containments introduced in the area considered, from which data could be generated which may be needed for pollution event countermeasures.

One of the more important results anticipated from these modeling studies would be a better understanding of water movements and circulations in these areas.

This task is ambitious. To our knowledge, only a few modeling studies of such large regions have been made where rather accurate results have been required. Most modeling studies of coastal shelf areas have been directed toward confirmation of certain observed phenomena.

The work here is directed toward prediction, and consequently the emphasis is different. For example, higher demands are required to extend usage and processing of data for these models.

Our work presented here is strongly based upon modeling studies for engineering investigations in which we have been involved for more than a decade. As a consequence, representations are generally somewhat different than those used in the oceanographic community.

When we responded to a request from NOAA to participate in the studies, the idea was to model the Eastern Bering Sea. In discussions with the project monitor and other participants it appeared that insufficient data would become available from the field surveys to provide inputs for the model, and also the model would cover an area outside the region of interest. As a result of these discussions, modeling was started on two areas of interest, namely, the Bristol Bay/St. George Basin area and Norton Sound (Fig. 1). It could be expected that from these areas sufficient data would become available for modeling.

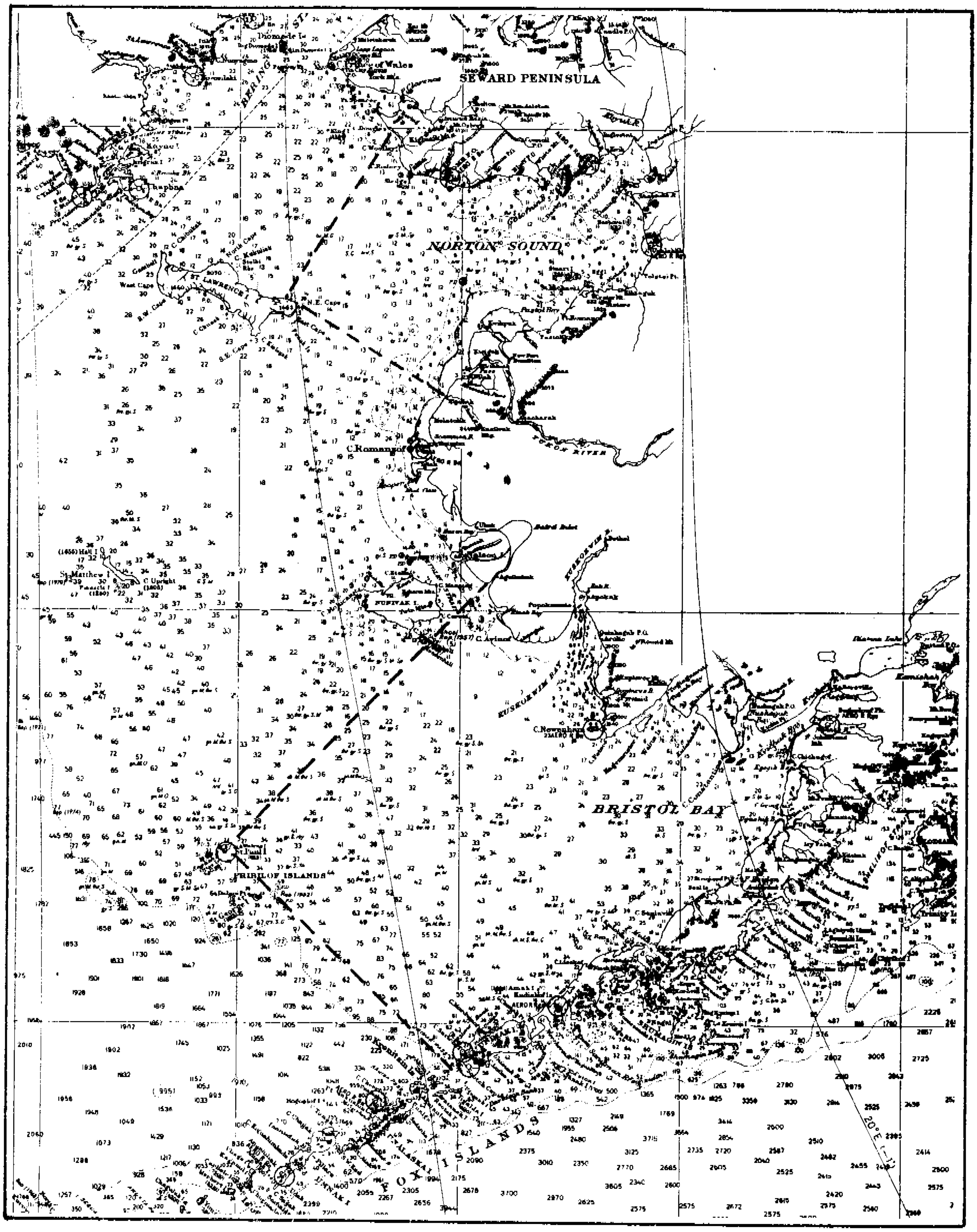


Fig. 1--Location map of Eastern Bering Sea and approximate boundaries of Bristol Bay and Norton Sound models

II. DESCRIPTION OF THE PHYSICAL PROCESSES SIMULATED WITH THE MODEL

A. CONCEPTS

In mathematical models of geophysical problems the approach is taken of using discrete representations of the differential equations which describe the main physical processes.

Generally mass balance equations are used, together with momentum equations. This approach is taken here also, as we will describe later in more detail. The main difficulty encountered, however, is that the discrete representation forces us to work with values for the variables which are characteristic for the region described by the finite representation. If a horizontal grid representation of 10 miles is used, the model can only represent the average velocity, pressure, etc. of the grid distance of 10 miles. Naturally, significant variations do occur which, for example, cause mass and momentum exchanges which can be considerably larger than the advective transports expressed by average velocities and concentrations.

The exchanges are traditionally expressed as functions of the local mass and momentum gradients. In the horizontal motions it is generally assumed that these functions are linear with the gradients; thus we used horizontal momentum and mass exchange coefficients.

In the vertical this approach was even far less satisfactory, and generally the exchange coefficient is taken as a function of the square of the vertical velocity gradient. This assumption seemed justified, as with larger gradients more turbulence is generated, thus more vertical exchange.

In addition to the above-mentioned relationship between the mean flow field and the vertical exchange coefficient, an additional relationship is generally used between the exchange coefficient and the Richardson number. The Richardson number is an expression for the ratio of the density gradient and the local turbulent energy.

When we started with the model investigation, this was the basic model we were using. It became apparent that many exchange coefficients would be involved, and we switched to a more extended model which was being developed.

In that more extended model the vertical exchange coefficients are related to the small-scale turbulence energy. The movements of the water on a small scale cannot be described, but we are able to compute the small-scale energy by considering the energy transfer from the larger scales to the smaller scales and the decay of these small-scale motions.

The horizontal exchange coefficients in the extended model are now related to the horizontal deformation of the flow field (Fig. 2).

In the Bering Sea models the vertical grid size differs by orders in magnitude from the horizontal grid size. The vertical grid size is typically about ten meters, while the horizontal grid size in thousands of meters; this reflects naturally the differences in dimensions of this coastal shelf region.

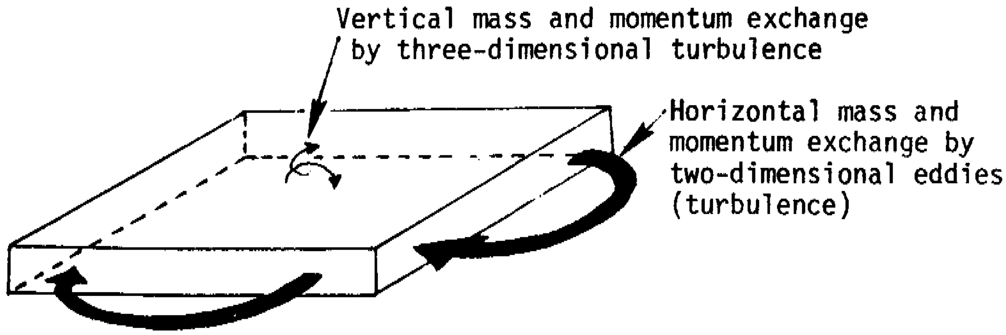


Fig. 2--Concept of mass and momentum exchange in the model

The vertical exchanges are typically induced by the turbulence generated by the flow moving over the bottom, by the turbulence generated by the air moving over the water, and by the turbulence generated by differences in the mean velocities at different locations in the vertical. If the turbulent energy is used as an indicator for the intensity of turbulence, then exchange coefficients can be taken as a function of the subgridscale energy and a length scale. This approach requires that the subgridscale energy be computed. In the model used here the computed subgridscale energy is transported like a constituent, and is dissipated at a rate dependent on the local energy intensity. The subgridscale energy in our model is produced as a function of the local mean flow gradients and, as stated above, at the upper and lower boundaries of the water body. With this concept we generate the subgridscale energy predominantly near the bottom, and if wind is present, also in the fluid near the surface.

The vertical momentum and mass exchange concept presented here also has a length scale which has to be determined. Two approaches are available, namely, use of an algebraic expression or by computing the length scale also from mean flow information. Presently the most simple approach is used, and we made the length scale a function of the depth.

The vertical mass and momentum exchanges are suppressed if vertical density gradients are generated. In the model the vertical exchange rates are also taken as a function of the Richardson number in a similar manner to that presented in reports describing the three-dimensional model published previously, only here we use the subgridscale energy in computing the Richardson number.

The horizontal exchanges are mainly due to horizontal eddies which are considerably larger than the eddies in the turbulence mentioned earlier.

These large eddies are two-dimensional, since they will be limited by the water depth in the vertical scale, and also by density differences if these are present. The horizontal exchanges should actually also include an exchange generated by turbulence from the bottom and the wind-driven water surface, but in our model we neglected this. Thus the horizontal mass and momentum exchanges were taken only due to turbulence with lower frequencies (smaller wave numbers) than are generated by the bottom and surface momentum transfers.

The simplest and most primitive model for the horizontal momentum exchange is to take it as a function of the local gradient with fixed constant horizontal exchange coefficients for the momentum and mass transfer. This was the approach taken previously by us. It seems more appropriate, however, to take this coefficient as a function of the local velocity deformation calculated in the finite difference grid.

Even though the larger subgridscale motions are predominantly two-dimensional rather than three-dimensional, upon which this hypothesis is based, this assumption has produced good results in similar three-dimensional computations with predominant two-dimensional horizontal motions. We will discuss the computation of the horizontal exchange terms in more detail.

B. HYDRODYNAMIC PROCESSES AND GOVERNING EQUATIONS

Flows in an estuary or coastal sea are mainly horizontal and primarily turbulent. The equations of horizontal motion for an incompressible, internally source-free fluid on a rotating earth in Cartesian coordinates with the z-axis positive upward are:

$$\frac{\partial u}{\partial t} + \frac{\partial (uu)}{\partial x} + \frac{\partial (uv)}{\partial y} + \frac{\partial (uw)}{\partial z} - f\,v + \frac{1}{\rho}\frac{\partial p}{\partial x} - \frac{1}{\rho}\left(\frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + \frac{\partial \tau_{xz}}{\partial z}\right) = 0 \quad (1)$$

$$\frac{\partial v}{\partial t} + \frac{\partial (vu)}{\partial x} + \frac{\partial (vv)}{\partial y} + \frac{\partial (vw)}{\partial z} + f\,u + \frac{1}{\rho}\frac{\partial p}{\partial y} - \frac{1}{\rho}\left(\frac{\partial \tau_{yx}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{yz}}{\partial z}\right) = 0 \quad (2)$$

The vertical acceleration of fluid motion associated with the predominant hydrodynamic processes such as tidal and wind-induced circulations are extremely small in comparison with the gravitational acceleration. Therefore we can neglect the vertical acceleration and advection, and the equation of motion becomes the hydrostatic equation:

$$\frac{\partial p}{\partial z} + \rho g = 0 \quad (3)$$

The equation of continuity is:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \quad (4)$$

The equations of salt and heat balance are:

$$\frac{\partial s}{\partial t} + \frac{\partial (us)}{\partial x} + \frac{\partial (vs)}{\partial y} + \frac{\partial (ws)}{\partial z} - \frac{\partial (D_x \frac{\partial s}{\partial x})}{\partial x} - \frac{\partial (D_y \frac{\partial s}{\partial y})}{\partial y} - \frac{\partial (\kappa \frac{\partial s}{\partial z})}{\partial z} = 0 \qquad (5)$$

$$\frac{\partial T}{\partial t} + \frac{\partial (uT)}{\partial x} + \frac{\partial (vT)}{\partial y} + \frac{\partial (wT)}{\partial z} - \frac{\partial (D_x \frac{\partial T}{\partial x})}{\partial x} - \frac{\partial (D_y \frac{\partial T}{\partial y})}{\partial y} - \frac{\partial (\kappa' \frac{\partial T}{\partial z})}{\partial z} = 0 \qquad (6)$$

and the equation of state

$$\rho = \overline{\rho} + \rho'(s,T) \qquad (7)$$

Similar balance equations can be written for turbulent densities and dissolved pollutant constituents:

$$\frac{\partial e}{\partial t} + \frac{\partial (ue)}{\partial x} + \frac{\partial (ve)}{\partial y} + \frac{\partial (we)}{\partial z} - \frac{(\partial D_x \frac{\partial e}{\partial x})}{\partial x} - \frac{\partial (D_y \frac{\partial e}{\partial y})}{\partial y} - \frac{\partial (\kappa \frac{\partial e}{\partial z})}{\partial z} + hDe \pm S_e = 0 \qquad (8)$$

and

$$\frac{\partial P}{\partial t} + \frac{\partial (uP)}{\partial x} + \frac{\partial (vP)}{\partial y} + \frac{\partial (wP)}{\partial z} - \frac{(\partial D_x \frac{\partial P}{\partial x})}{\partial x} - \frac{\partial (D_y \frac{\partial P}{\partial y})}{\partial y} - \frac{\partial (\kappa \frac{\partial P}{\partial z})}{\partial z} + hK'_P \pm S_P = 0 \qquad (9)$$

where u,v,w are respective components of velocity; s and T are salinity and temperature; e and P are turbulent (subgridscale) energy density per unit mass and pollutant concentration, respectively; D is the dissipation rate for turbulent energy; K' is the decay rate for the pollutant concentration; and S_e and S_p are the source and sink terms for the turbulent energy and pollutant concentration, respectively.

The model described in this note uses a grid system with equidistant points in the horizontal direction. In the vertical direction, it is possible to use an unequal grid distance. The top layer, bounded by the free surface, has a time-variable thickness. In the computation, the origin of the vertical coordinates is taken at the mean sea level, whereas the water surface $z = \zeta(x,y,t)$ is the upper boundary of the system.

The finite difference approximation of the differential equations (1) through (6), and (7) and (9) are accomplished in the following manner: First, the equations for the layers were divided by vertically integrating the variables over the layer thickness, and subsequently, finite difference approximations for the layer equation were established [1,2]. Figure 3 shows the location of variables on the vertical grid. A space-staggered grid (Fig. 4) was selected. The position of the variables in the horizontal grid is indicated by indices i,j, indicating a position $i\Delta x$ and $j\Delta y$ from the origin of the coordinates, with $i,j = 0, \pm 1/2, \pm 1, \pm 3/2, \ldots$ The vertical position is determined as to its location in the center of the layer numbered from the top with integer $k = 1,2,3 \ldots$ or at horizontal interfaces with half-integer values $k = 1/2, 3/2, 5/2 \ldots$ etc. Time is discretized into number of time steps $(n\Delta t)$ from the reference time, with n an integer value. We adopted compact sum, difference and time-level notations for x, y, z and t. In the x direction,

$$\overline{F}^{x} = \tfrac{1}{2}\left\{F[(i + \tfrac{1}{2})\,\Delta x, j\Delta y, k\Delta z, n\Delta t] + F[(i - \tfrac{1}{2})\,\Delta x, j\Delta y, k\Delta z, n\Delta t]\right\} \quad (10)$$

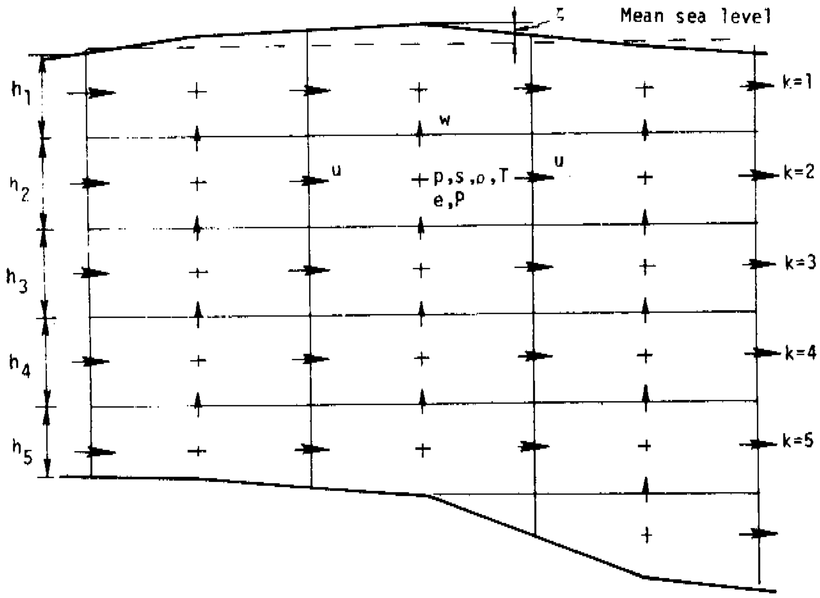


Fig. 3--Location of variables on the vertical grid

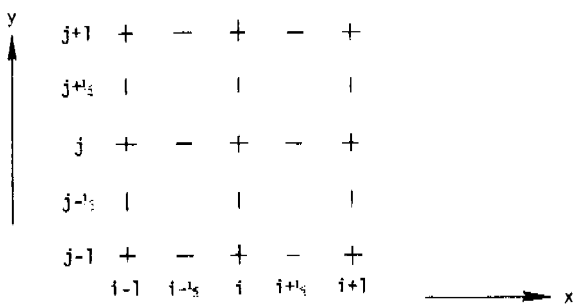


Fig. 4--The location of u (-) and v (|) and other parameters (+) in the space-staggered grid

$$\delta_x F = \frac{1}{\Delta x}\left\{F[(i+\tfrac{1}{2})\Delta x, j\Delta y, k\Delta z, n\Delta t] - F[(i-\tfrac{1}{2})\Delta x, j\Delta y, k\Delta z, n\Delta t]\right\} \quad (11)$$

$$F_+ = F[i\Delta x, j\Delta y, k\Delta z, (n+1)\Delta t] \quad (12)$$

$$F_- = F[i\Delta x, j\Delta y, k\Delta z, (n-1)\Delta t] \quad (13)$$

With these notations, Eqs. (1) through (6), and (8) and (9) for the level k with layer-averaged values take the following form:

$$\overline{\delta_t \zeta}^t = -\sum_k \left\{\delta_x(\overline{h}^x u) + \delta_y(\overline{h}^y v)\right\} \quad \text{at } i, j, n \quad (14)$$

$$\overline{\delta_t(\overline{h}^x u)}^t = -\delta_x(\overline{\overline{h}^x u}^x \overline{u}^x) - \delta_y(\overline{\overline{h}^y v}^x \overline{u}^y) - \overline{h}^x \delta_z(\overline{u}^z \overline{w}^x) + f\overline{h}^x \overline{v}^{xy} - \frac{1}{\overline{\rho}^x}\overline{h}^x \delta_x p$$

$$+ \frac{1}{\overline{\rho}^x}\left[h\delta_z E_x \delta_z \overline{u}^{2t} + \delta_x\left\{hA_x \delta_x u\right\}_- + \delta_y\left\{\overline{\overline{h}^x \overline{A_y}^x}^y \delta_y u\right\}_-\right] \quad \text{at } i+\tfrac{1}{2}, j, k, n \quad (15)$$

$$\overline{\delta_t(\overline{h}^y v)}^t = -\delta_x(\overline{\overline{h}^x u}^y \overline{v}^x) - \delta_y(\overline{\overline{h}^y u}^y \overline{v}^y) - \overline{h}^y \delta_z(\overline{v}^z \overline{w}^y) - f\overline{h}^y \overline{u}^{xy} - \frac{1}{\overline{\rho}^y}\overline{h}^y \delta_y p$$

$$+ \frac{1}{\overline{\rho}^y}\left[h\delta_z E_y \delta_z \overline{v}^{2t} + \delta_x\left\{\overline{\overline{h}^y \overline{A_x}^y}^x \delta_x v\right\}_- + \delta_y\left\{hA_y \delta_y v\right\}_-\right] \quad \text{at } i, j+\tfrac{1}{2}, k, n \quad (16)$$

$$\overline{\delta_t(hs)}^t = -\delta_x(\overline{h}^x u \overline{s}^x) - \delta_y(\overline{h}^y v \overline{s}^y) - h\delta_z(w\overline{s}^z)$$

$$+ \delta_x\left\{\overline{h}^x D_x \delta_x s\right\}_- + \delta_y\left\{\overline{h}^y D_y \delta_y s\right\}_- - h\delta_z\left\{\kappa \delta_z \overline{s}^{2t}\right\}$$

$$\text{at } i, j, k, n \quad (17)$$

$$\overline{\delta_t(hT)}^t = -\delta_x(\overline{h}^x u\overline{T}^x) - \delta_y(\overline{h}^y v\overline{T}^y) - h\delta_z(w\overline{T}^z)$$

$$+ \delta_x\left\{\overline{h}^x D_x \delta_x t\right\}_- + \delta_y\left\{\overline{h}^y D_y \delta_y T\right\}_- + h\delta_z\left\{\kappa' \delta_z \overline{T}^{2t}\right\}$$

at i, j, k, n (18)

$$\overline{\delta_t(he)}^t = -\delta_x(\overline{h}^x u\overline{e}^x) - \delta_y(\overline{h}^y v\overline{e}^y) - h\delta_z(w\overline{e}^z)$$

$$+ \delta_x\left\{\overline{h}^x D_x \delta_x e\right\}_- + \delta_y\left\{\overline{h}^y D_y \delta_y e\right\}_- + h\delta_z\left\{E_e \delta_z \overline{e}^{2t}\right\}$$

$$+ S - D$$ at i, j, k, n (19)

$$\overline{\delta_t(hP)}^t = -\delta_x(\overline{h}^x u\overline{P}^x) - \delta_y(\overline{h}^y v\overline{P}^y) - h\delta_z(w\overline{P}^z)$$

$$+ \delta_x\left\{\overline{h}^x D_x \delta_x P\right\}_- + \delta_y\left\{\overline{h}^y D_y \delta_y P\right\}_- + h\delta_z\left\{\kappa \delta_z \overline{P}^{2t}\right\} - S$$

at i, j, k, n (20)

The density is computed using s(i,j,k,t) and T(i,j,k,t) according to the equation of state

$$\rho = [5890 + 38T - 0.375T^2 + 3s] / [(1779.5 + 11.25T - 0.0745T^2) - (3.8 + 0.01T)s + 0.698(5890 + 38T - 0.375T^2 + 3s)] \quad \text{at } i, j, k, n+1 \tag{21}$$

A graphical representation of the density as a function of temperature for water with different salinity is shown in Fig. 5.

The finite difference equation used to compute the vertical velocity component w

$$\delta_z w = - \delta_x\left(\overline{h}^x u\right) - \delta_y\left(\overline{h}^y v\right) \quad \text{at } i, j, k, n+1 \tag{22}$$

This equation is used for the bottom layer first, and then for the layer above, etc. The horizontal pressure gradients are computed from the top layer downward with increasing k by use of

$$\delta_x p = g\overline{\rho}^x \delta_x \zeta + \tfrac{1}{2} \overline{h}^x \delta_x \rho \quad \text{at } i + \tfrac{1}{2}, j, 1, n+1 \tag{23}$$

$$\delta_y p + g\overline{\rho}^y \delta_y \zeta + \tfrac{1}{2} \overline{h}^y \delta_y \rho \quad \text{at } i, j + \tfrac{1}{2}, 1, n+1 \tag{24}$$

$$\delta_z(\delta_x p) = g\delta_x \overline{\rho}^z \quad \text{at } i + \tfrac{1}{2}, j, k + \tfrac{1}{2}, n+1 \tag{25}$$

$$\delta_z(\delta_y p) = g\delta_y \overline{\rho}^z \quad \text{at } i, j + \tfrac{1}{2}, k + \tfrac{1}{2}, n+1 \tag{26}$$

Once the horizontal pressure gradients are known, the water level and velocities can be computed again by the sequence of finite difference equations (14) through (26). Special procedures are

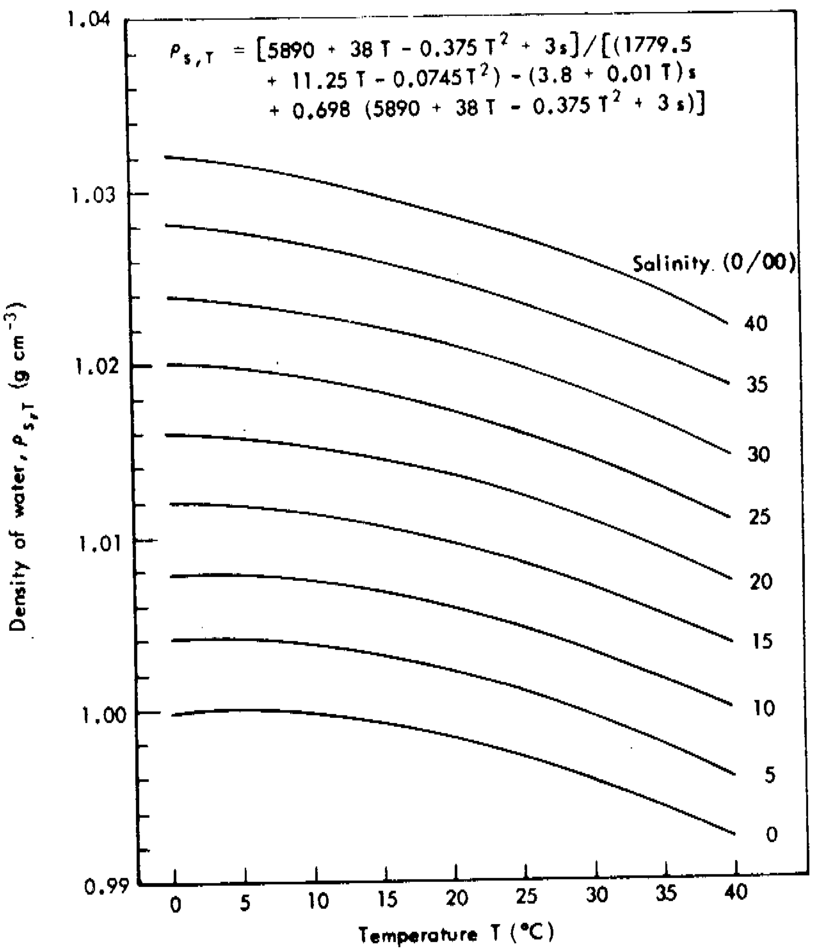


Fig. 5--Equation of state and graphical representations of several selected ranges of S and T values

required for the computation of variables on or near the boundaries, particularly the seaward boundaries. They will be discussed, together with the specification of the initial conditions in Sect. IV of this note.

C. VERTICAL EXCHANGE OF MOMENTUM AND CONSTITUENTS

In the computational model the turbulent exchanges of momentum and constituents in the vertical which cannot be represented by the computational grid are accounted for by means of exchange coefficients. The magnitude of these exchange coefficients varies not only with space and time, but it is also a function of local turbulence level. Their values are also influenced by the local vertical stability induced by the density stratification. In our computational model, the vertical exchange coefficients are taken according to the basic theoretical considerations of Kolmogorof (1941) and Prandtl (1945) as a function of local turbulent energy level.

$$\varepsilon = L\sqrt{e} \tag{27}$$

where L is a length scale, evaluated as a function of distance to the bottom and free surface according to

$$L = k' z(1 - z/d)^{\frac{1}{2}} \tag{28}$$

where k' is the von Karman constant, z represents the vertical distance from the bottom to the point considered, and d is the local water depth.

In fluids with vertically stable density gradients, the turbulent intensity is suppressed. Therefore, lower values of exchange coefficient would result. The criteria for the onset of the turbulence-suppressing process in a nonhomogeneous flow system can be obtained by multiplying by a proportionality coefficient which is a function of the local Richardson number, defined as

$$Ri = - \frac{g}{\rho} \frac{\partial\rho/\partial z}{e} L^2 \tag{29}$$

Mamayav (1958) indicates that the reduction of vertical exchange due to stratification can be expressed in an exponential manner. For momentum exchange in the x-direction,

$$E_x = \overline{\rho}^{xz} \, \overline{L\sqrt{e_-}}^{xz} \exp\left[m \frac{g}{\overline{\rho}^{xz}} \frac{(\overline{L}^z)^2 \delta_z(\overline{\rho}^x)}{\overline{e_-}^{xz}} \right] \tag{30}$$

The exponential term in this equation describes the Richardson number dependency, and m represents a constant.

The mass exchange coefficients are computed at a different location, namely, at the layer interface between the points where the concentrations are computed, as shown in Fig. 3.

Consequently, the expression for the mass-exchange coefficient is somewhat different than the momentum exchange coefficients. In the model we are using:

$$\kappa = a_4 \overline{L\sqrt{e_-}}^{z} \exp\left[r \frac{g}{\overline{\rho}^{z}} (\overline{L}^{z})^2 \frac{\delta_z \rho}{\overline{e_-}^{z}} \right] \tag{31}$$

where r = a constant.

A factor a appears in this formula, as the mass exchange is not the same as the momentum exchange.

The subgridscale energy is transported in a similar manner as the transport of constituents, thus the energy exchange coefficient can be written in the same form as the mass exchange.

$$E_e = a_1 \overline{L\sqrt{e_-}}^{z} \exp\left[m \frac{g}{\overline{\rho}^{z}} (\overline{L}^{z})^2 \frac{\delta_z \rho}{\overline{e_-}^{z}} \right] \tag{32}$$

In the horizontal direction we have assumed that the exchange processes are predominantly governed by two-dimensional turbulence, as the horizontal dimensions are much larger than the depth, and thus no isotropic three-dimensional turbulence can be generated. The two-dimensional turbulence has the property that the enstrophy (one-half vorticity squared) cascades from smaller to larger scales, while in three-dimensional turbulence, it cascades from larger scales to smaller scales. In the model the local enstrophy has to be dissipated, as we have limits to the vorticity which can be expressed on the grid. This dissipation is accomplished by introduction of nonlinear horizontal eddy viscosity coefficients:

$$A = \gamma \left| (\delta_x \overline{\omega}^{y} + \delta_y \overline{\omega}^{x}) \right| (\Delta \ell)^3 \tag{33}$$

where ω is vorticity, γ is a coefficient and $\Delta \ell$ is grid dimension.

D. GENERATION AND DISSIPATION OF SUBGRIDSCALE ENERGY

In the interior of the fluid in our model, it is assumed that the interlayer shear generates the subgridscale energy. This source can be expressed as:

$$S = \varepsilon\left(\frac{\delta\bar{u}}{\partial z}\right)^2 \tag{34}$$

where $\bar{u}$ = mean velocity

$\varepsilon = L\sqrt{e}$

In the model this source is determined at the interface between the layers at i, j, k + 1/2.

$$S = a_3\overline{L\sqrt{e}_-}^{z}\left\{\left(\delta_z\overline{u}^x\right)^2 + \left(\delta_z\overline{v}^y\right)^2\right\} \tag{35}$$

It will be noted that only the energy is computed at the lower time level. This was necessary for stability of the computation.

The energy generated at this location is assumed to be distributed equally into the adjacent layers.

In the bottom layer another source exists. It is assumed that energy which is taken out of the mean flow through the bottom stress immediately enters the subgridscale energy system.

The stress term in the momentum equation in the direction of the mean flow is

$$\frac{\tau}{\rho} = gU^2/C^2 \tag{36}$$

where U = velocity in bottom layer in the direction of flow.

If this term is multiplied by U, we obtain the energy which is taken out of the mean flow system and the local source (S) for the subgridscale energy.

$$s = gu^3/C^2 \tag{37}$$

In the model, the subgridscale energy generation is computed at the layer interfaces and the local finite difference source term becomes

$$s = g\left[(\overline{u}^x)^2 + (\overline{v}^y)^2\right]^{3/2} \Big/ C^2 \quad \text{at } i,\ j,\ K+\tfrac{1}{2},\ n \tag{38}$$

The energy is completely introduced in the layer K.

At the water surface the generation of the subgridscale energy is different. Here the energy source is the wind which generates surface waves, and through these waves, turbulence. Wave and swell conditions depend on wind intensity, duration of the wind and the fetch. In the test cases a fully-developed sea under moderate wind speed was used as input. Under these conditions the waves are so-called deep water waves, and the total wave energy can be found from the Pierson-Moskowitz spectral sets (Neumann and Pierson [6]). Per unit area, the total wave energy is

$$E_t = 5.6 \times 10^{-9} u_w^4 \quad (39)$$

where u_w = wind speed in cm/sec at 19.5 m above mean sea surface

E = wave energy

Half of this energy is kinetic energy. If we assume that all this kinetic energy is in the top layer (h_1) of the model, then the vertically-average subgridscale energy intensity in this layer is

$$e = 2.8 \times 10^{-9} u^4 / h_1 \quad (40)$$

at i, j, 1, n

As the wave theory presents an energy intensity for a given wind condition, we are not concerned with influx of the subgridscale energy into the system, but with maintaining this energy level during the duration of the wind condition in the simulation.

We have assumed that all the kinetic wave energy is in the top layer. From deep water wave theory it is known that the wave-induced water motions are effectively zero at a depth which is half the wave length. This puts an upper limit upon the wind speed which we were able to allow in the simulation. This wind speed can be estimated from the average wave period belonging to the wind speed (Neumann and Pierson [6]).

$$\tilde{\tilde{T}} = .81 \times 2\pi u_w/g \tag{41}$$

and from the wave-length-wave-period relation

$$\tilde{\tilde{L}} = g\tilde{\tilde{T}}^2/2\pi \tag{42}$$

The maximum wind that is allowed in a model with an upper layer thickness h for use in Eq. (40) can then be found from Eqs. (41) and (42):

$$u_w = \ldots \sqrt{\tfrac{1}{2}\tilde{\tilde{L}}} < \ldots \sqrt{h} \tag{43}$$

Higher wind velocities would also involve subgridscale energy inputs in lower layers. The model at present does not include inputs other than in the surface layer.

For the dissipation of energy, use is made of the now classical concepts developed by Kolmogorov [3] and Prandtl [4] that the dissipation rate depends on the transfer process from larger eddies to smaller eddies according to

$$D = a_2\, \underline{e}^{3/2}/L \tag{44}$$

To demonstrate the generation and decay of turbulent energy in a transient hydrodynamic system, the computational scheme has been tested on a seiche oscillation with an initial amplitude of 25 cm in a rectangular basin. This basin was 46 km long, 14 km wide and 12 meters deep. The interior computational field contained 23 x 7 x 6 grid points and an equal layer thickness for each layer of 2 meters. Constants in the computation are

$$a_1 = 0.68$$

$$a_2 = 0.1$$

$$a_3 = 1.0$$

$$a_4 = 1.0$$

$$a^1 = 0.4$$

The initial value of SGS energy density was set to 0.4 ergs per unit mass throughout the system. At the starting time, all the energy resolvable in the mean flow is stored in the form of potential energy. Immediately after the start of the computation, a system of current is set up. The stresses at the bottom introduce vertical gradients for the horizontal velocity, which causes subgridscale energy generation. The gradual establishment of the vertical velocity distribution is illustrated in Fig. 6. The velocities obtained from an analytical solution of the long wave equation in the basin for ideal fluid is also shown in the graph.

The subgridscale maxima occur shortly after the occurrence of the maximum velocities in the system. The subgridscale energy fluctuation for the first two oscillations is shown in Fig. 7. Note that

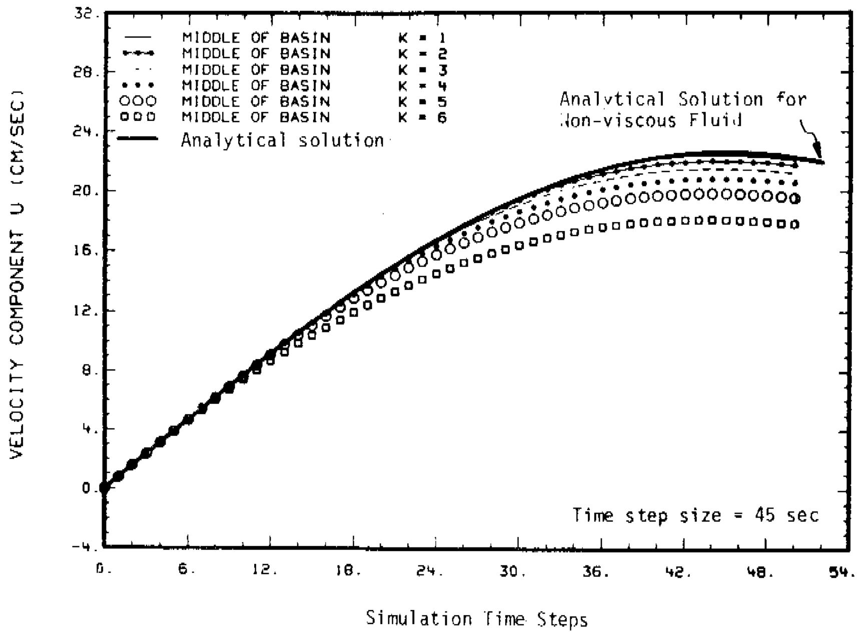


Fig. 6--Comparison of computed mean flow velocity component u by numerical method to non-viscous fluid by analytical solution

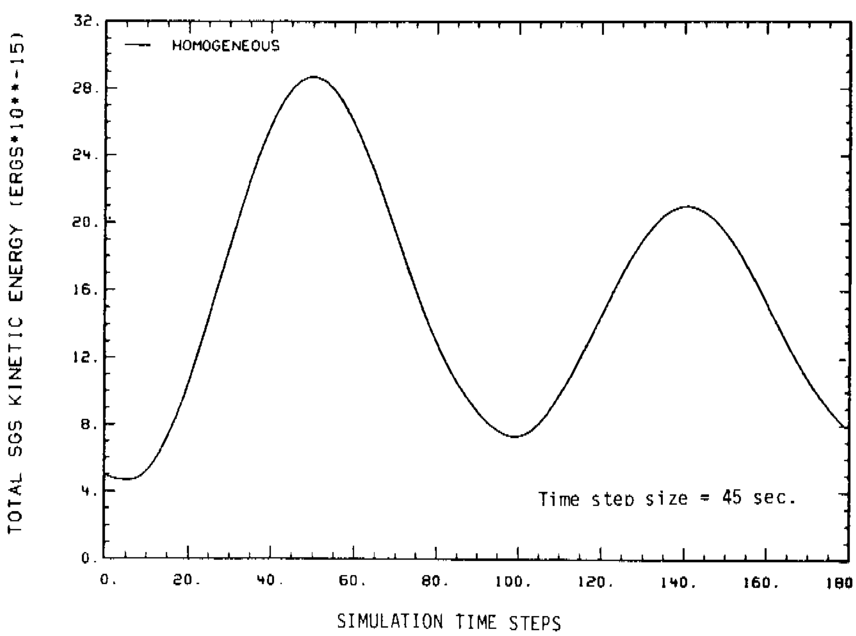


Fig. 7--Generation and decay of the total subgridscale kinetic energy in the oscillating basin

immediately after the start of the simulation the energy decays, as the velocities are still small, and consequently the generation is small.

The simulation was carried out to 1500 time steps (18.75 hrs real time). At that time the oscillation had decayed significantly. In Fig. 8 the maxima and minima of the total SGS content are shown. Both the maxima and minima decay exponentially.

Figure 9 shows the vertical distributions of the u velocity components at several time intervals. The distribution appears to be near logarithmic only if the flow is well established and approaches a steady state condition.

In a model of Long Island Sound [7], which we used to test our computational procedures at a time previous to our modeling of the Bering Sea, turbulent energy and the total kinetic energy at each level appeared to increase gradually from three and one-half percent at the surface to sixteen percent near the bottom, where both local production and dissipation are most intensive. The vertical distribution from that experiment is shown in Fig. 10.

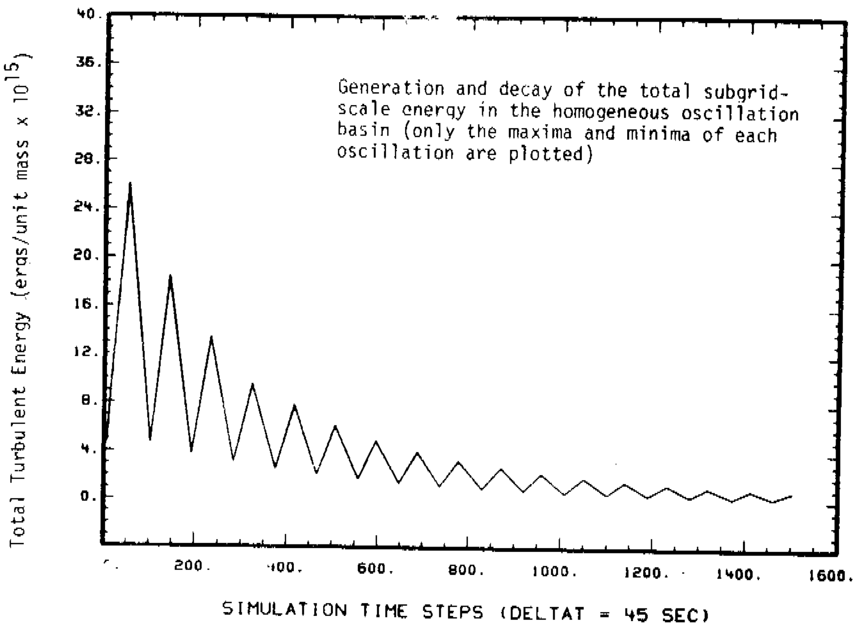


Fig. 8--The generation and decay of turbulent energy in the homogeneous rectangular oscillating basin

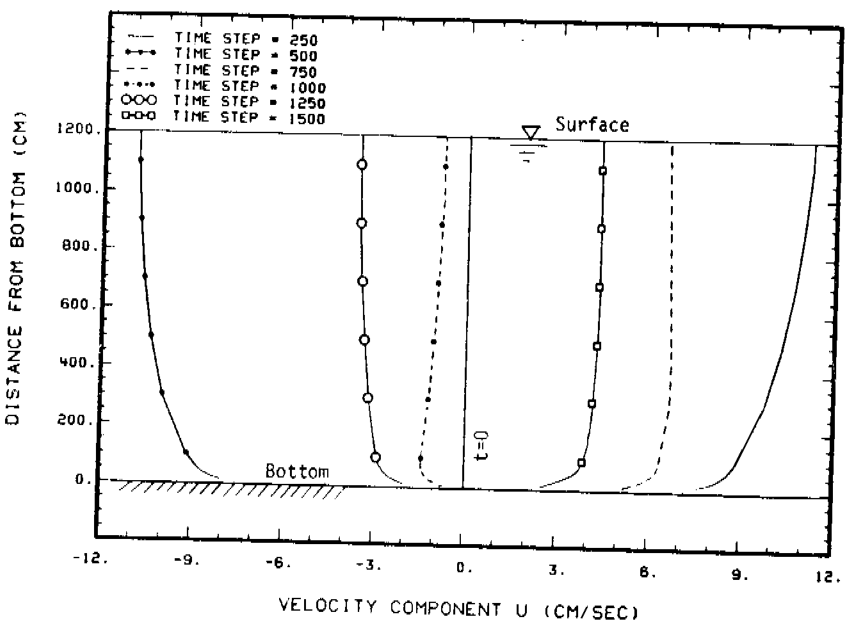


Fig. 9--Vertical distribution of velocity component u in the middle of homogeneous oscillating basin (linear vertical scale)

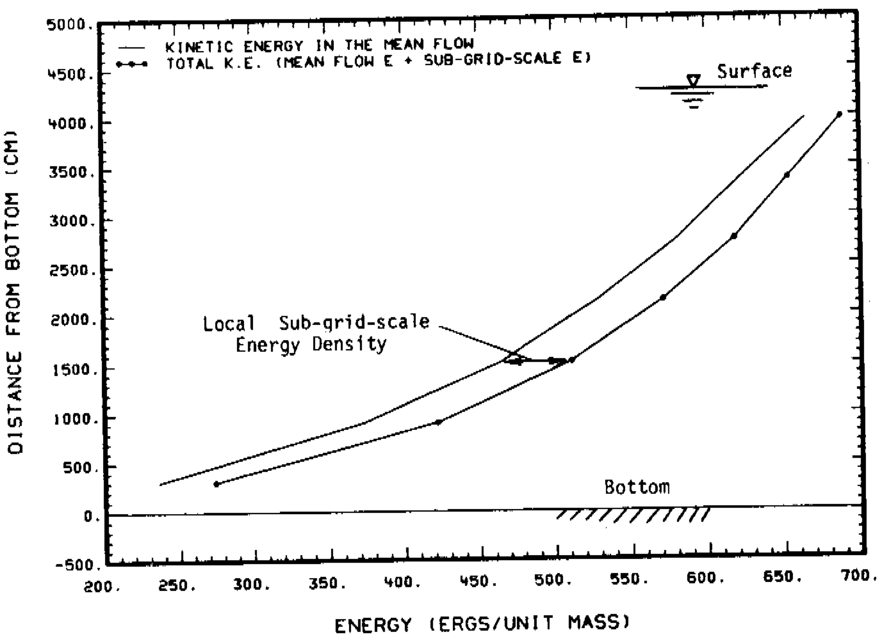


Fig. 10--Computed vertical distribution of tide-induced total kinetic energy at a particular location curing ebb tide in a model of Long Island Sound (Leendertse and Liu, 1977)

III. MODEL SETUP

In the planning stage of the model investigation we had to determine the grid dimensions of both model areas and the grid direction.

It has been our experience that the selection of the grid has to be made with care, as it can have considerable influence on the model results. Generally, the more detail that is used, the larger the computational arrays we have to work with. The computational effort appears to be related to the third power of the inverse of the selected horizontal grid dimension, and the required computer memory increases with the square of the horizontal grid size.

At the beginning of the investigation we had no clear view of the dynamic behavior of the system, nor how the density would be distributed over the vertical. At that time we considered that the model should contain at least 7 layers. Since the thickness of each layer can be set, we still have considerable flexibility in the choice of the vertical representation.

Initially the layer thickness was set at 10 fathoms (1828.8 cm) for all seven layers. This vertical representation has been used for the model experiments described in this Working Note. Now that field data has become available, another vertical representation will be used, as will be described later.

The Bristol Bay system is schematized into a computational grid system of 60 x 42 x 7 points with a horizontal grid size (x, y) of

13.62 km (Fig. 11). These grid dimensions cause the model to use much computer memory. We are quite close to the maximum available to us, while anticipated model growth is still possible.

The direction was chosen so that maximum use could be made of the field data collection program which had already started when our modeling work began. In considering the direction of the grid, we tried as much as possible to put the open boundaries perpendicular on the anticipated main flow directions.

Norton Sound is schematized into a model with a grid system of 43 x 39 x 7 points (Fig. 12). The horizontal grid point distances are 10000 m, while the vertical grid system is set to be 6 fathoms (598.6 cm) for all layers. When salinity and density data become available, another vertical grid representation can be made.

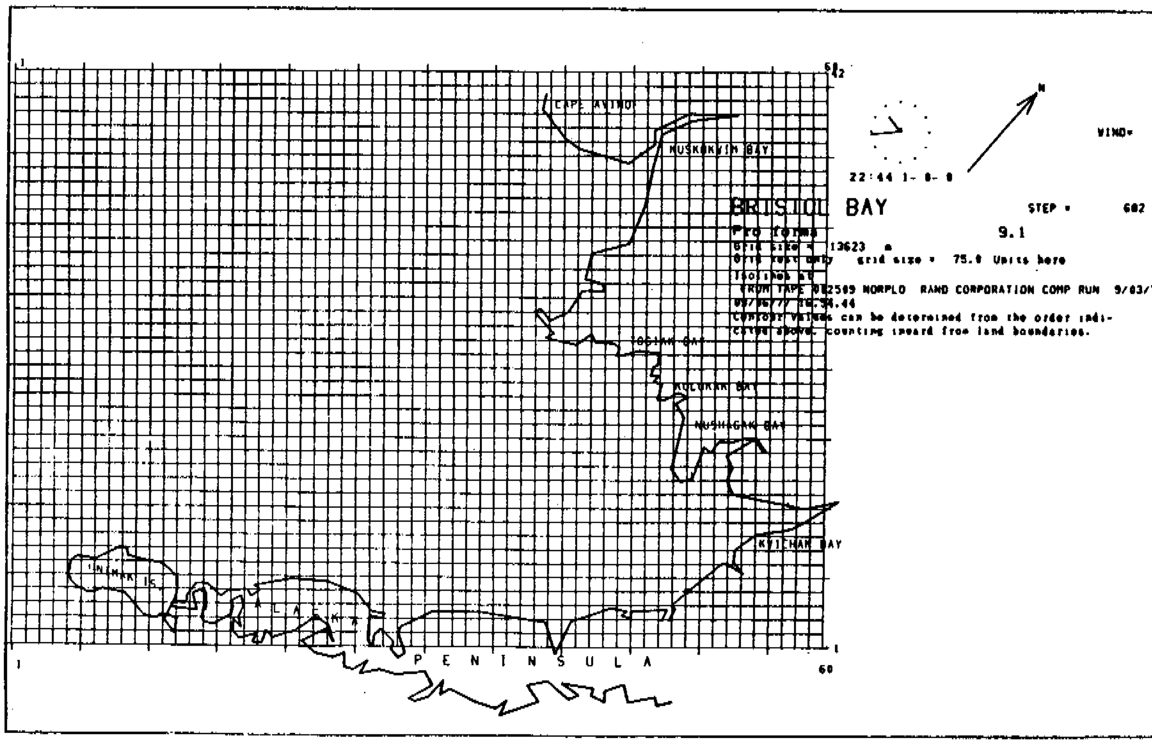


Fig. 11--Schematization of Bristol Bay model

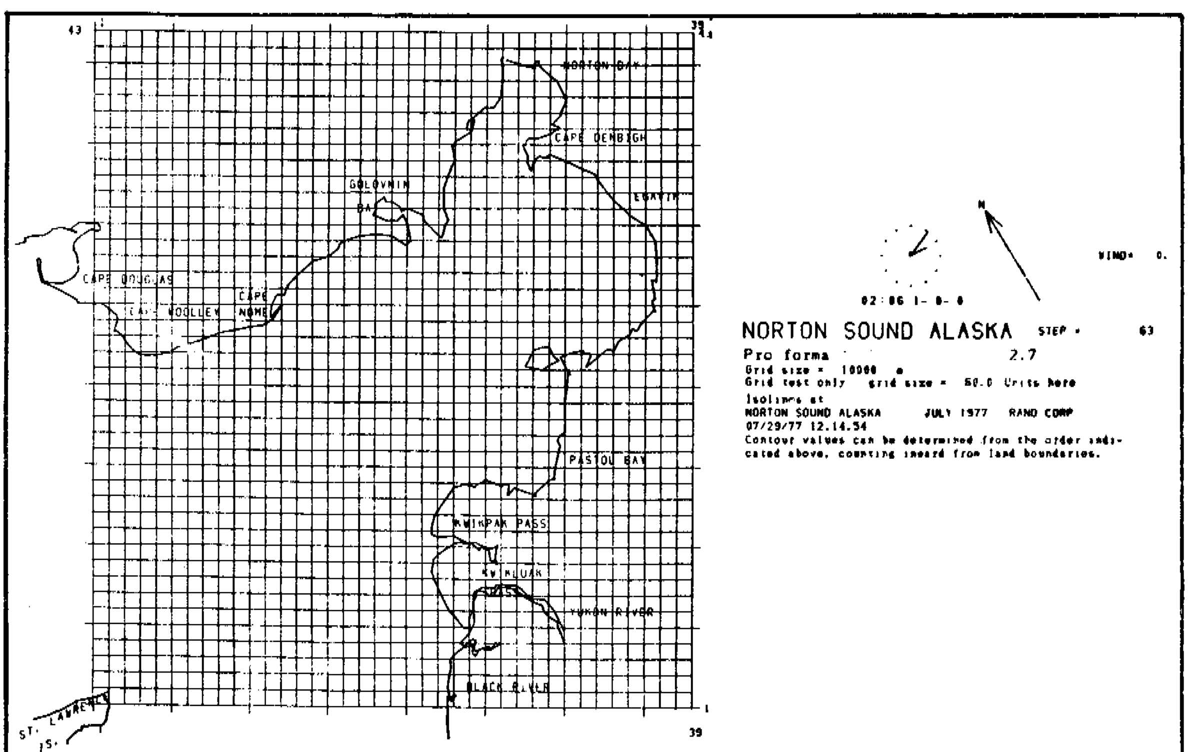


Fig. 12--Schematization of Norton Sound model

IV. INITIAL AND BOUNDARY CONDITIONS

To specify proper initial and boundary condition constitutes one of the most important and difficult tasks in numerical simulation work. Not only water level (sometimes current) variations at open boundaries are required to "drive" the model, but the manner in which temperature and salinity and other dissolved constituents flow in and out through the open boundaries also has to be estimated by the investigator. When the Bristol Bay model was first set up, constant (homogeneous) temperature (5 degrees C) and salinity (32 0/00) were assumed to exist. The preliminary model was driven only from the western open boundary. After several initial tests the initial salinity and temperature fields were schematized with observed data.

The properties of water from the deep Bering Sea slope to the shallow shelf of Bristol Bay can be characterized in the summer as changing gradually in the direction toward shore from warm, salty water to cold, less saline water. In the deeper waters, the thickness of mixed layers varies from 10 to 30 meters, often accompanied by a moderate thermocline. A more pronounced thermocline is associated with waters of intermediate depth (around 80 meters). Vertically homogeneous waters are found in most of the shallow areas. The initial salinity and temperature fields are schematized in the model according to recent field survey data (Kinder 1977). Initial salinity and temperature distribution in the surface and third layers are shown in Figs. 13 through 16. In these figures the observed field data is shown, together with the initial model input.

In the first simulations reported here, the temperature and salinity fields of the Norton Sound model area are assumed to be homogeneous. In the following simulations we intend to use the temperature and salinity fields shown in the figures.

Two types of open boundary conditions are required during the simulation. First, tide level along the open boundary has to be specified every time step to drive the model. This information is imposed at the boundary by means of numerical convolution of major tidal constituents estimated from field data. For example, along the western and northern boundaries of the Bristol Bay model, a total of eight sections were used. Within each section, for a given frequency, amplitude and phase values are given at the beginning and end of that section. Linear interpolation is then carried out at each grid point within the section. This procedure is repeated for each section and for each frequency. The final water level at each grid point is then the convoluted value from all the contributing frequencies. The input data used for the first experiments are only one diurnal tide component and one semidiurnal tide component.

These data were obtained from co-tidal charts prepared by other investigators in the OCSEAP project. These charts are shown in Figs. 17 and 18.

Tides in Bristol Bay can be characterized as primarily of the progressive Kelvin type for the M2 component, and a K1 amphidromic point exists between Pribilof Island and Nunivak Island. Substantial

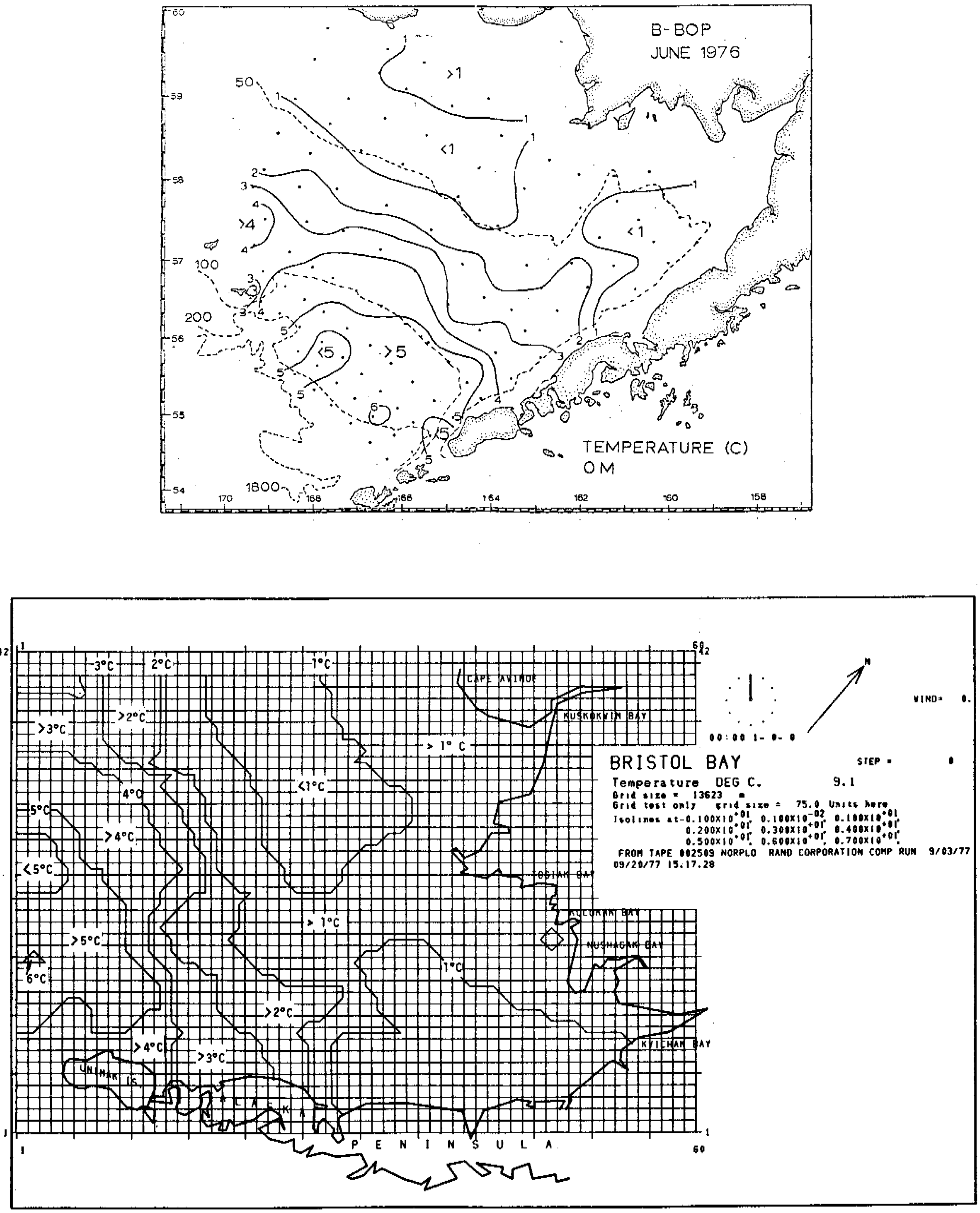


Fig. 13--Observed surface temperature field (Kinder, 1977) and the schematization in the model

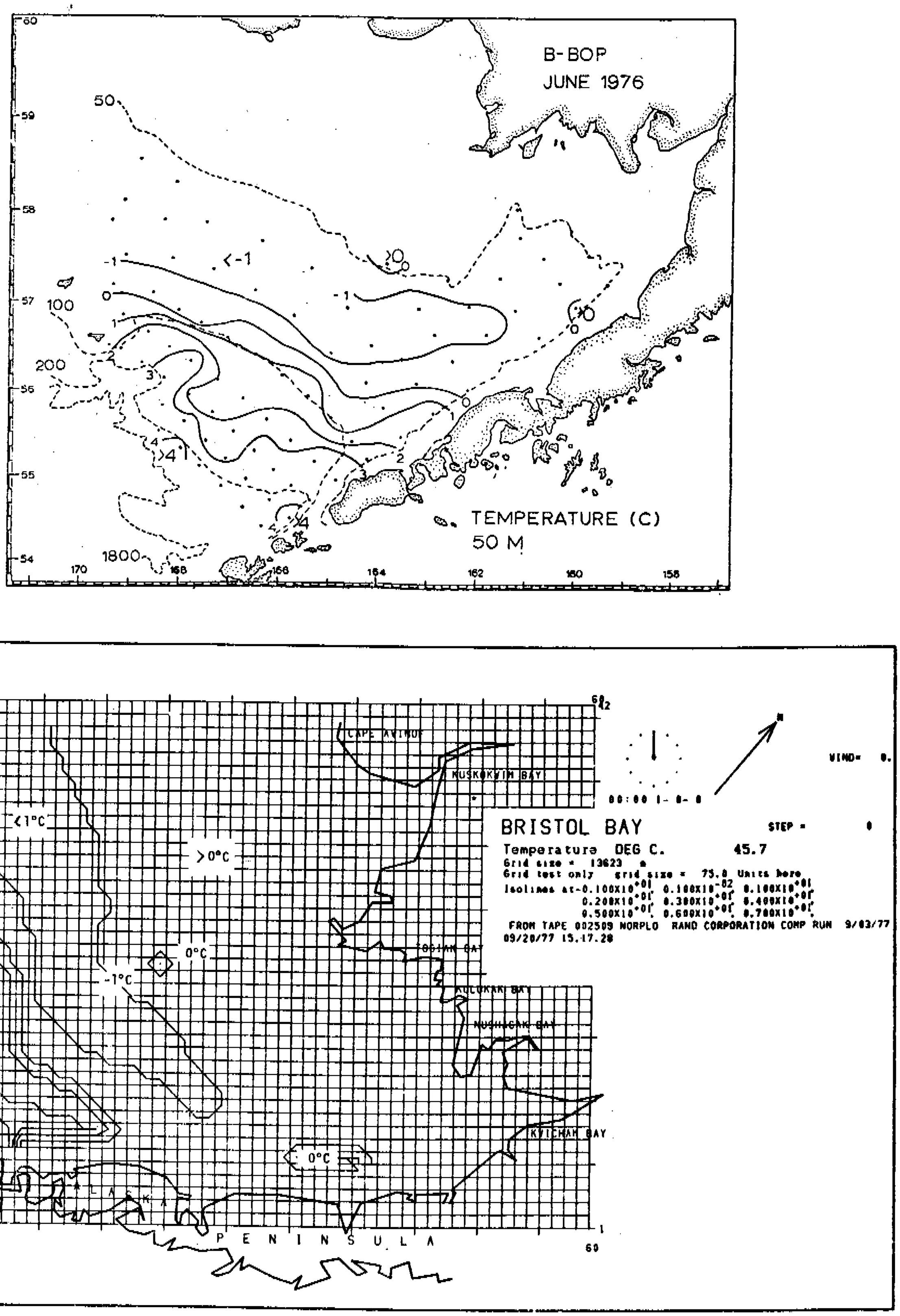
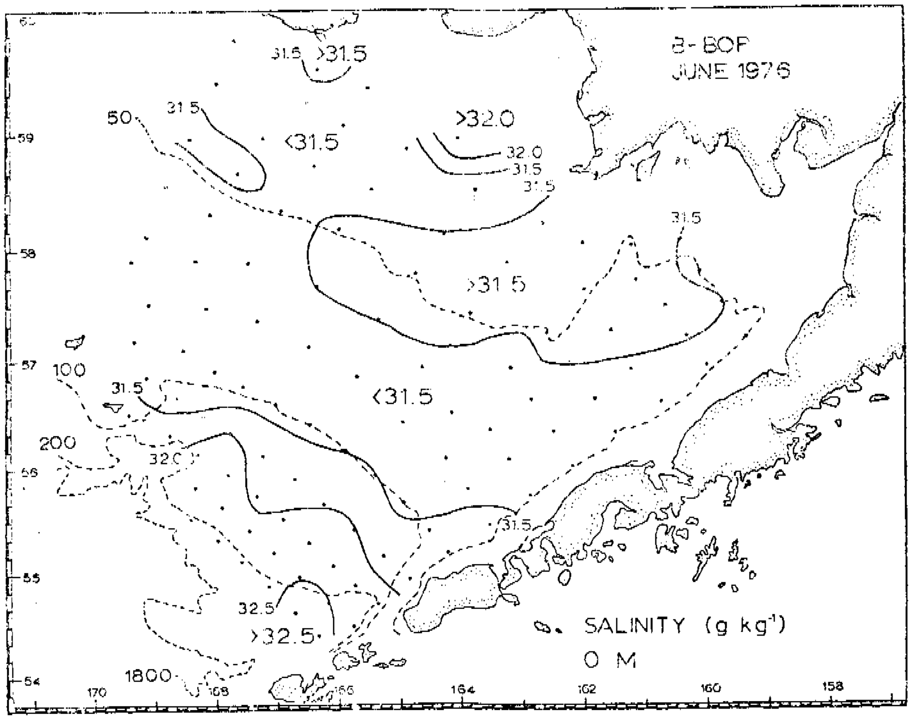


Fig. 14--Observed temperature field at 50 m (Kinder, 1977) and the schematization in the model's third layer



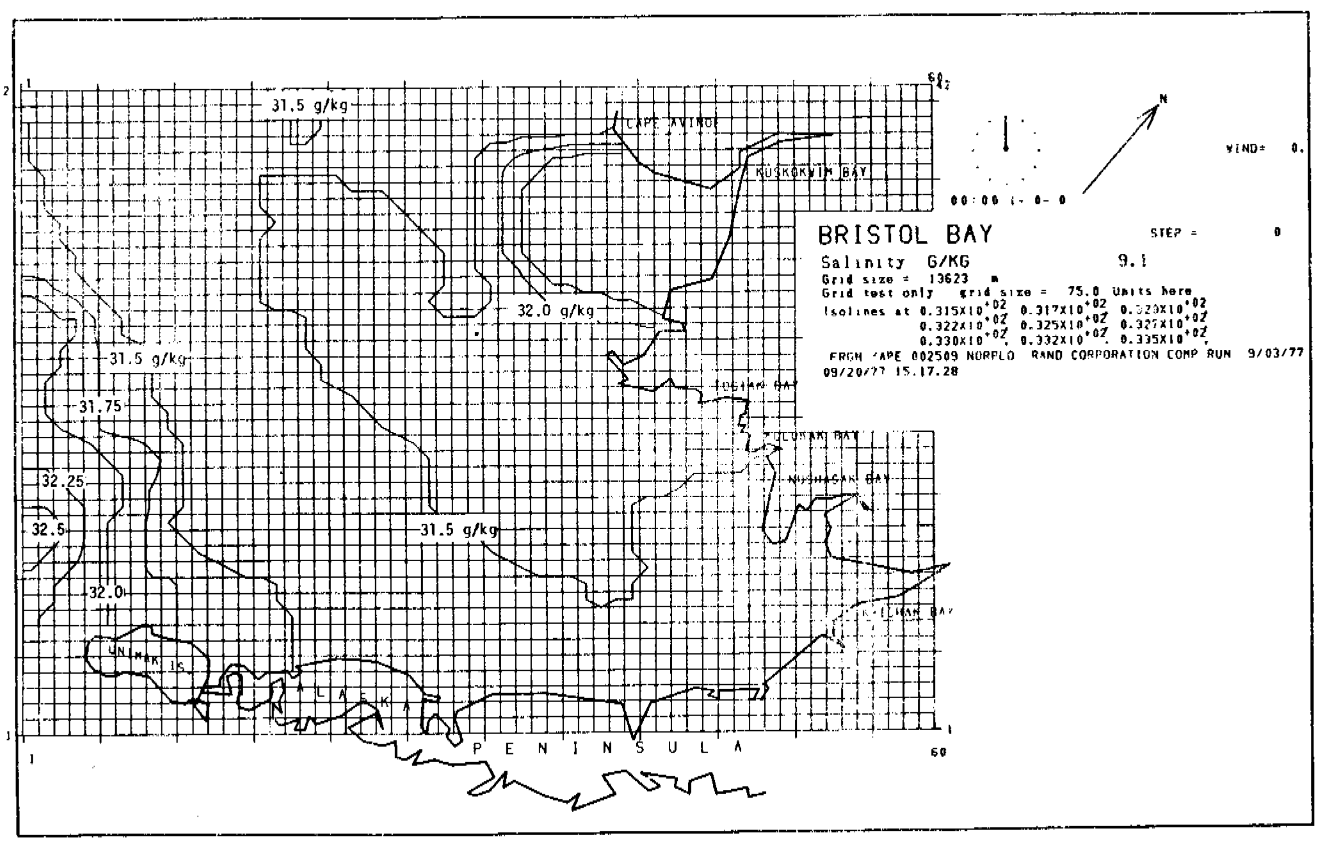
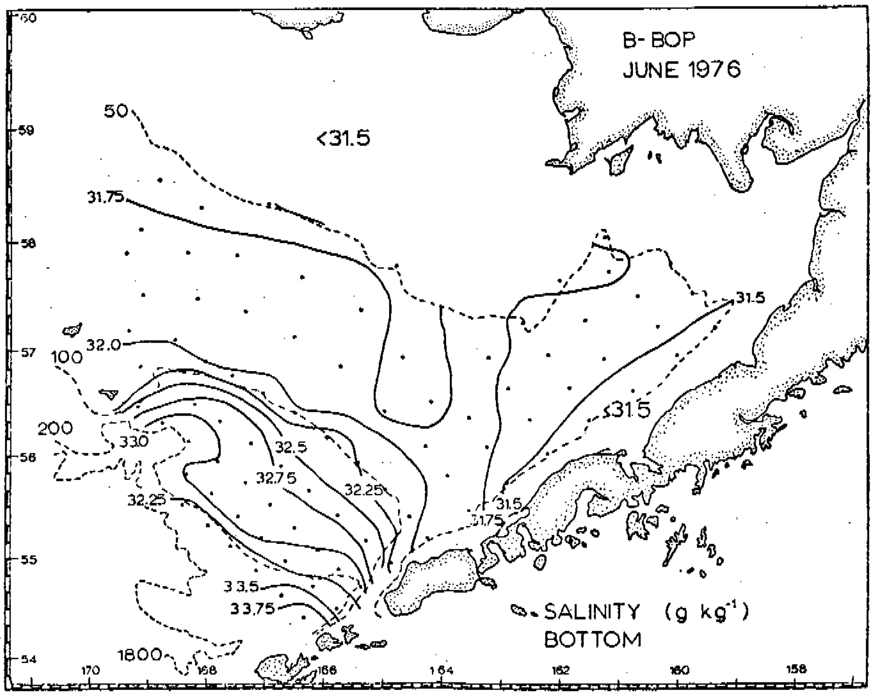


Fig. 15--Observed salinity distribution (Kinder, 1977) and the schematization in the model



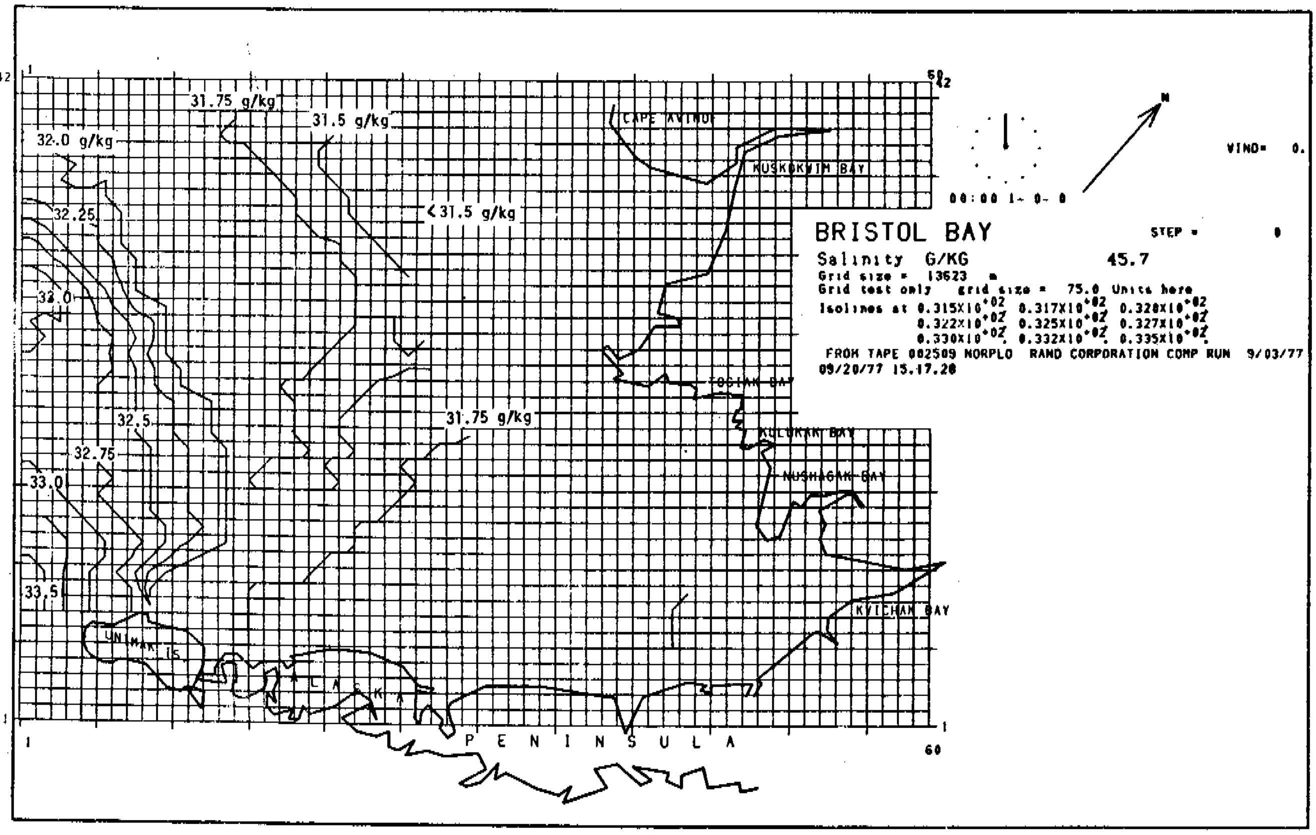


Fig. 16--Observed salinity distribution (Kinder, 1977) and the schematization in the model's third layer

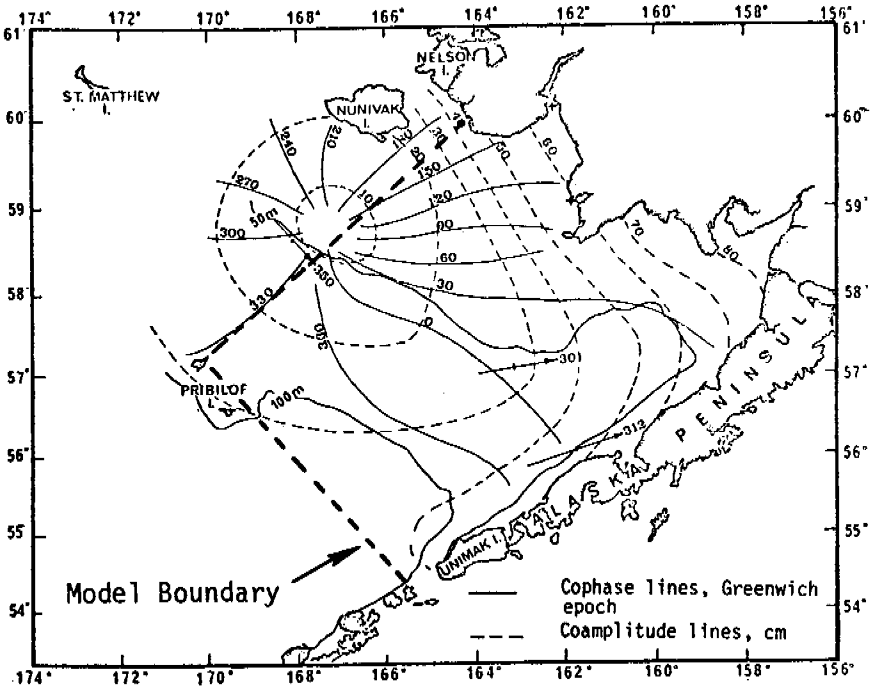


Fig. 17--Co-tide chart of K1 component in Bristol Bay (compiled by PMEL)

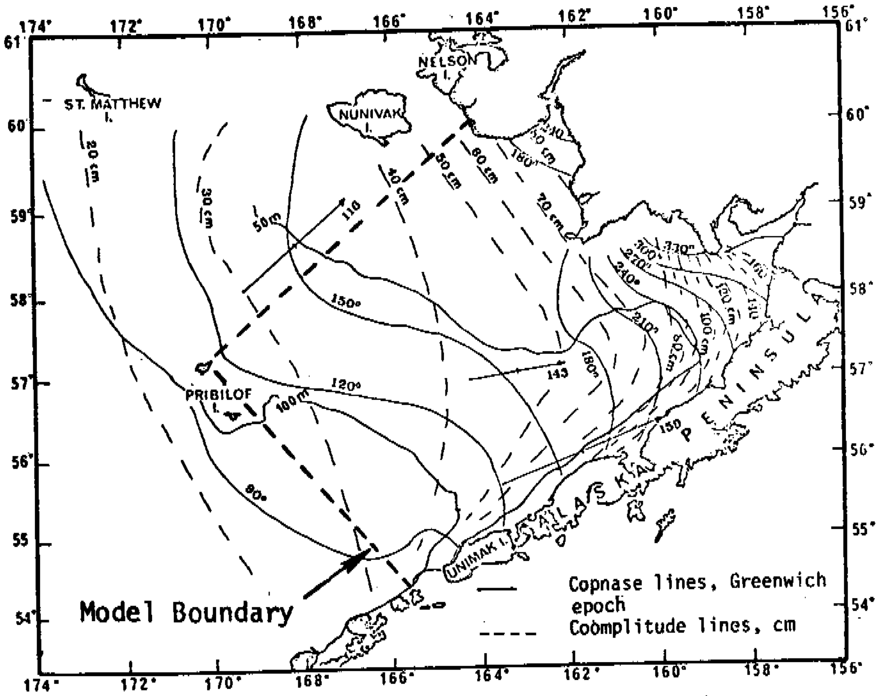


Fig. 18--Co-tide chart of M2 component in Bristol Bay (compiled by PMEL)

shoaling occurs near the head of the bay, with increasing tidal dissipation in the shallow areas.

Because of these tidal characteristics, model adjustment technique will play an important role in the numerical modeling effort.

Another important task will be the determination of the manner in which constituents (including turbulent energy and momentum) are transported across the model's open boundary.

Presently, the following procedures are used at the open boundary. During outflow, the concentration at the boundary point is computed using information from inside the computational field, thus posing no particular problem except that all the data for computation of the nonlinear advection and diffusion terms are not computed near the boundary. As the tide changes and flow returns toward the coast, the concentration at the model's boundary can no longer be determined from the values inside the computational field. These values have to be estimated according to the circulatory conditions outside the computational field from the field survey. As these values may not exactly match with the concentration values at the time of direction change, the functional relationship describing the variation of concentration from slack-water value to the preset recovering value is assumed to be a half-cosine variation.

V. SIMULATION TESTS

During the course of the investigation, a sequence of simulation tests was performed with the models of Bristol Bay and Norton Sound. The first experiments were made with the model with fixed exchange coefficients, the later experimens with the model which computes the subgridscale energy.

The primary function of this series of experiments was to test various ways of handling boundary conditions and presentation of graphical results. Particularly, a series of runs was made to check the feasibility of linear interpolation of tidal constituents using some hypothetical tide data at the models' open boundaries.

Recently, portions of observed tide data in the Bristol Bay area collected by the Pacific Marine Environmental Laboratory were made available to us. With this group of tide data, some further modifications were made in the manner in which open boundary conditions are specified.

Two sequences of simulations have been made with the new tide data of Bristol Bay. In the first group, water levels at the boundaries are specified exactly according to the co-tidal charts as they have been derived from the observed data. The imposed time histories of the water levels at three locations of the boundary are shown in Fig. 19. Initially the bottom frictional coefficient value was chosen similar to that of a typical estuary. The subsequent results from the simulations indicated that a lower tidal energy

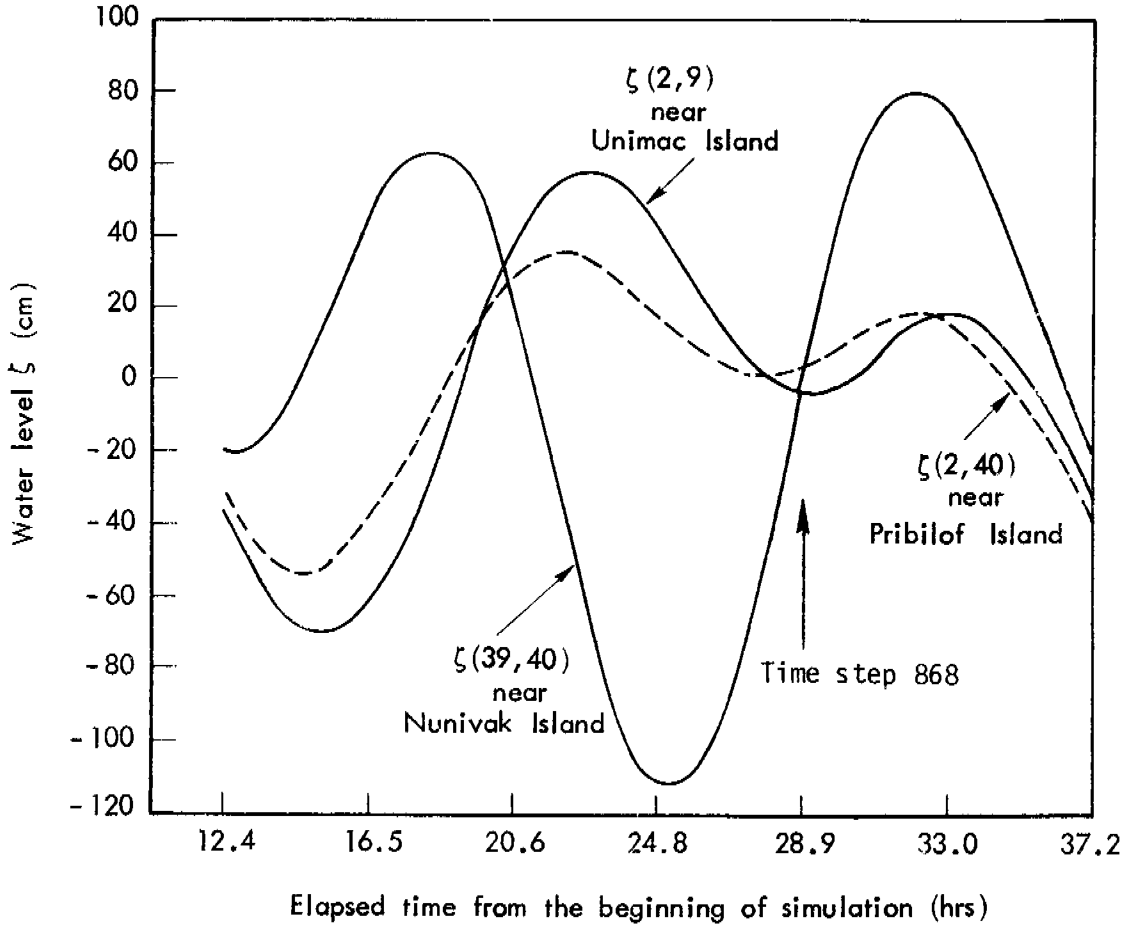


Fig. 19--Prescribed water level at three boundary locations

dissipation would produce more appropriate tidal amplification and shoaling characteristics in the shallow areas of the bay.

There is evidence that the preliminary co-tidal charts as compiled from field data may have certain data deficiencies in the vicinity of Cape Avinof, where substantial shoaling is expected. This is to be expected, as no coastal tide gaging records were used in the preparation of these charts. On reviewing the computation results, it was found that the computed current velocity is locally very high, as shown in Fig. 20. This can be caused by the local estimated gradient of tidal amplitude from Fig. 18. A question was then raised as to whether the estimated co-range lines should be perpendicular to the coastal areas near Cape Avinof in a similar fashion to that found near the northern shore of Kvichak Bay.

Figure 20 is a typical graphical representation which we are able to make from the computation results. This graph presents isocontours of the water level as listed in the table underneath the title. In the computation field certain values are drawn which represent the computed local water level. From these values the value of the isoline can then be determined. In this case only four isolines are present, namely, -30, 0, 30 and 60 cm. The zero contour is actually at 0.01 cm, as our graphical contour routine would ignore contouring at the zero value, considering it as being at a land-water boundary. The graph which is made at time step 868 (at 4.56 hrs of the second day of the simulation) shows also that the water level is generally rising in the computation field except near Unimak Island, where the small squares indicate a fall. In addition, we find on this graph the intensity and direction of the current in the top layer of the model.

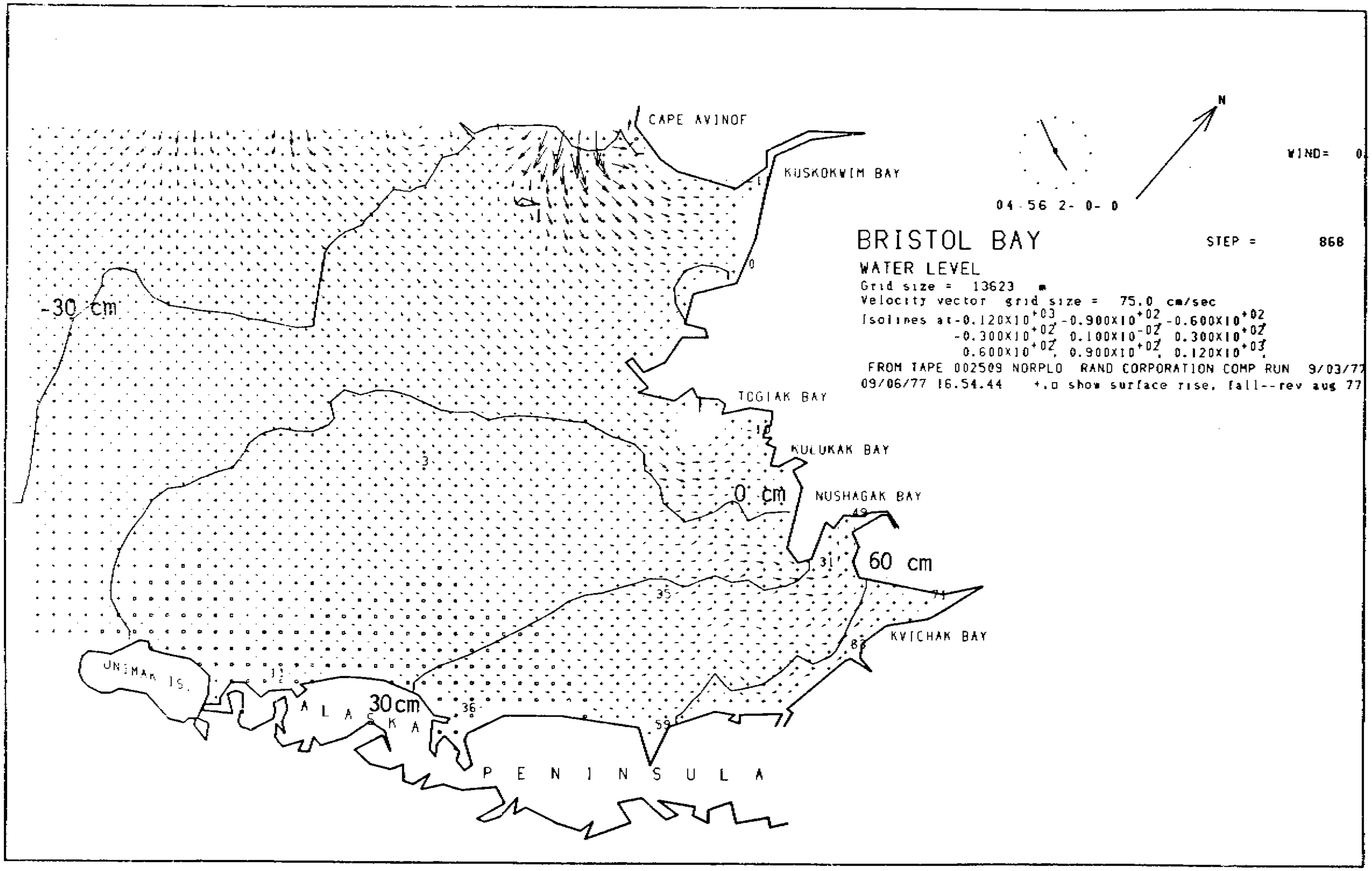


Fig. 20--Computed water levels and rise or fall of water surface at 28 hr 56 min from the beginning of the simulation

Figure 21 presents the computed currents in the top layer. The isocontours in this graph are related to the current magnitudes and the value of the current is indicated at several locations in the flow field.

The unevenness of current pattern along the northern boundary of the model is due to the presence of the amphidromic point and the lack of smoothness in the interpolation of amplitude and phase between different points along this boundary. The prescription of boundary condition along this boundary has been improved during the subsequent simulation tests.

The computed distribution of velocity in the third layer (average depth = 45.7 m) is shown in Fig. 22. Slight differences in the current direction compared with the surface current are caused by the Coriolis acceleration. The magnitude of currents is somwhat smaller due to the bottom frictional resistance. This can be seen more clearly in the computed vertical profiles of velocity through three typical sections, as indicated in Fig. 23. The velocity vectors shown in these graphs are the projections of vectors on the cross-sectional plane. The isocontour lines of velocity components u or v are slightly inclined in the vertical, indicating the vertical velocity gradients.

We have also prepared a program to plot time histories of computed variables in the field. For example, Figs. 24a,b,c show the east-west velocity component, the north-south velocity component and the vertical current component. It will be noted that the north-south current component is predominantly semidiurnal, but in the east-west component the diurnal tide is quite significant. At a more southward station

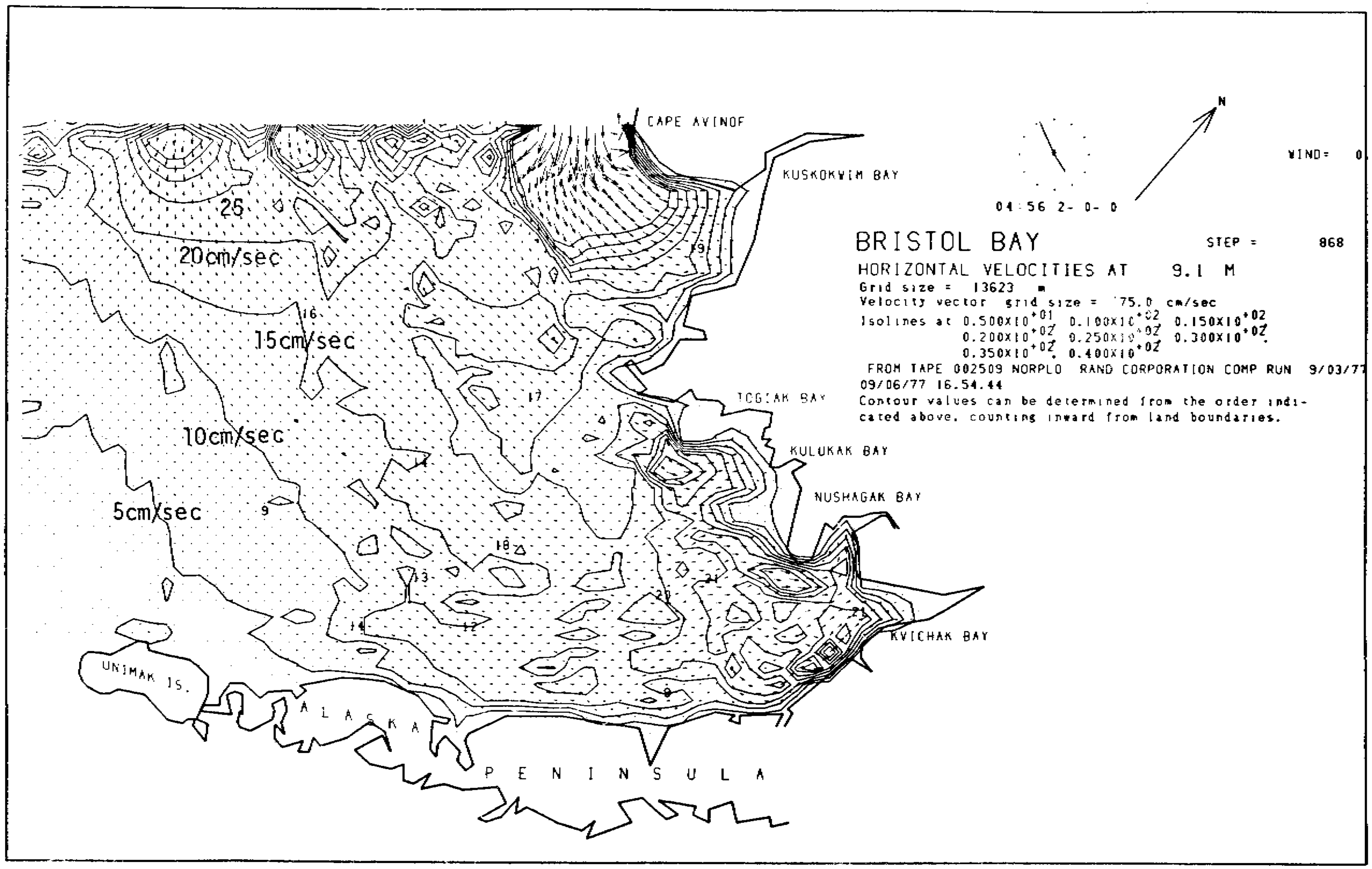


Fig. 21--Computed distribution of surface current pattern and isocontours of speed at 28 hr 56 min from the beginning of the simulation

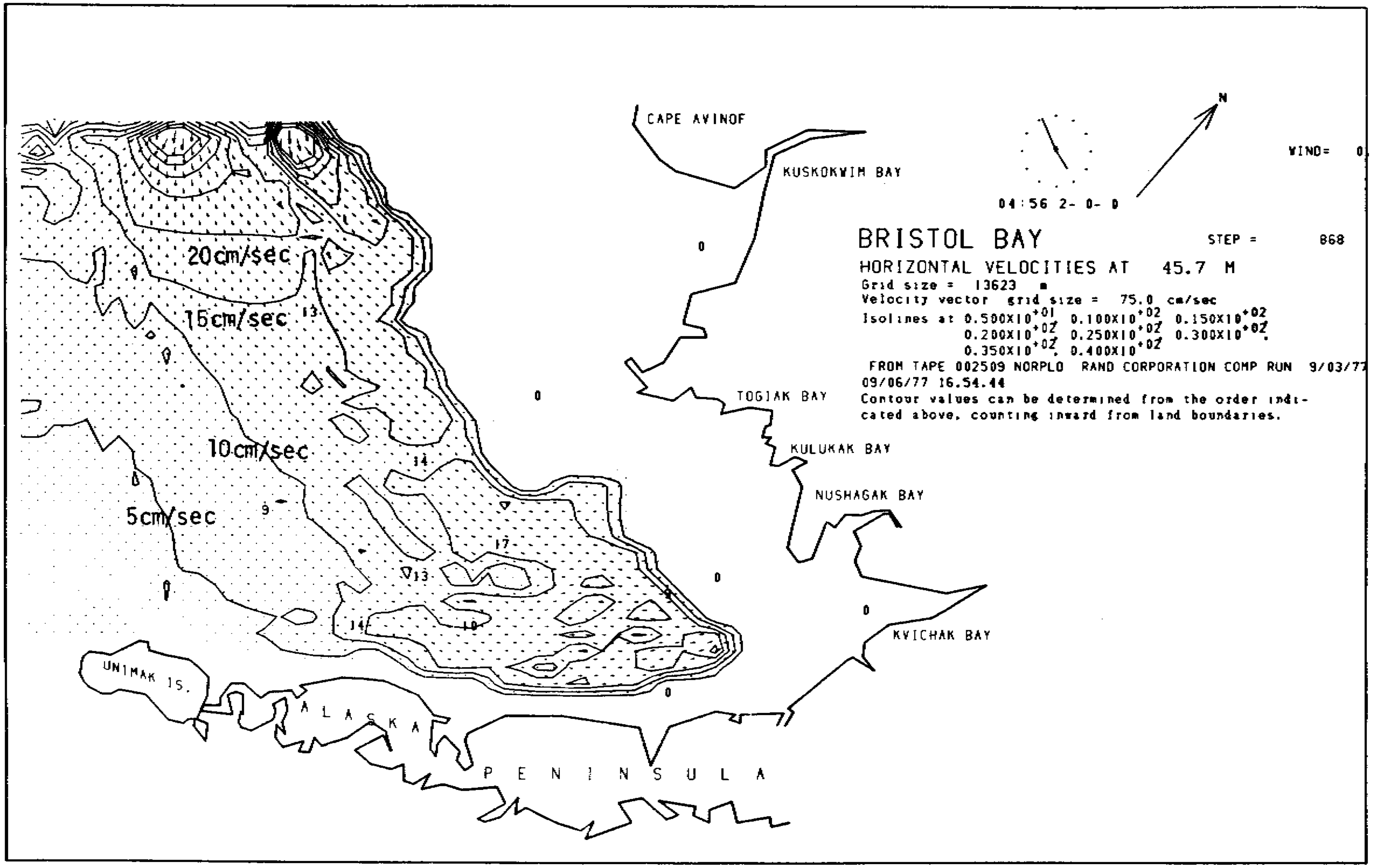


Fig. 22--Computed distribution of currents at 45.7 m depth, 28 hr 56 min from the beginning of the simulation

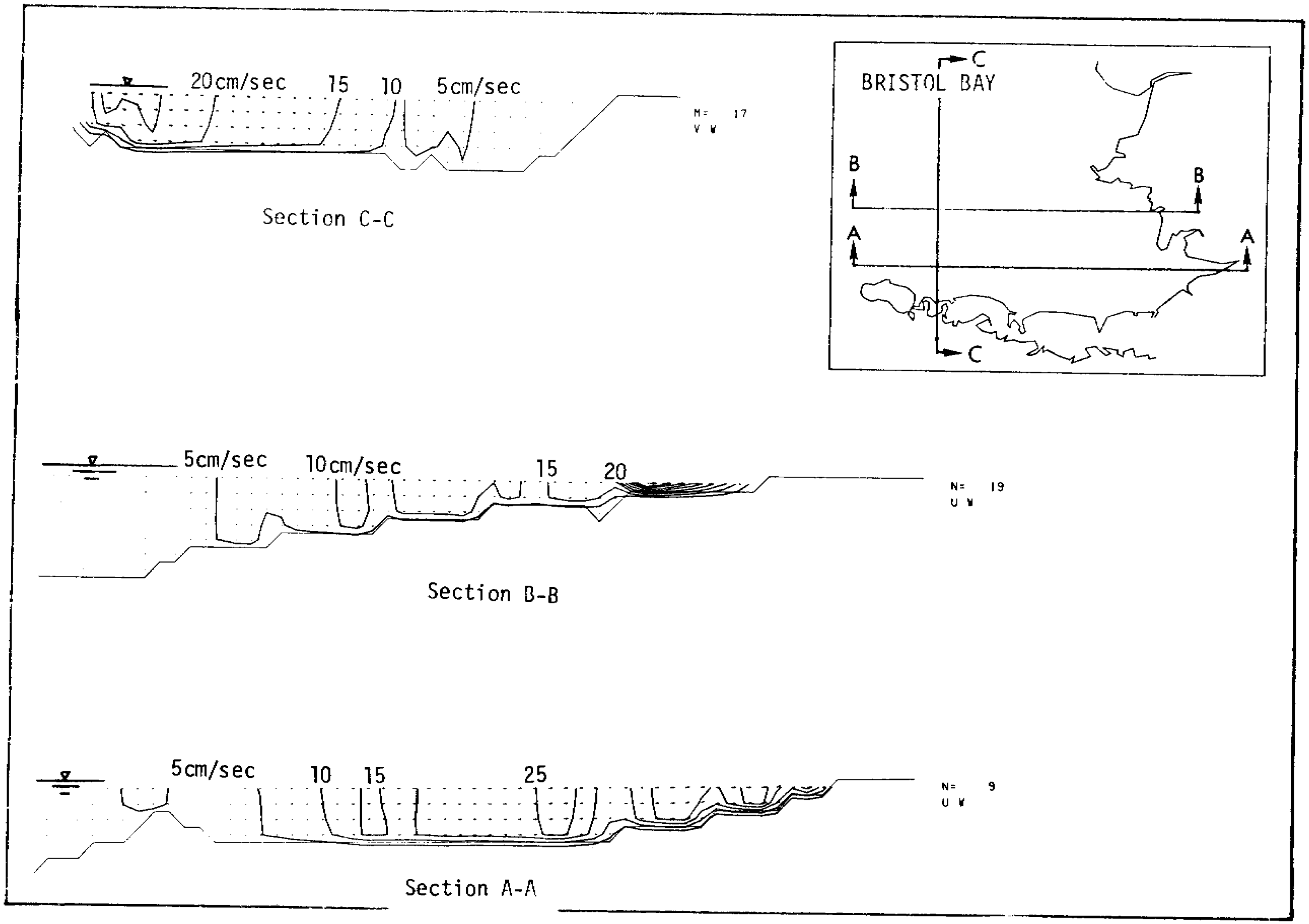


Fig. 23—Computed distribution of currents in three representative profiles through the Bristol Bay model

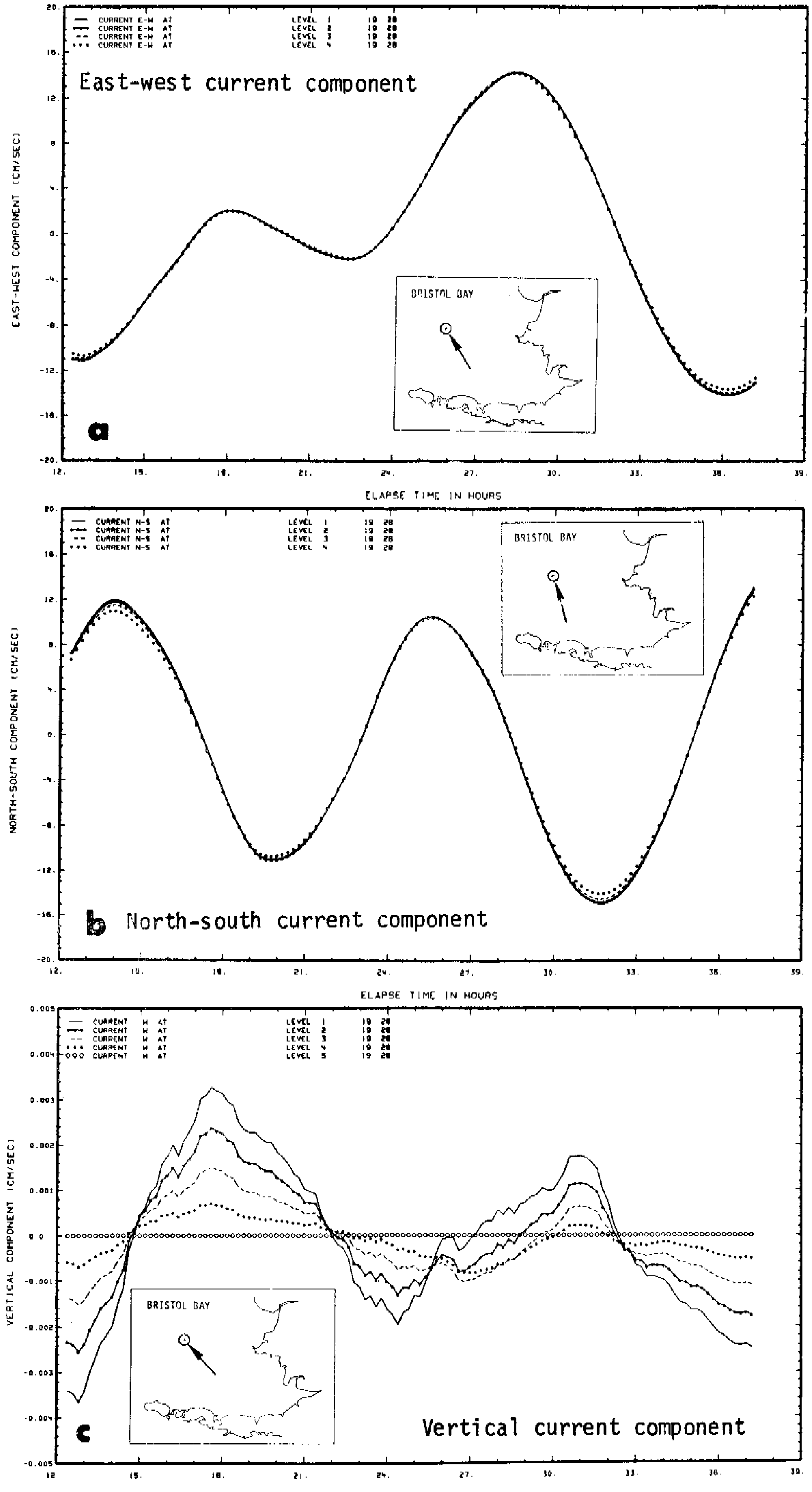


Fig. 24--Time histories of computed current components at a particular location in the Bristol Bay model, showing semidiurnal dominance.

the currents appear to be semidiurnal in both directions (Figs. 25a,b,c).

The computational results from this group of tide data are presented in Appendix A in graphical form, covering a simulation period of approximately 12.4 hours after an initial run-in time of a lunar day (25 hours). The total simulation covers a real time of 37.2 hours, with an integration time step equaling 2 minutes. Other important parameters used in the simulation are listed in Table A-1. The selected water level and current stations in the Bristol Bay model are listed in Table A-2. In this table, the grid location in the model, together with the National Ocean Survey's station designation, if applicable, are given.

During the initial adjustment period for the tidal computation, wind speed for the majority of the simulation tests was assumed to be zero.

During the first year of our investigation simulations made with the Norton Sound model were somewhat limited due to the lack of the required boundary information. However, a sequence of runs was made for model setup and for testing the graphical system. Figure 26 shows the graphical output of the Norton Sound model, illustrating isocontours of water levels, rise and fall of the water surface, and currents in the top layer at a particular time in a simulation run. During this run, water levels at open boundaries are specified according to the rough estimates from the tide table.

Subsequent to the tests described above, a simulation was made with the Bristol Bay model, but now with the initial temperature and salinity described in Figs. 13 through 16. The simulation did not appear to present any computational problems. The results of this simulation are now being processed.

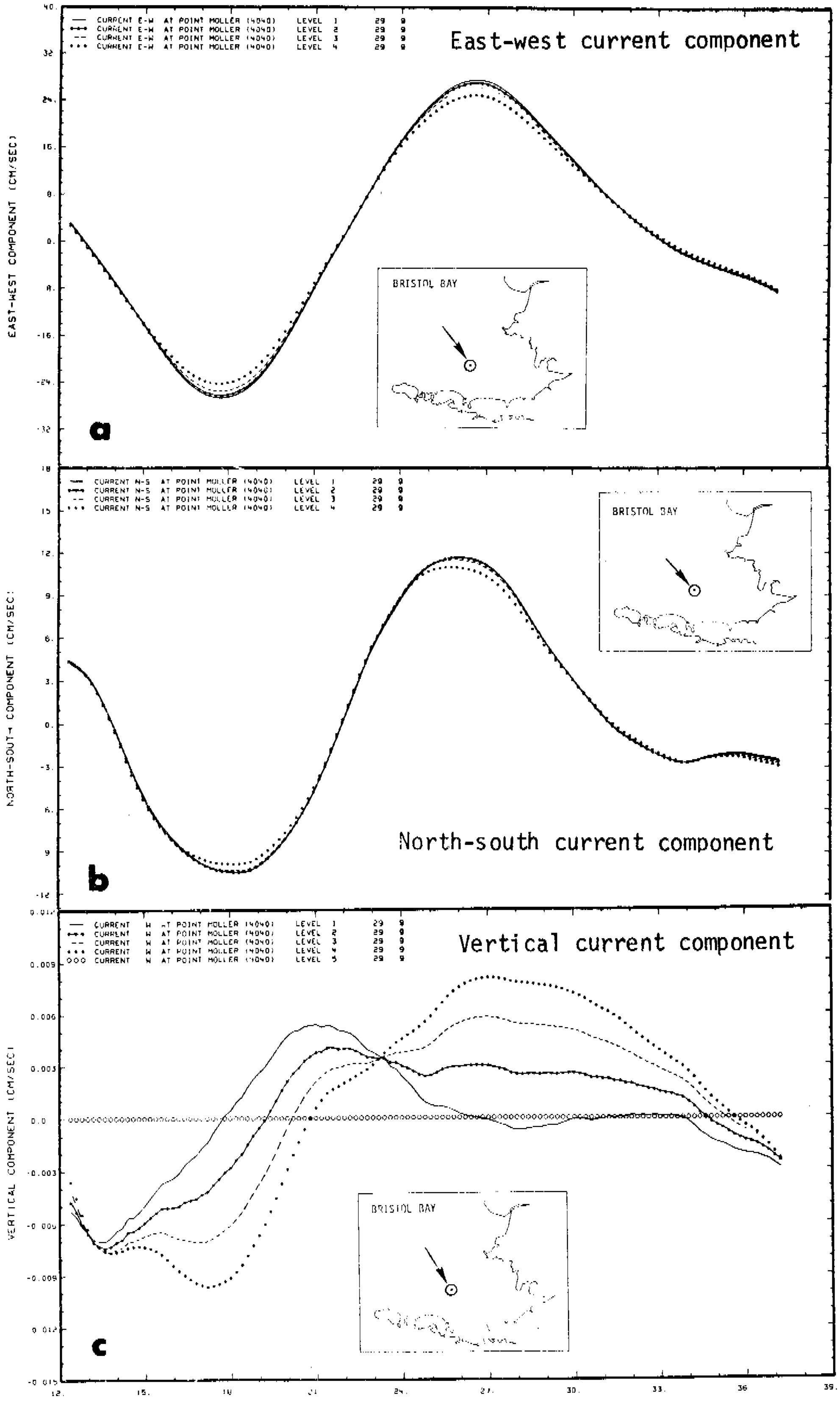


Fig. 25--Time histories of computed current components at a particular location in the Bristol Bay model, showing diurnal dominance

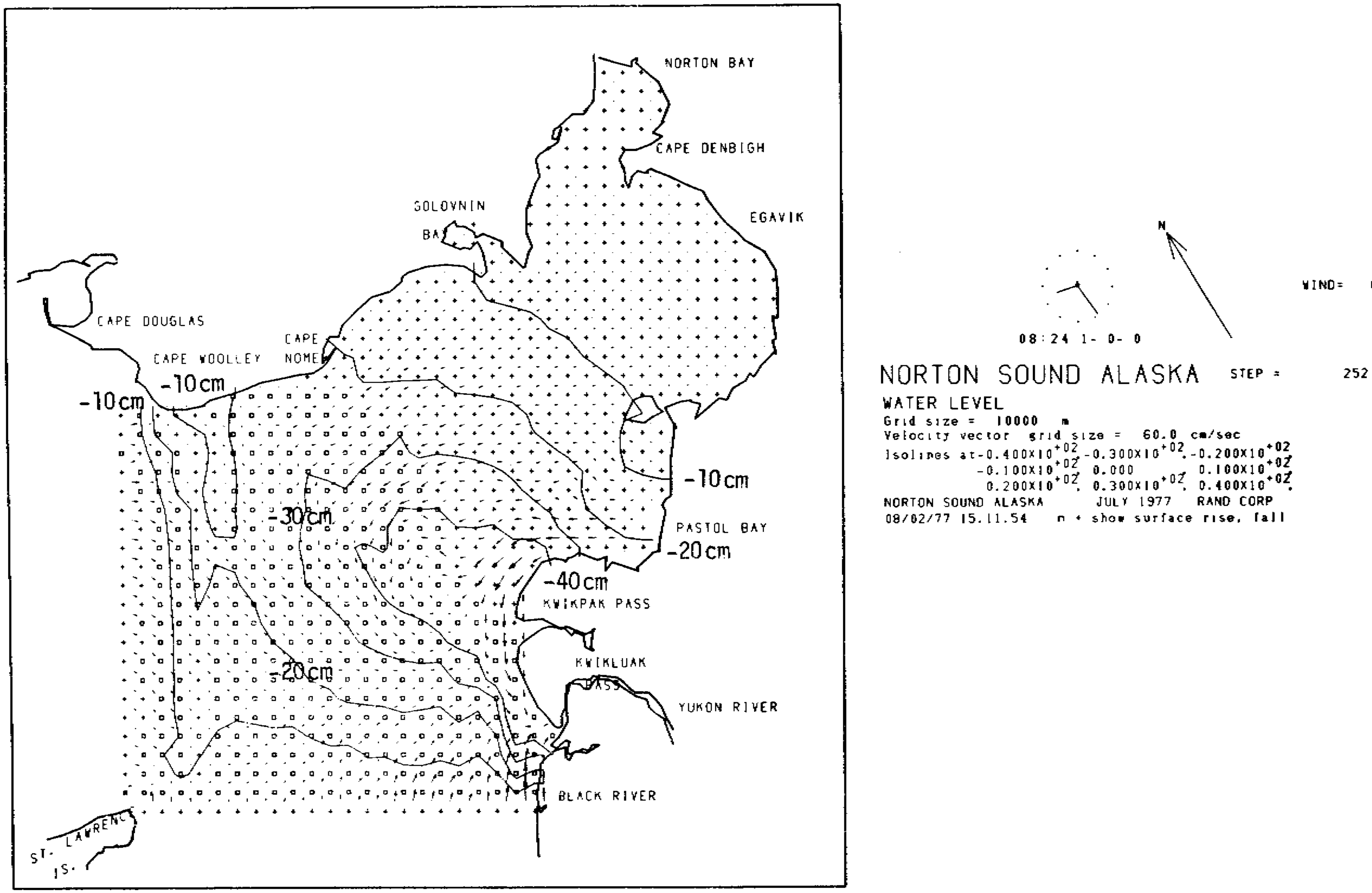


Fig. 26--Graphical output of the Norton Sound model showing isocontours of water levels, rise and fall of the water surface and currents in the top layer at a particular time in a simulation

VI. DISCUSSION

A. MATHEMATICAL FORMULATION AND PROGRAMMING SYSTEM

The use of the Richardson number dependency of the vertical exchange coefficient could have been introduced in a somewhat different manner. The objection we presently have to the method of turbulence closure is that the energy generation is independent of the vertical density gradient. If vertical density gradients are present, then the vertical momentum exchange becomes smaller as the turbulence intensity is suppressed. Also in that case, less energy is taken out of the mean flow system. Thus the generation term in the subgridscale energy equation should also contain a Richardson number dependency like the vertical momentum mass and energy exchange terms. If the generation term has this dependency, the system is more consistent. We are now generating too much subgridscale energy when gradients are present.

If this change is introduced, the movements of lighter and denser layers will become less coupled, and when strong gradients are present it can be expected that the effect of a strong wind field will take much time to penetrate into the lower layers.

The closure problem at the bottom layer could possibly also have been handled more elegantly. Presently the energy taken out of the mean flow system is determined only from the local velocity intensity. Naturally, here also the turbulence intensity has influence on the rate that energy is taken out of the mean flow system and the dissipation term in the momentum equation of the bottom layer could probably better contain a product of the square root of the local energy times the velocity. The generation term in the subgridscale energy at the bottom should then contain also the square root of the local energy, similar to the generation term at the interface between the layers (Eq. 27).

The two-dimensional turbulence could also be represented by energy. This two-dimensional horizontal turbulence system can also have considerable memory, which is now not considered. We do not plan to introduce this at the present time.

As will be noted from the illustrations in this Working Note, the basic elements of graphical representation of model results are now available. In addition to the programs for charting of computed spatial fields such as water levels and currents, many of the computed functions at a particular location can be plotted against time. We have available a program to compute the spatial distribution of amplitudes and phases of the computed water level variations. To speed up our adjustment effort it is very desirable to have this data plotted in co-tidal charts. In the next phase of the addition of our spatial plotting routine to this program this will have a high priority.

Since we are computing velocities and water levels, it is possible to compute the net water transport in a certain direction. This net transport is not necessarily in the same direction as the mean velocity.

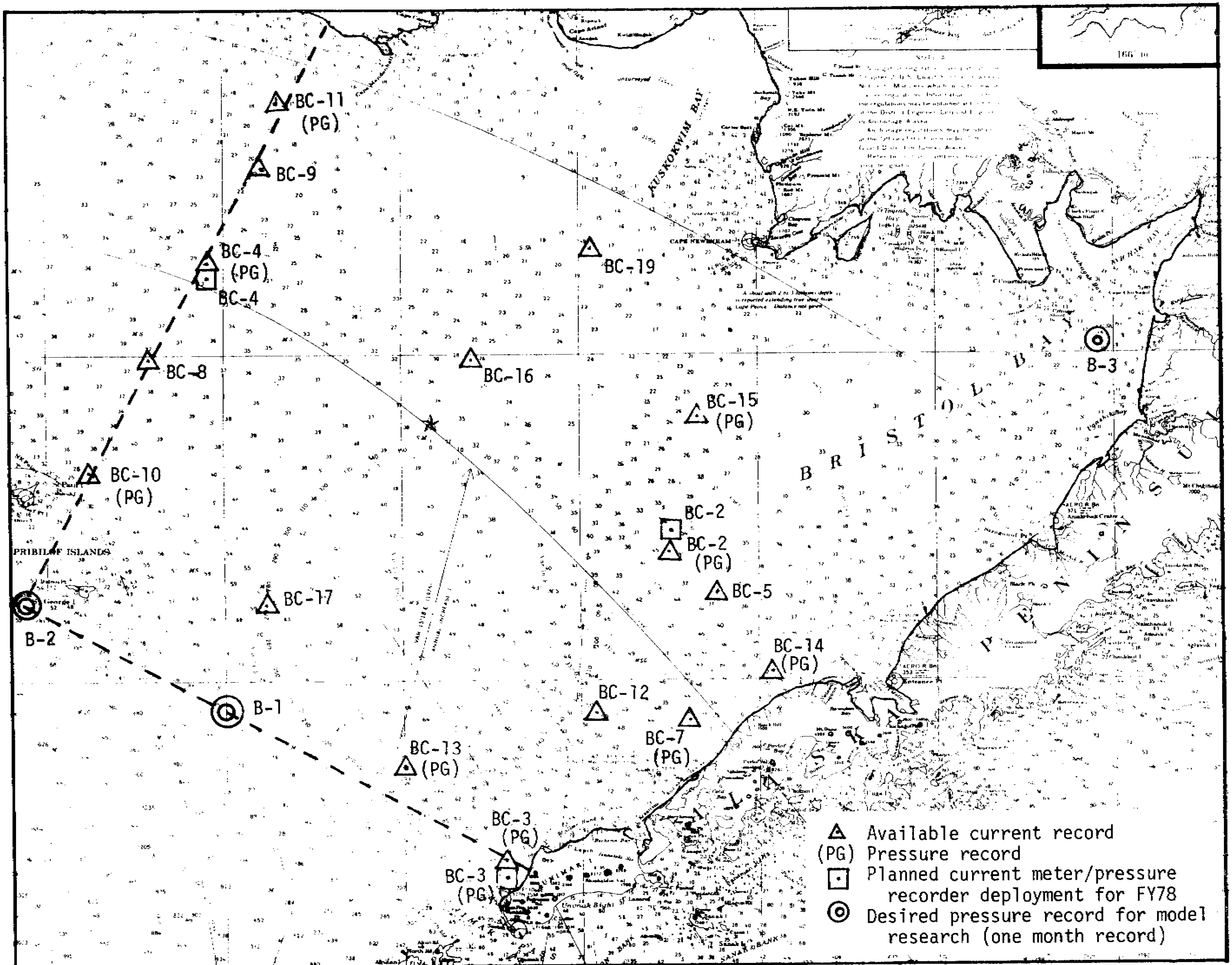
B. BRISTOL BAY MODEL

From the experiments so far we have obtained a good understanding of the behavior of the tidal flow in the system. Also, the bottom friction term which we have been using in the last run is getting close to the final value. Several runs were made before the one presented in this report, so we have a feeling as to subsequent changes which have to be made.

When we started the modeling effort, very limited data were available, and the model was laid out according to the insights at that time. From the field data, as well as from our short simulation experiments, we conclude that the major problem is along the northwestern boundary. This boundary intersects an amphidromic point of one of the major tidal components. Consequently, on this boundary intersection large variations in tidal components occur which were approximated sectionwise by linear interpolation of amplitudes and phases. In addition, no data are available at Cape Avinof.

The southwestern boundary did not give any particular problems, as the magnitudes of the components are much smaller and variations in amplitude and phase are much smaller than along the northwestern boundary.

For the continuation of our studies with this model configuration we would need preferably simultaneously observed data along both boundaries. Reviewing now our data needs at the request of the Project Manager, and in view of our simulation results, we have come to the conclusion that it would be much more advantageous to realign the model as shown in Fig. 27. In that way we would take full advantage of data obtained recently from the range of pressure gages



... of the Bristol Bay model with current and pressure record stations and current meters between the Pribilof Islands and Nunivak Island.

On the southwestern boundary pressure data is also available from a station (BC-3) near Unimak Island, but near the westernmost corner of the model the data has to be estimated from records from BC-10 and historical records of the Pribilof Islands pressure gage. Fortunately, the co-tidal charts of the main tide components (K1,M2) show that the spatial variations in amplitude and phase are small. Nevertheless, it would be very advantageous if field data from pressure gages would become available next year to confirm our estimates. We would like to have these two stations located as shown in Fig. 27.

For the adjustment of the model it would be very advantageous to have a pressure record near the end of Bristol Bay. The tidal amplification is considerable, and is highly dependent on the bottom resistance parameter.

Presently it is not clear to what extent simultaneous data from all pressure gages and current meters are available. Fortunately we now have considerable experience in "filling in" data gaps by cross-correlation of records obtained from other time intervals [9].

We are ready to make experiments with wind fields; the procedures for applying the wind effects have been tested on short simulation runs.

C. NORTON SOUND MODEL

From the few experiments we have made with the Norton Sound model we have evidence that the tidal movements are quite complicated. It is known that in certain parts of the bay the tides are predominantly diurnal, in other parts predominantly semidiurnal. Consequently, we can expect that the open boundary conditions may have considerable influence on the computed velocity and elevation fields.

The field data which will become available from this season's survey does not present sufficient data to drive the model to make meaningful simulations.

If in the next summer season data could be collected for this investigation, it would be preferable to extend the model (Fig. 28). The boundaries would be better defined, a larger area would be covered, and the computer memory allows us to maintain present grid size.

Five simultaneous pressure records would be required in addition to the instrumentation planned for FY78. Four of these gages would determine the ends of the boundary, and the fifth pressure reading station would be used for the adjustment of the bottom friction parameter in the eastern part of Norton Sound (Fig. 28). With these boundaries, maximum use would be made of the planned deployment of pressure gages and current meters.

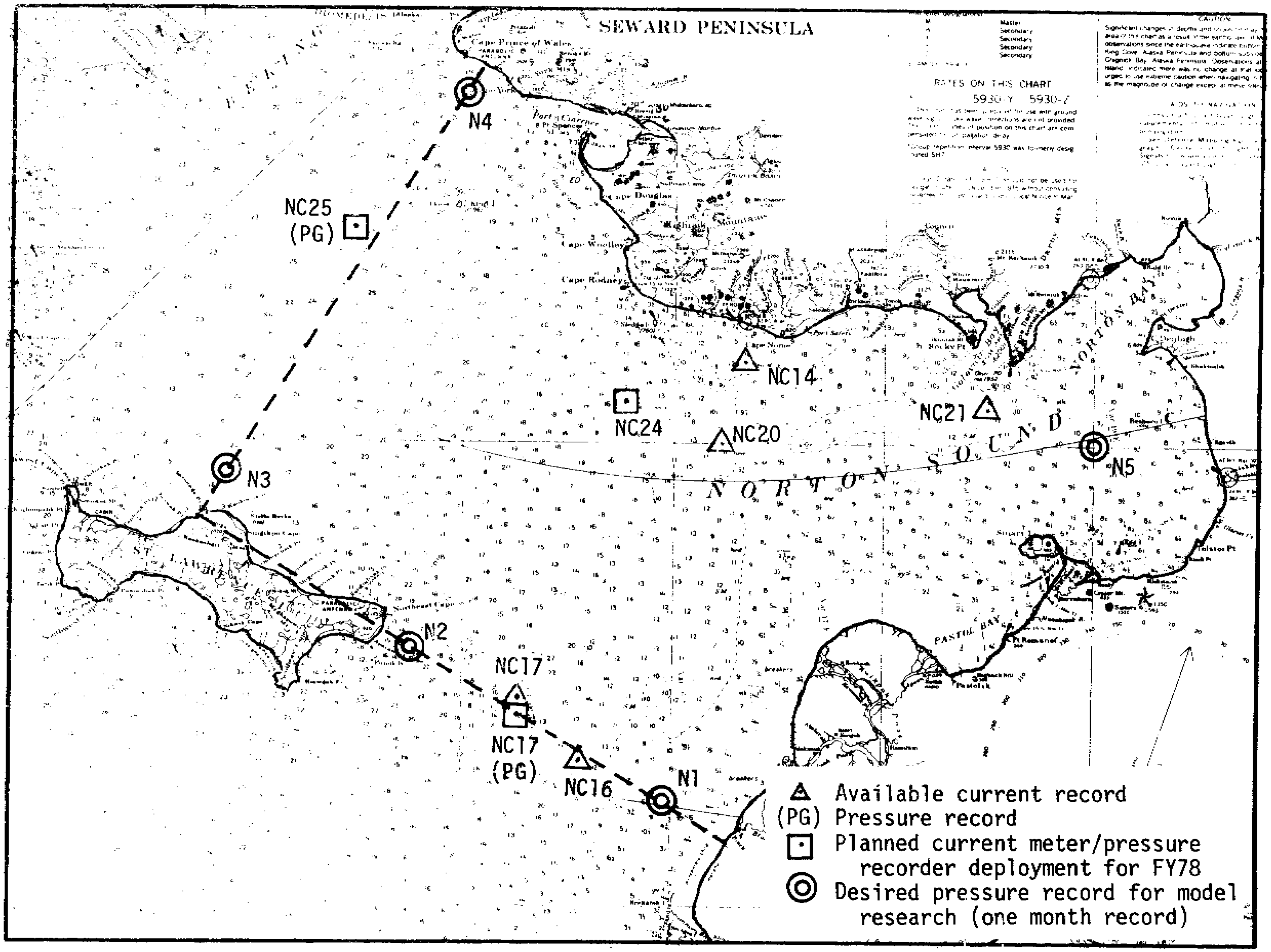


Fig. 28--Revised layout of the Norton Sound model with current and pressure record stations

VII. CONCLUSIONS AND RECOMMENDATIONS

With the model of Bristol Bay described in this report the water movement and water level variations due to tides and wind can be computed after further adjustment of the model.

From the model experiments of Bristol Bay, it appears advantageous to realign the model with the new layout shown in Fig. 27. The most effective use can then be made of data collected up to now. The modeling effort would be enhanced considerably if pressure data from two stations near the Pribilof Islands and from a station near the eastern end of Bristol Bay could become available. We recommend that simultaneously with deployment of the gaging stations in FY78, two pressure gage records be obtained during one month near the Pribilof Islands, as shown in Fig. 27.

With data which have been collected up to now in the OCSEAP project, and the data planned for FY78, there is still insufficient data available for meaningful modeling of Norton Sound. However, if five simultaneous pressure records can be obtained during one month, together with the already planned deployment of current meters and pressure gages, an effective modeling effort can be executed.

We recommend that these five records be obtained. The location of the five stations are indicated in Fig. 28, and listed in Table 1.

Table 1

OBSERVATION STATIONS REQUIRED FOR BRISTOL BAY AND NORTON SOUND MODELS

Station Number	Type	Location	Latitude	Longitude
B1*	Pressure	Bristol Bay	168°00'	55°50'
B2*	Pressure	Bristol Bay	170°37'	56°39'
B3*	Pressure	Bristol Bay	158°12'	58°07'
N1**	Pressure	Norton Sound	166°07'	62°25'
N2**	Pressure	Norton Sound	168°30'	63°07'
N3**	Pressure	Norton Sound	170°10'	63°53'
N4**	Pressure	Norton Sound	168°00'	66°23'
N5**	Pressure	Norton Sound	162°00'	64°00'

* Simultaneous deployment for one month during June 1978.
** Simultaneous deployment for one month during July 1978.

Appendix A

SIMULATION RESULTS AND PARAMETERS USED IN THE BRISTOL BAY MODEL

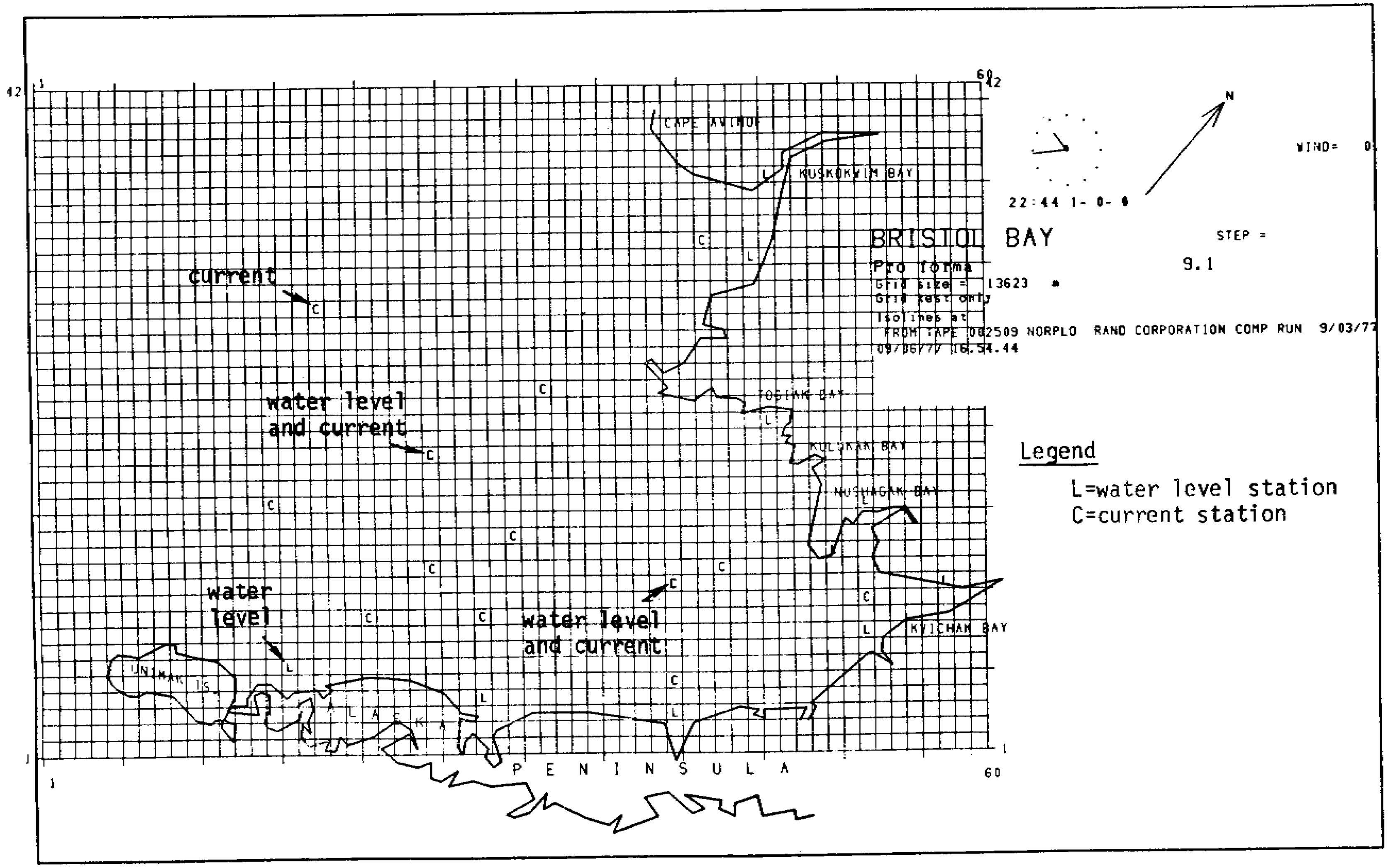


Fig. A-1--Horizontal schematization and the locations of water level and current stations in the Bristol Bay model

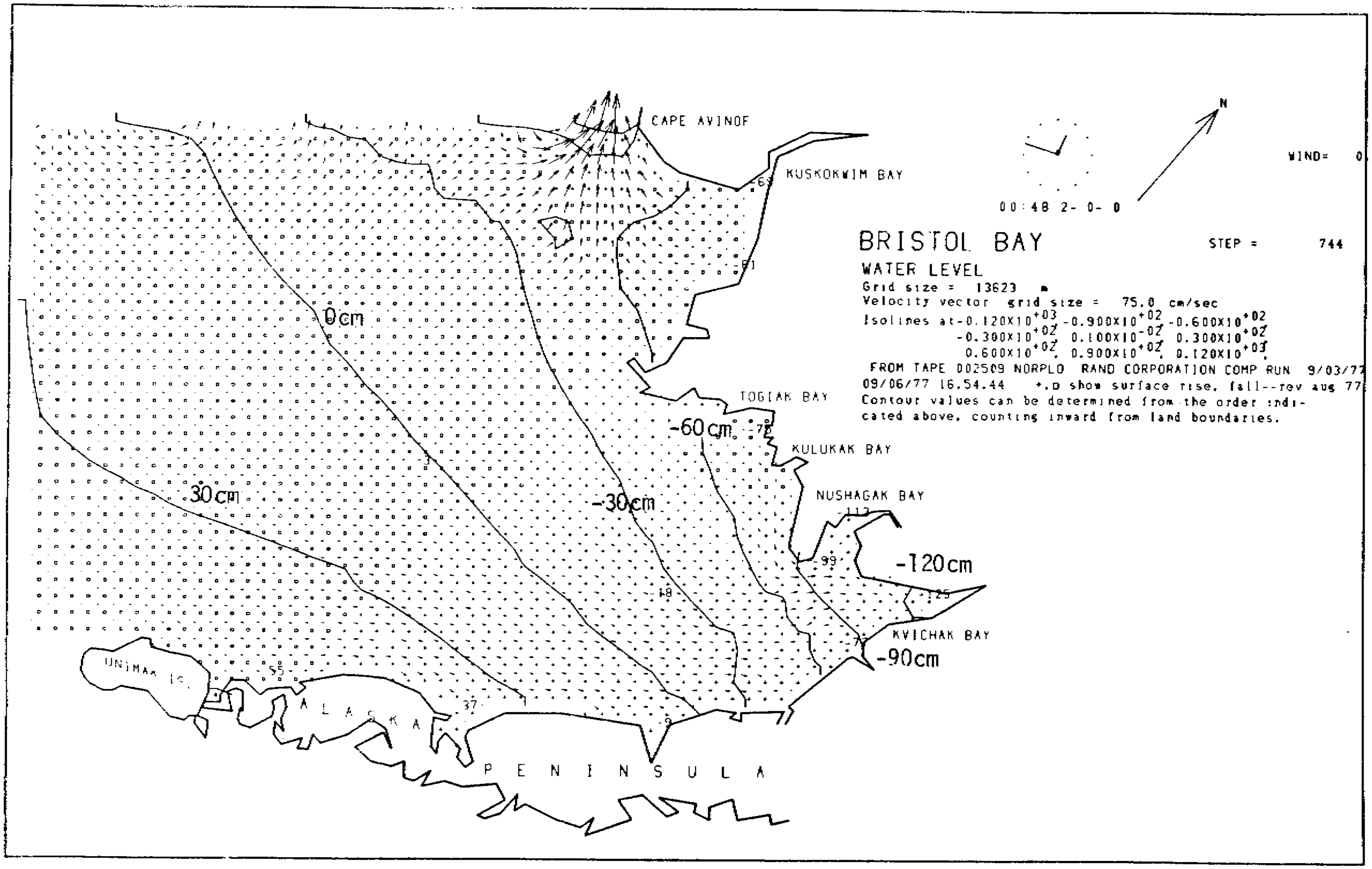


Fig. A-2--Graphical output of the Bristol Bay model, showing isocontours of water levels, rise and fall of the water surface and current in the top layer at 24 hr, 48 min after the beginning of the simulation

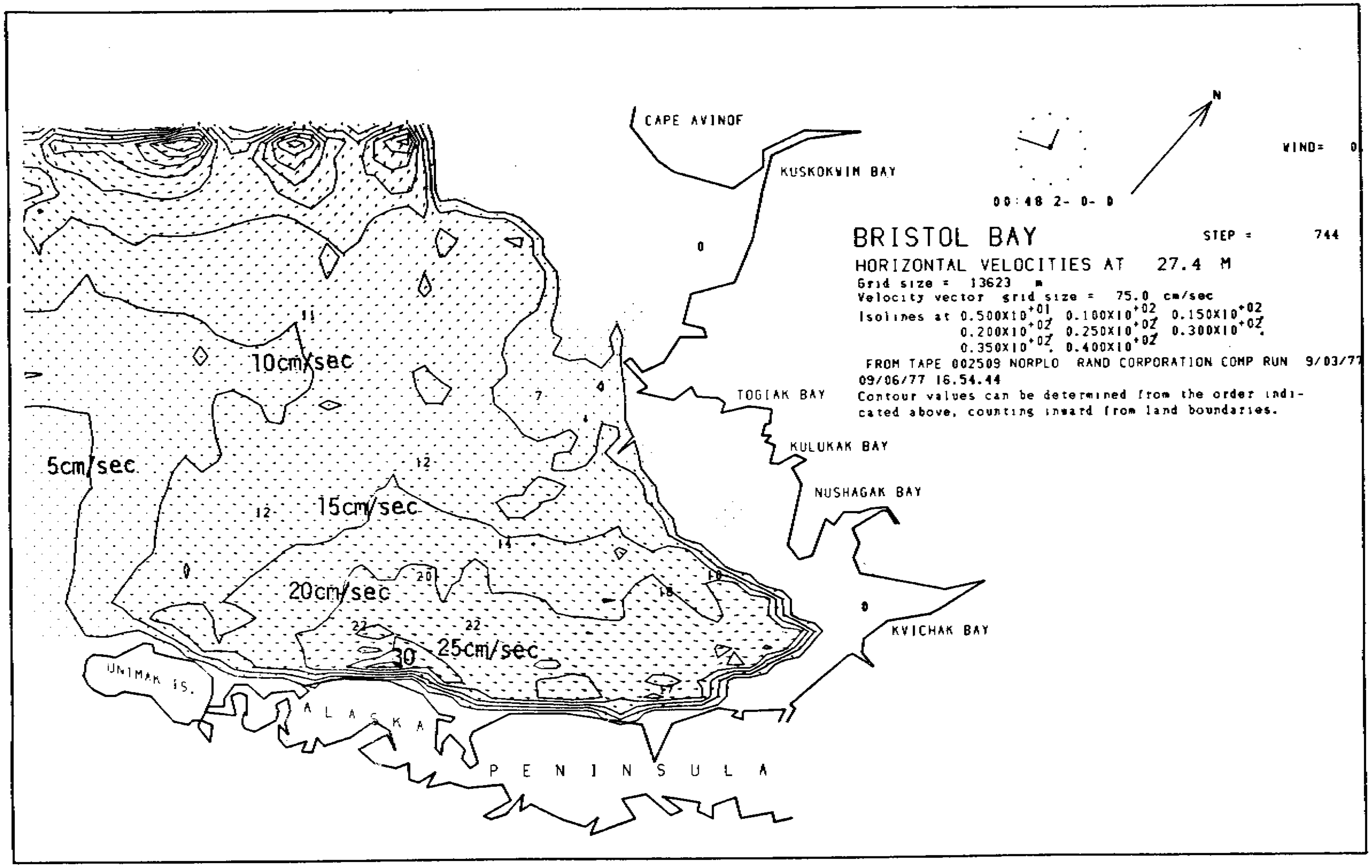


Fig. A-3--Graphical output of the Bristol Bay model, showing horizontal current pattern and the isocontours of velocity 27.4 meters below the reference level at 24 hr, 48 min after the beginning of the simulation

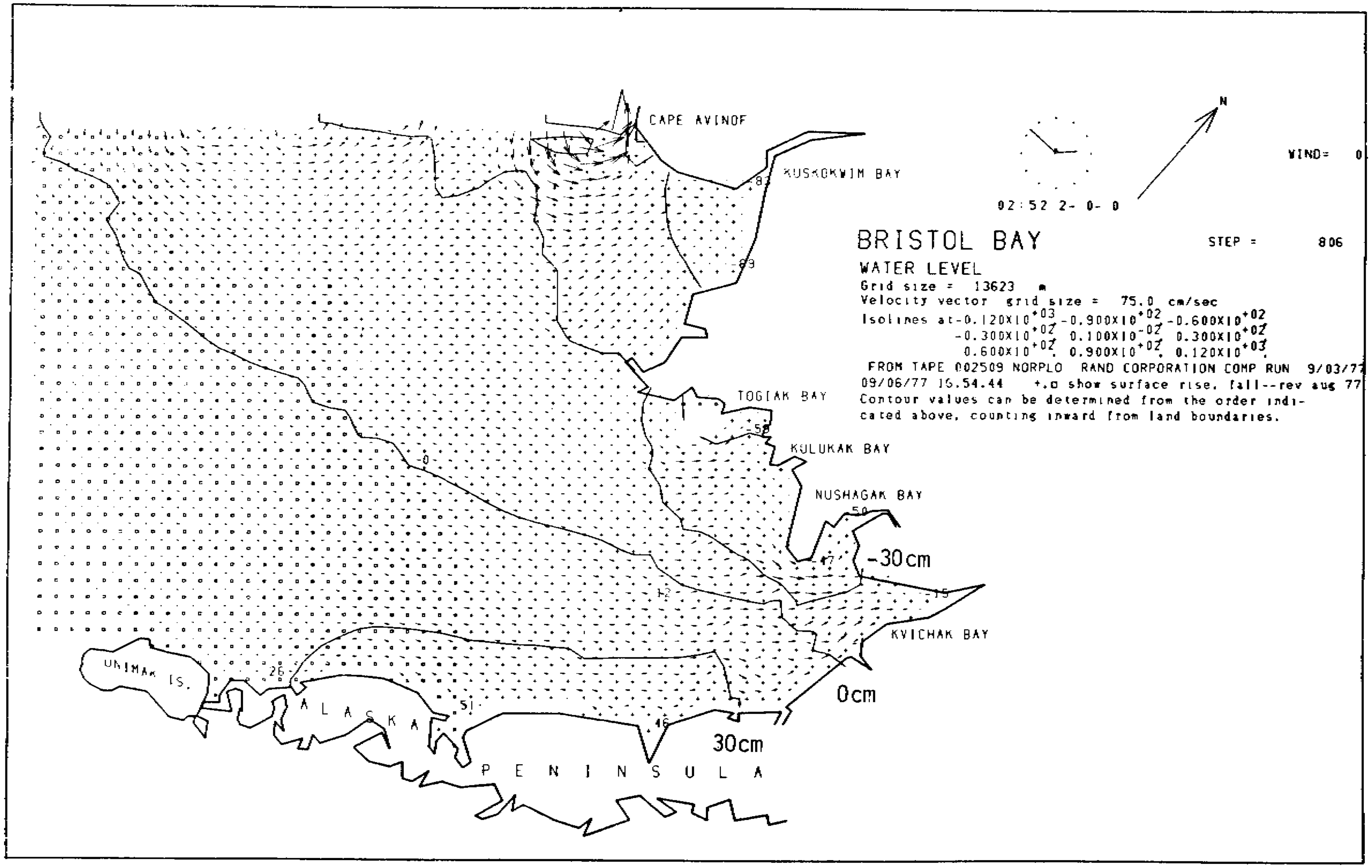


Fig. A-4--Graphical output of the Bristol Bay model, showing isocontours of water levels, rise and fall of water surface and current in the top layer at 26 hr, 52 min after the beginning of the simulation

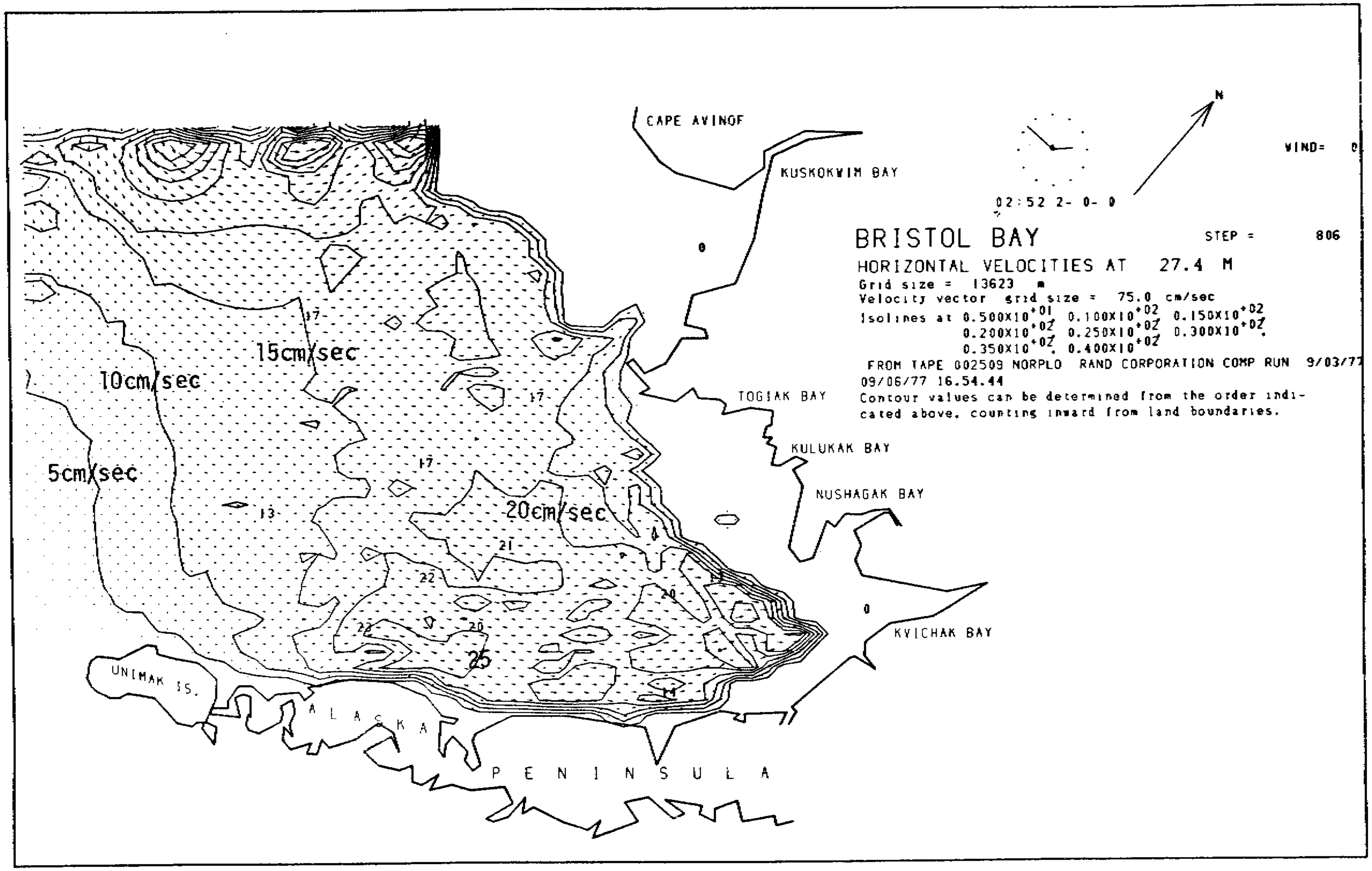


Fig. A-5--Graphical output of the Bristol Bay model, showing horizontal current pattern and isocontours of velocity 27.4 meters below the reference level at 26 hr, 52 min after the beginning of the simulation

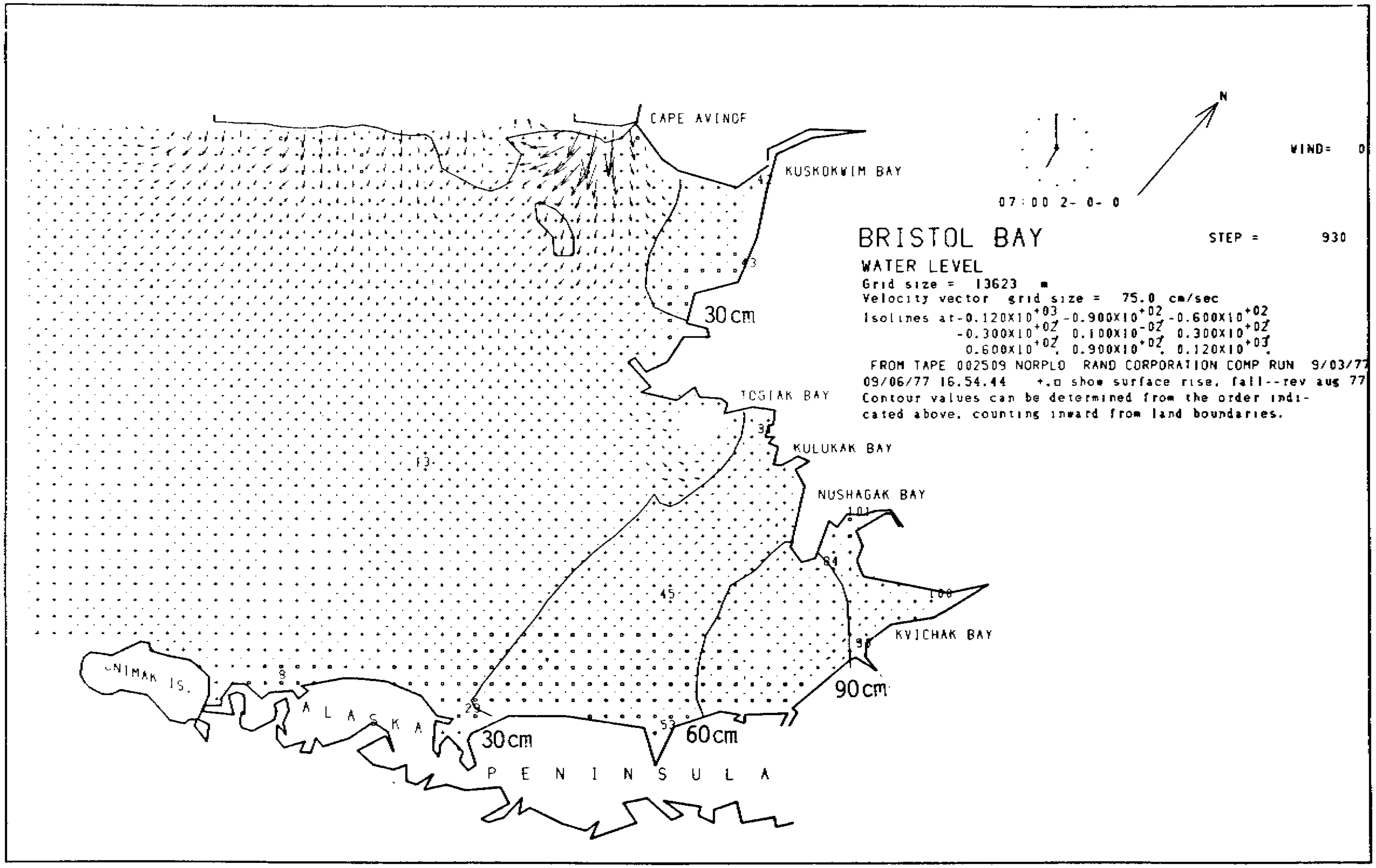


Fig. A-6--Graphical output of the Bristol Bay model, showing the isocontours of water level, rise and fall of water surface and current in the top layer at 31 hr after the beginning of the simulation

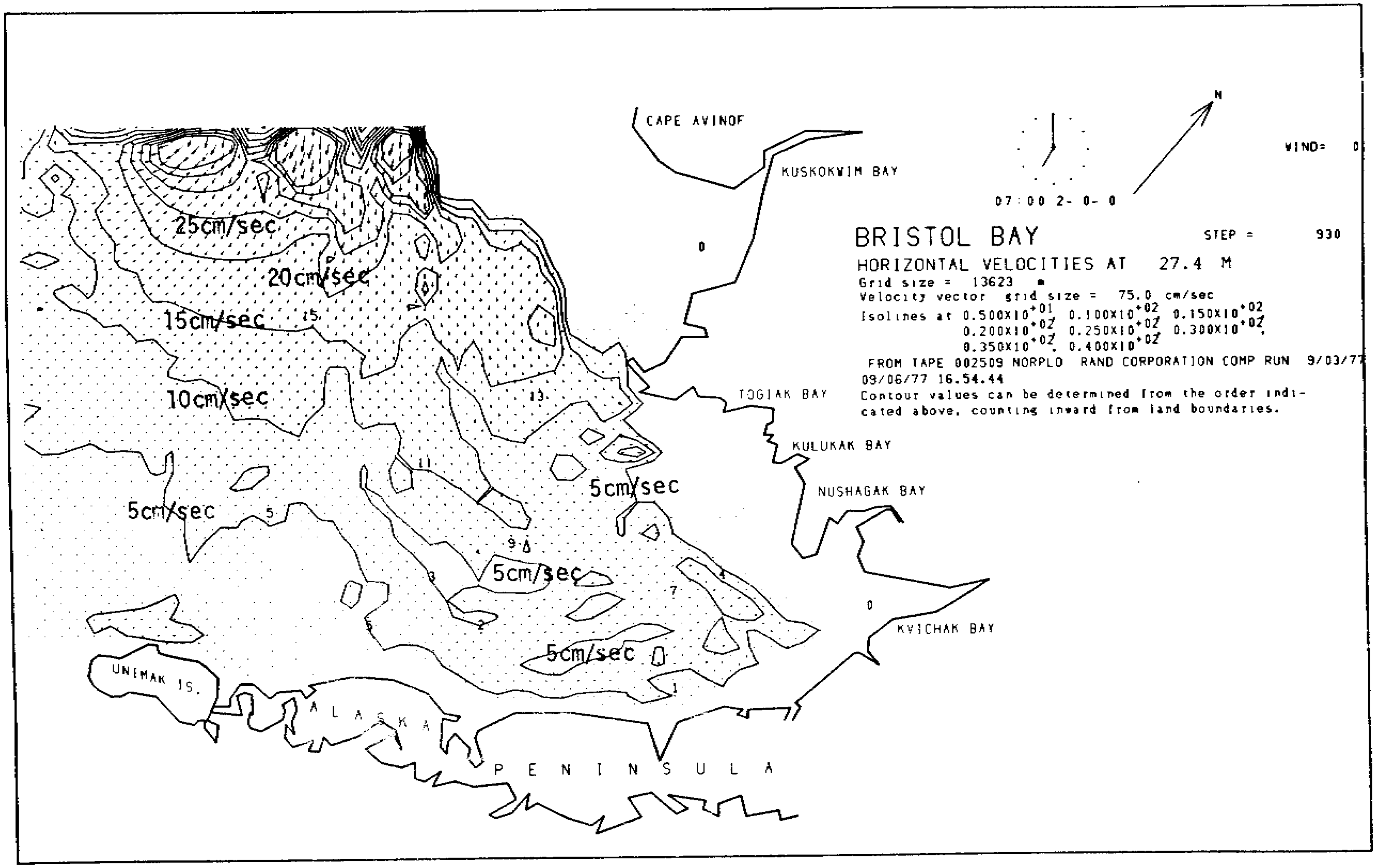


Fig. A-7--Graphical output of the Bristol Bay model, showing horizontal current pattern and isocontours of velocity 27.4 meters below the reference level at 31 hr after the beginning of the simulation

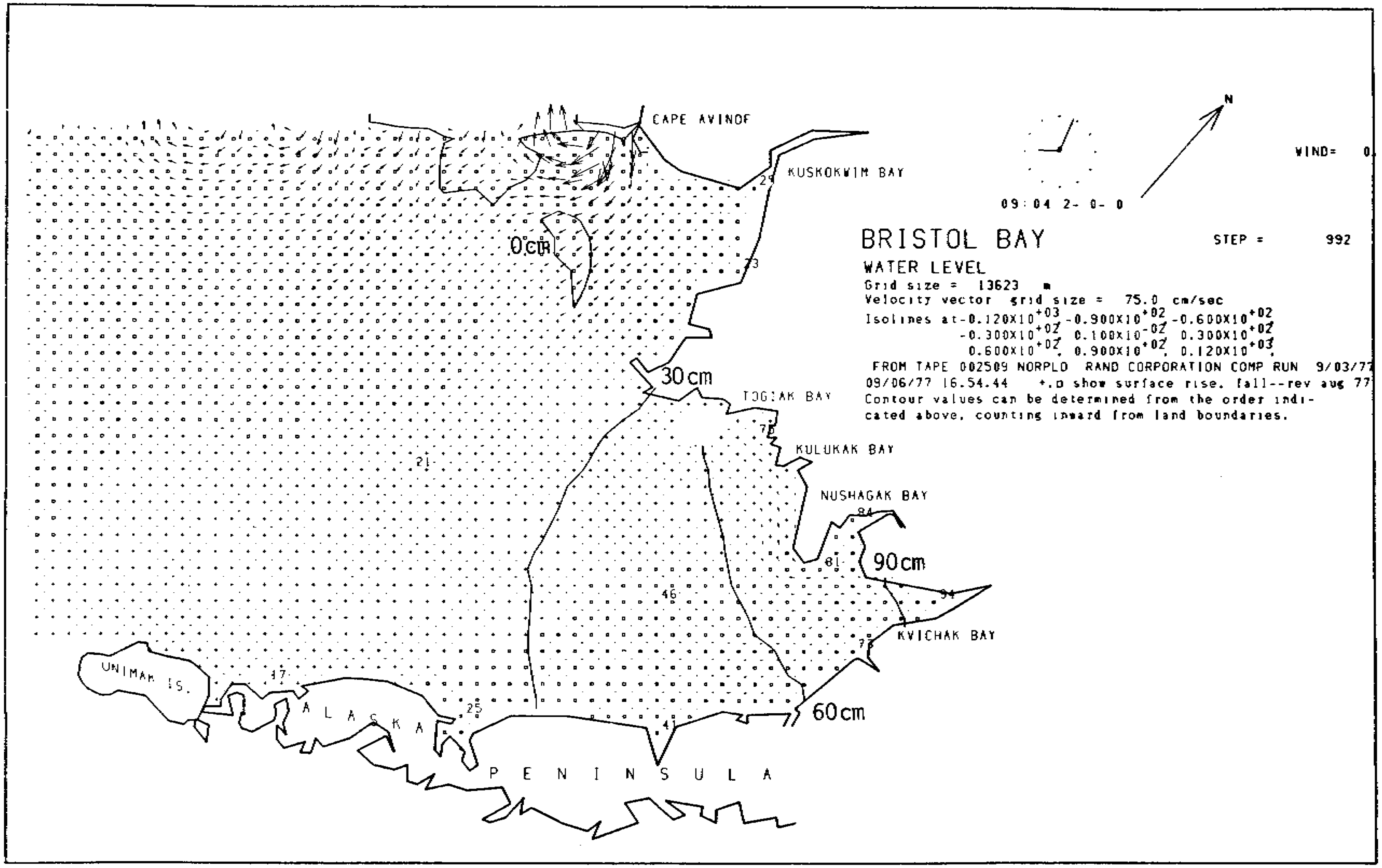


Fig. A-8--Graphical output of the Bristol Bay model, showing the isocontours of water level, rise and fall of water surface and current in the top layer 33 hr, 4 min after the beginning of the simulation

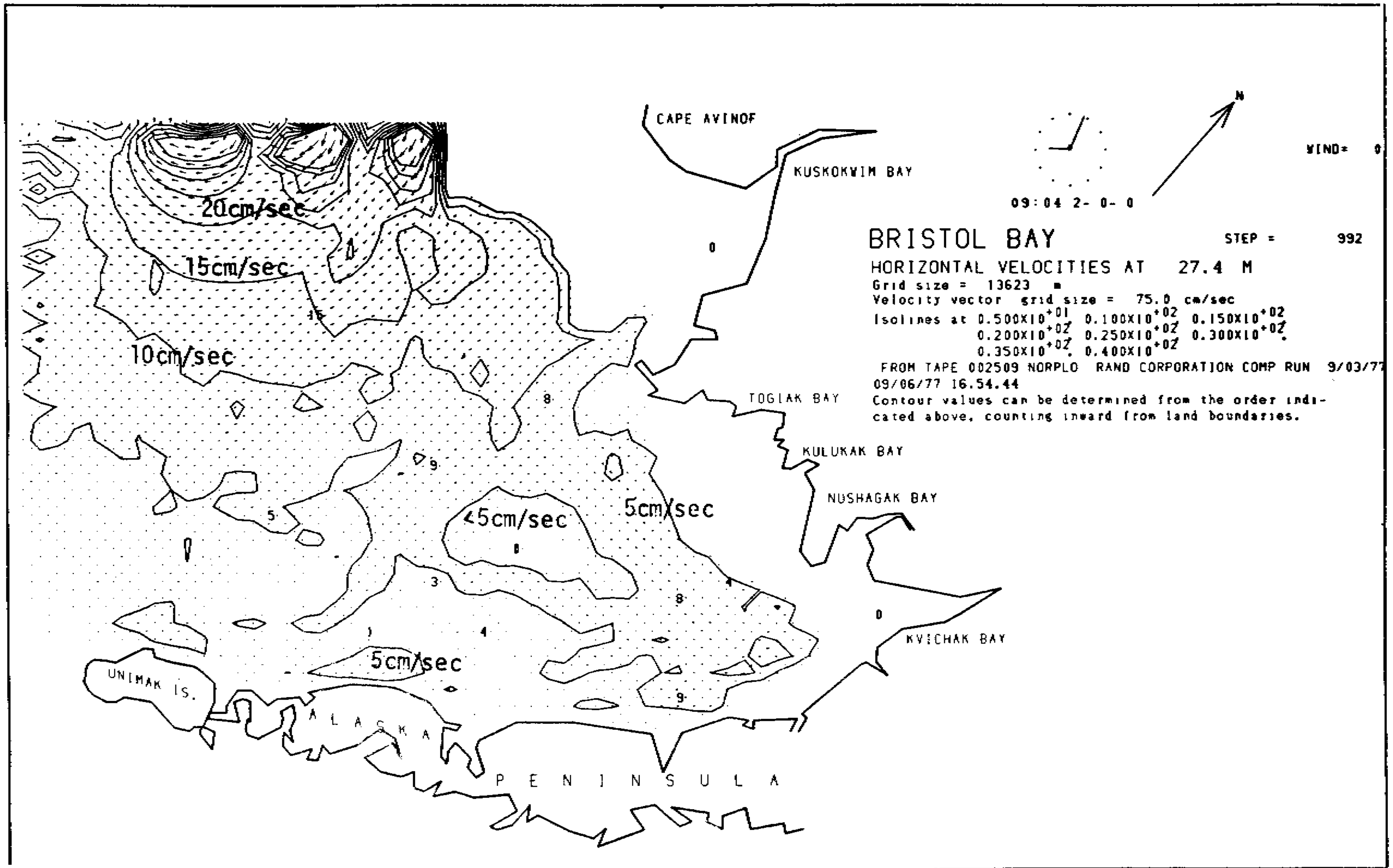


Fig. A-9--Graphical output of the Bristol Bay model, showing horizontal current pattern and isocontours of velocity 27.4 meters below the reference level at 33 hr, 4 min after the beginning of the simulation

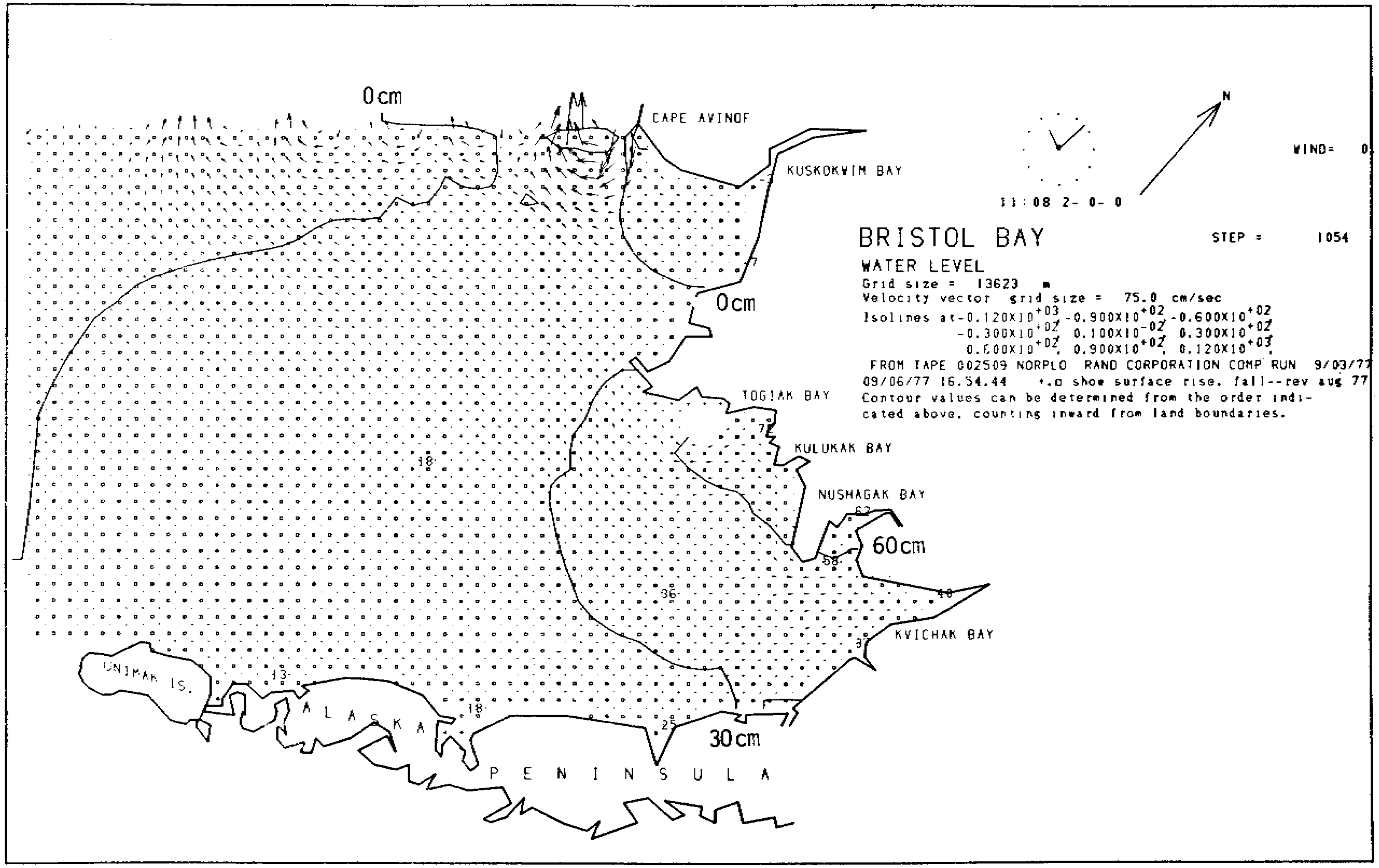


Fig. A-10--Graphical output of the Bristol Bay model, showing the isocontours of water level, rise and fall of water surface and current in the top layer 35 hr, 8 min after the beginning of the simulation

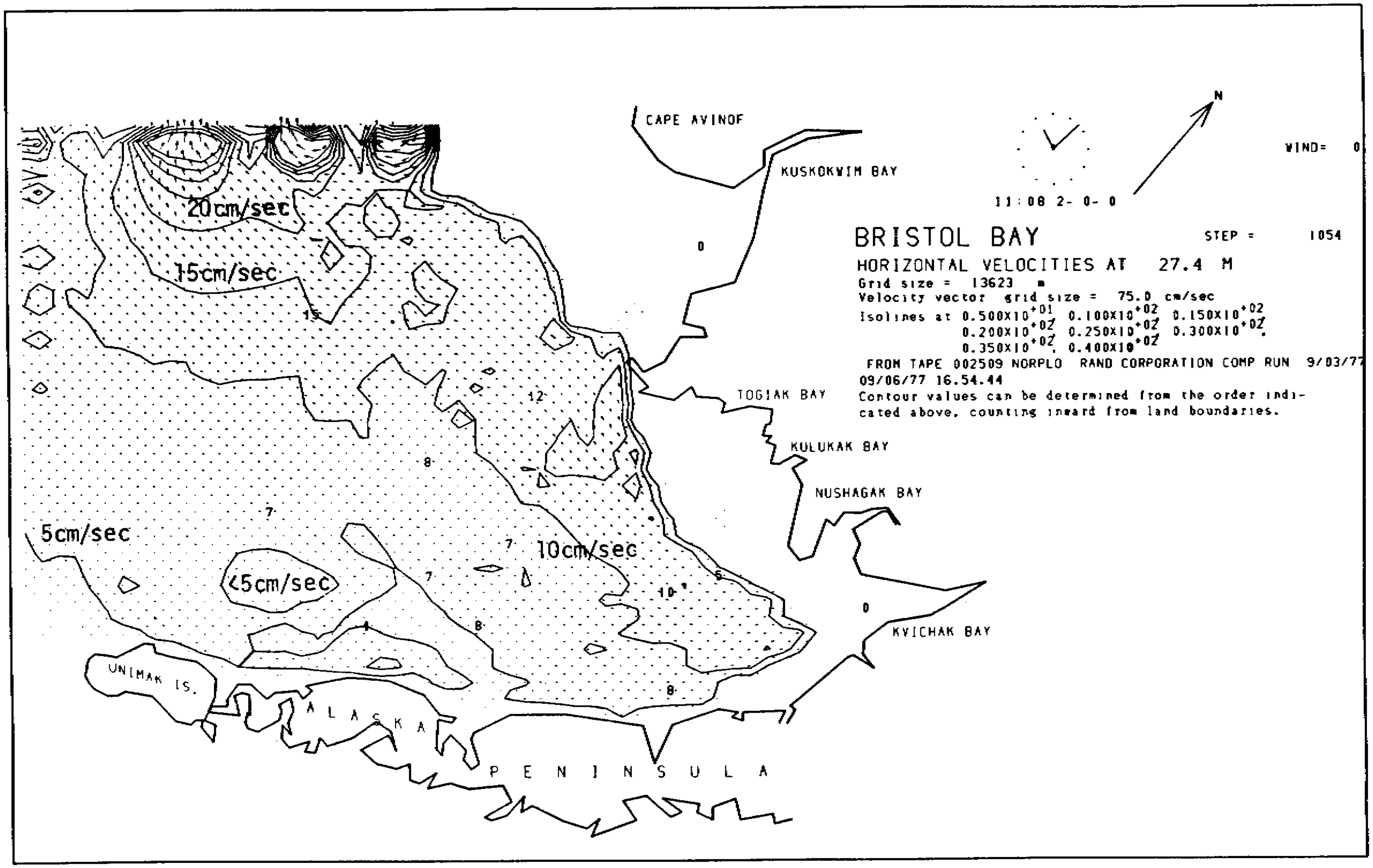


Fig. A-11--Graphical output of the Bristol Bay model, showing the horizontal current pattern and isocontours of velocity 27.4 meters below the reference level at 35 hr, 8 min after the beginning of the simulation

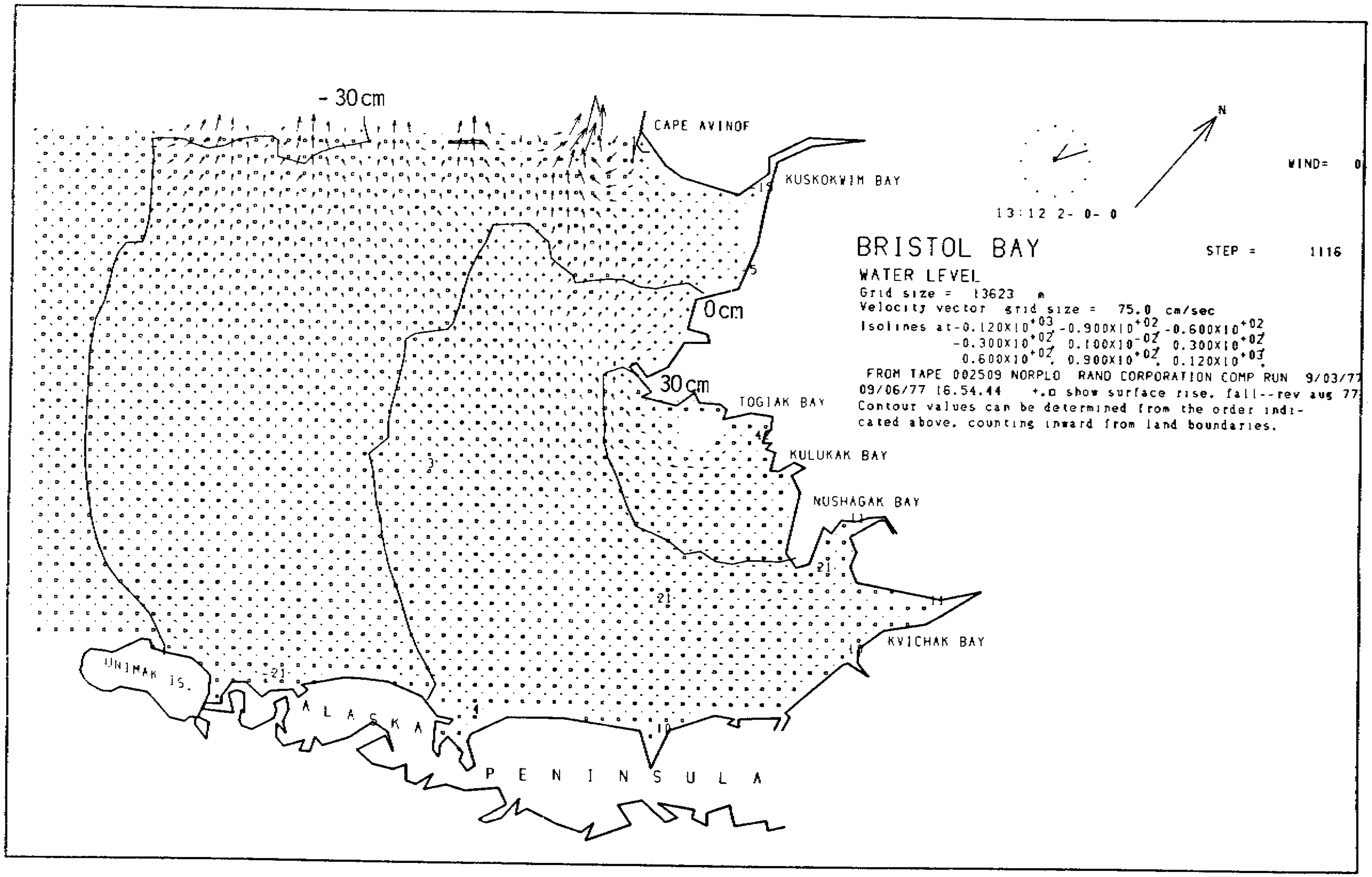


Fig. A-12--Graphical output of the Bristol Bay model, showing the isocontours of water level, rise and fall of water surface and current in the top layer, 37 hr, 12 min after the beginning of the simulation

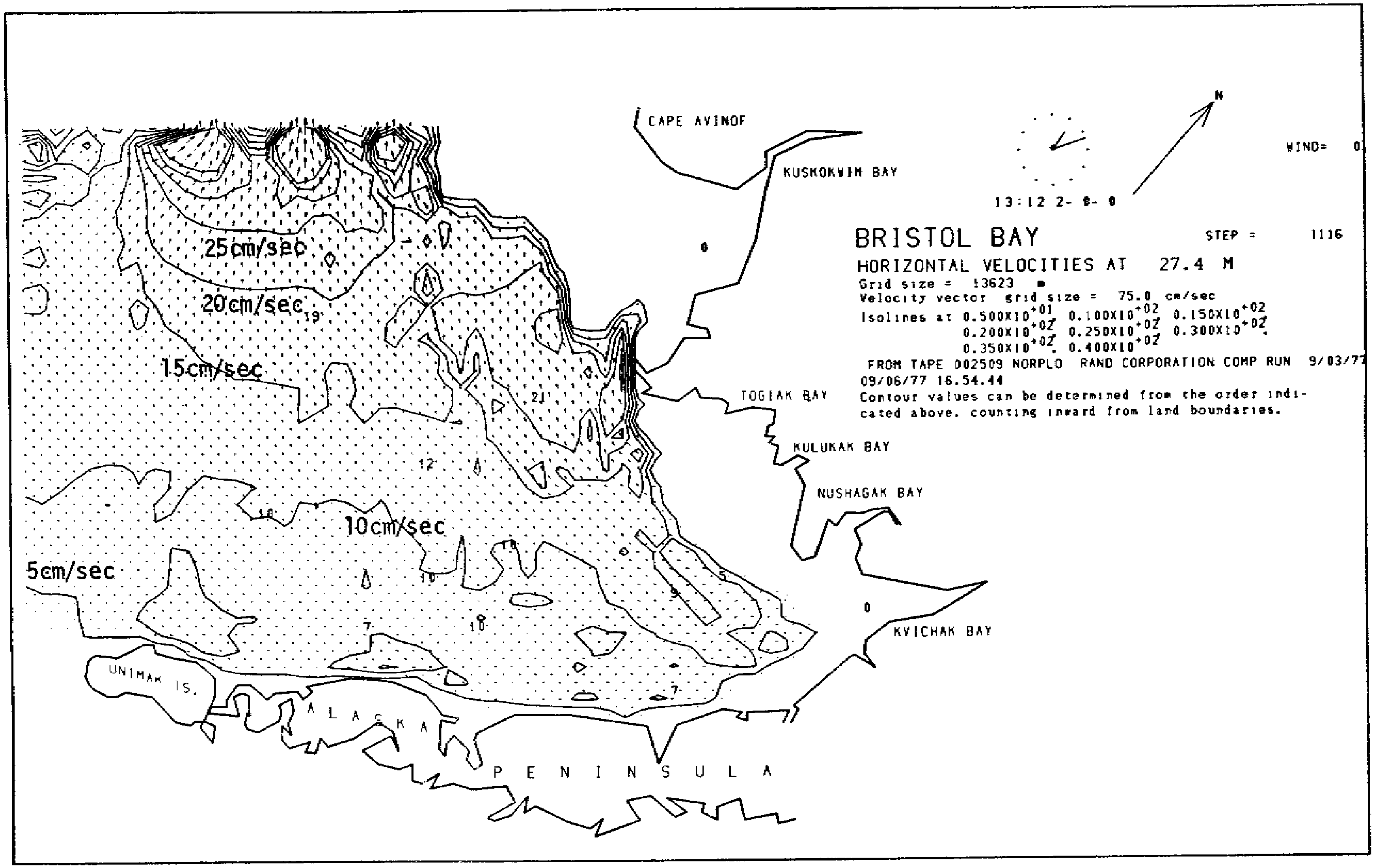


Fig. A-13--Graphical output of the Bristol Bay model, showing the horizontal current pattern and isocontours of velocity 27.4 meters below the reference level at 37 hr, 12 min after the beginning of the simulation

Table A-1

PARAMETERS USED IN THE BRISTOL BAY SIMULATION

Item	Parameter
Number of horizontal grid points	60 x 42
Maximum number of layers	7
Integration time step	120 seconds
Horizontal grid size	13.6 km
Vertical grid size	10 fathoms
Fixed portion of the horizontal momentum and contituent diffusion coefficient	10^7
Bottom shear stress coefficient (Chezy's coefficient)	800 $cm^{\frac{1}{2}}$/sec
Initial value of salinity	32 gr/l
Initial value of temperature	5 degrees C

Table A-2

WATER LEVEL AND CURRENT STATIONS IN THE BRISTOL BAY MODEL

Grid Location M	N	Type	NOS Station Name or Other Designation	NOS Station Number if Applicable
17	6	Water level	Amok Island	2043
29	4	Water level	Point Moller	2047
41	3	Water level	Point Heiden	2048
53	8	Water level	Egegic River	2049
58	11	Water level	Kvichak Bay	2053
53	16	Water level	Nushagak	2071
47	21	Water level	Walrus Islands	2075
46	31	Water level	Carter Spit	2079
47	36	Water level	Warehouse Bluff	208
26	19	Water level	B9	--
41	11	Water level	B10	--
51	13	Water level	B8	--
22	9	Current	Cape Lieskof	4035
29	9	Current	Point Moller	4040
41	5	Current	Point Heiden	4065
53	10	Current	Kvichak Bay	4070
43	32	Current	Carter Bay	4120
26	19	Current	B9	--
41	11	Current	B10	--
26	12	Current	B11	--
33	23	Current	B12	--
16	16	Current	--	--
31	14	Current	--	--
44	12	Current	--	--
19	28	Current	--	--

Appendix B

SIMULATION RESULTS AND PARAMETERS USED IN THE NORTON SOUND MODEL

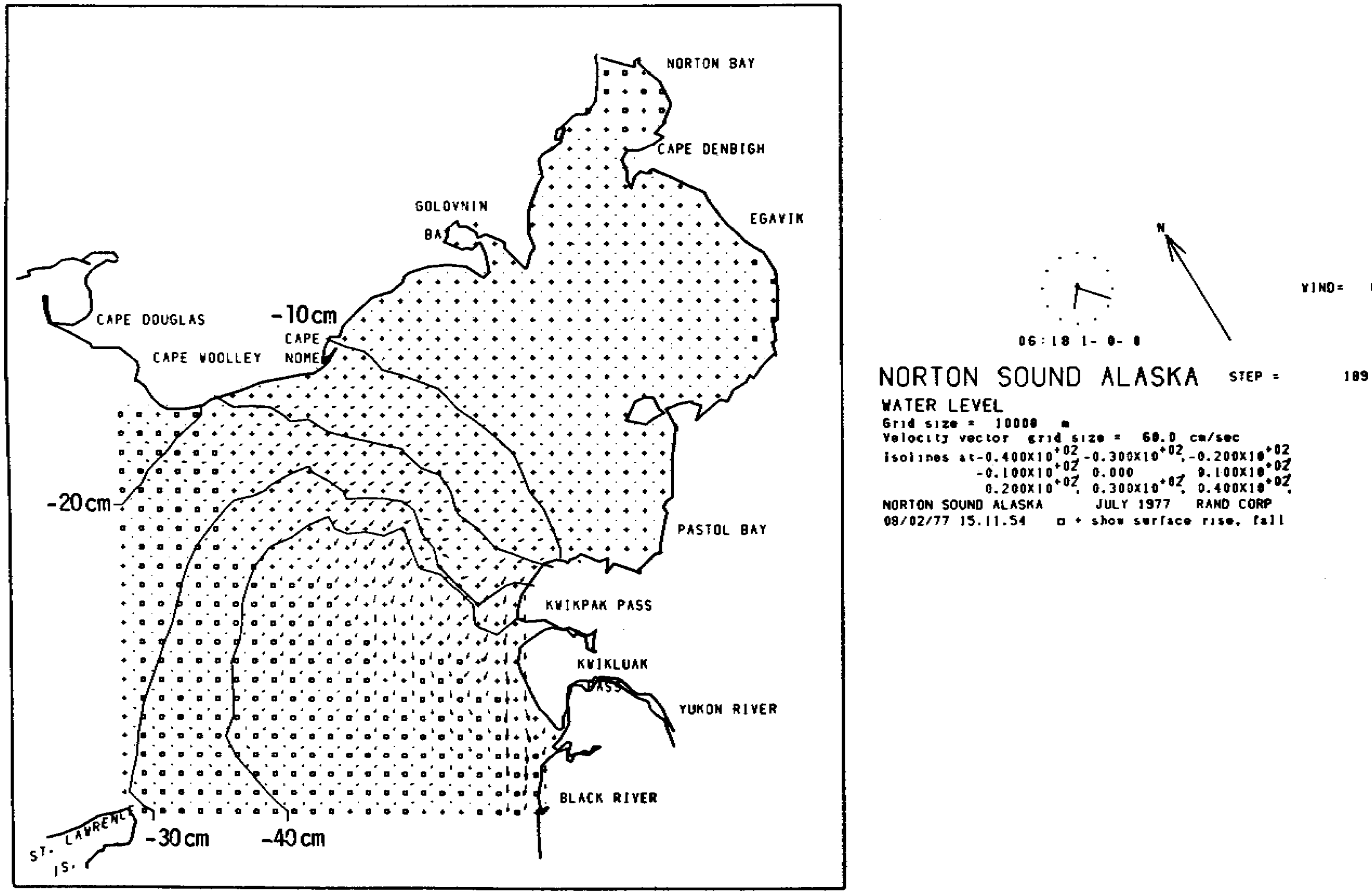


Fig. B-1--Computed water levels and rise or fall of the tide at a particular time in the Norton Sound model

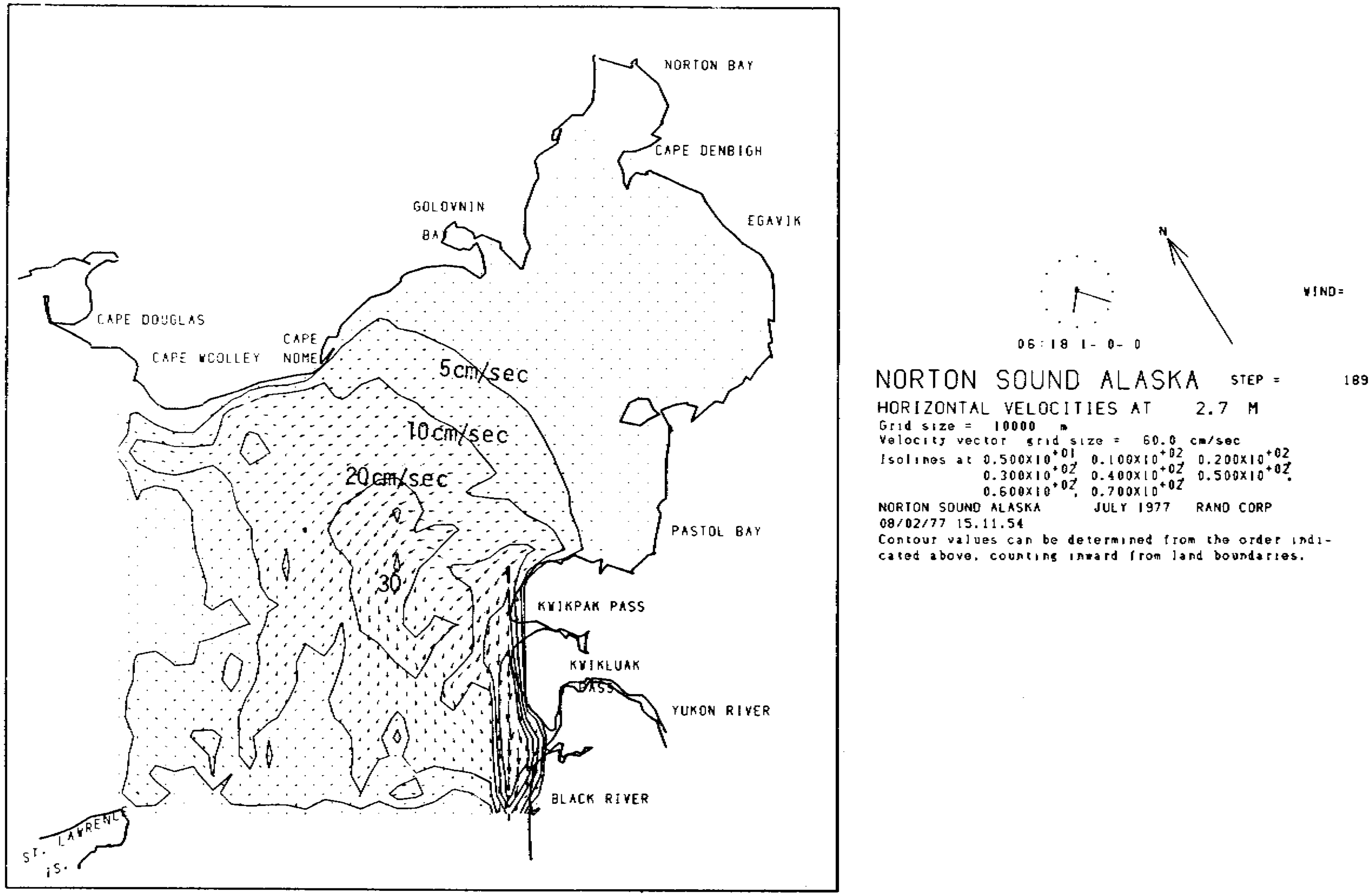


Fig. B-2--Computed horizontal velocities at 2.7 m at a particular time in the Norton Sound model

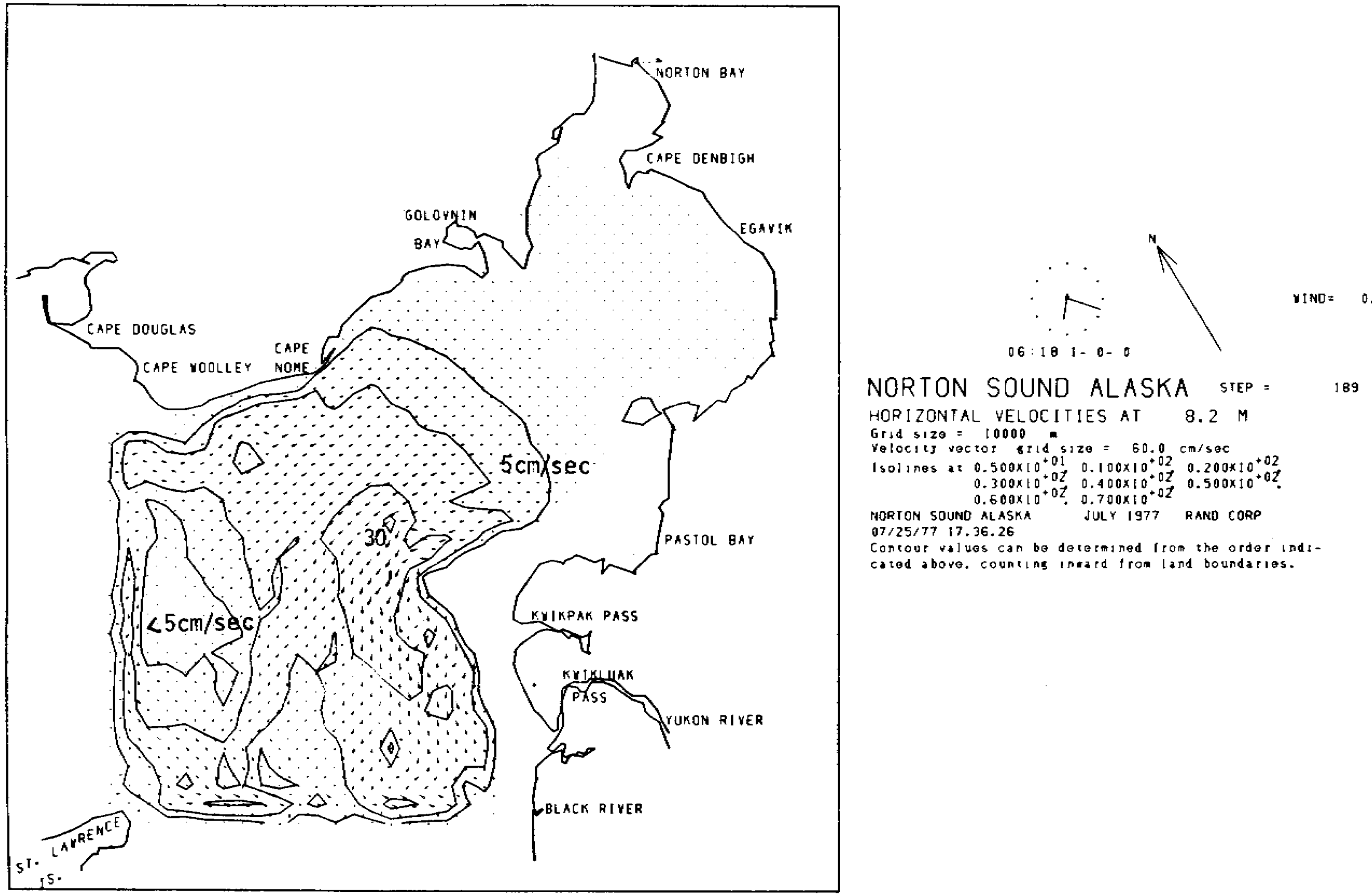


Fig. B-3--Computed horizontal velocities at 8.2 m at a particular time in the Norton Sound model

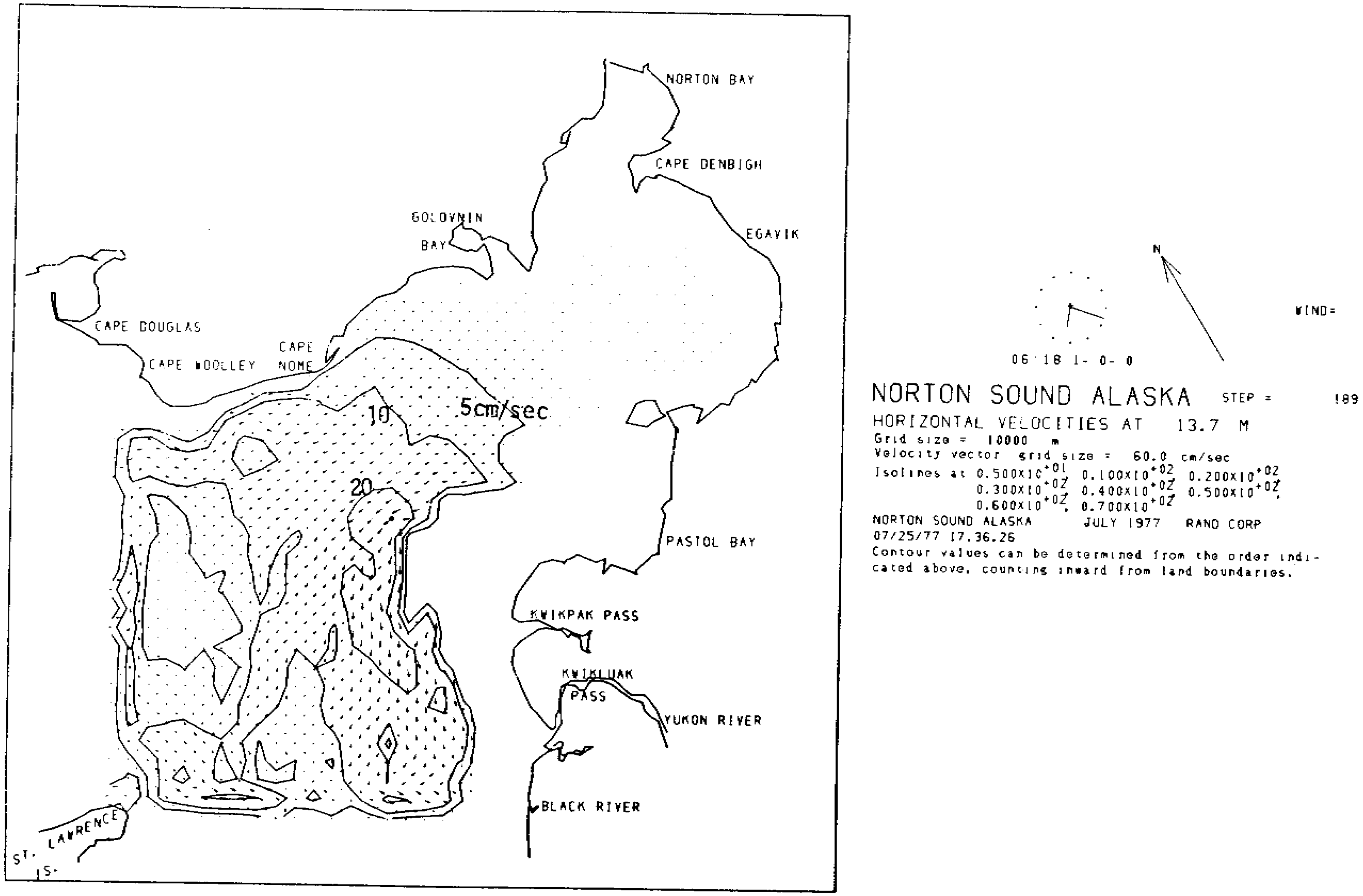


Fig. B-4--Computed horizontal velocities at 13.7 m at a particular time in the Norton Sound model

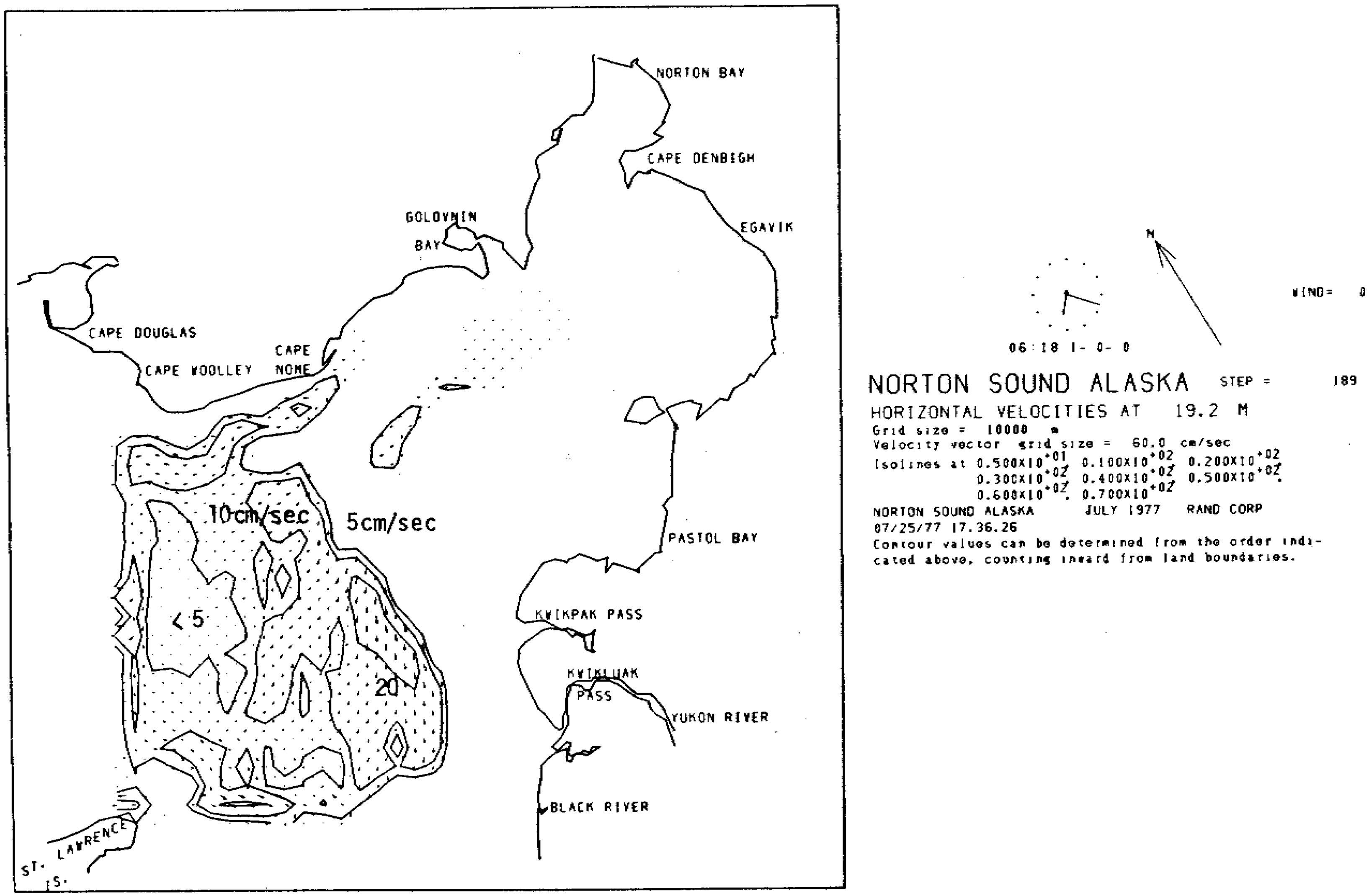


Fig. B-5--Computed horizontal velocities at 19.2 m at a particular time in the Norton Sound model

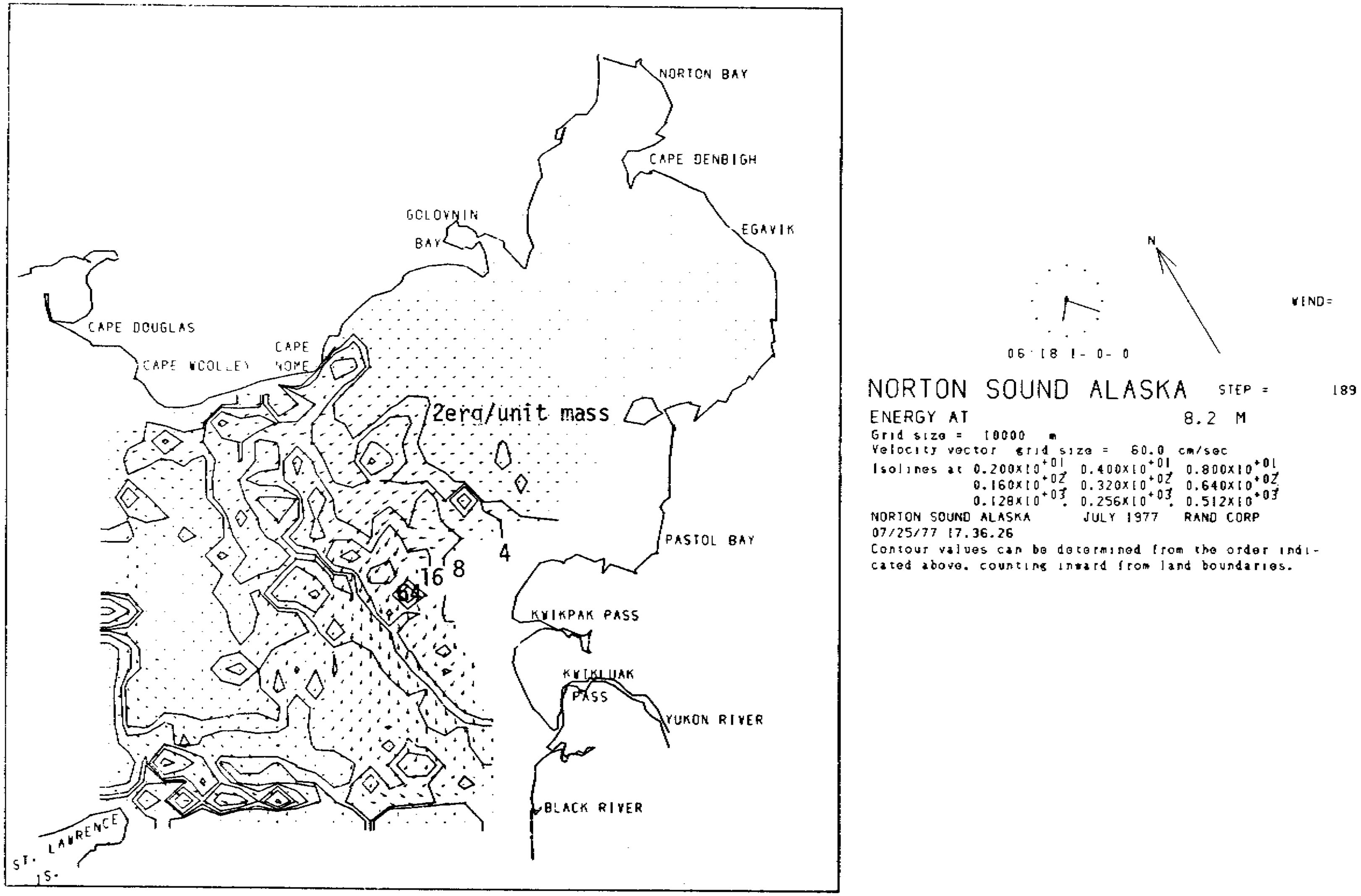
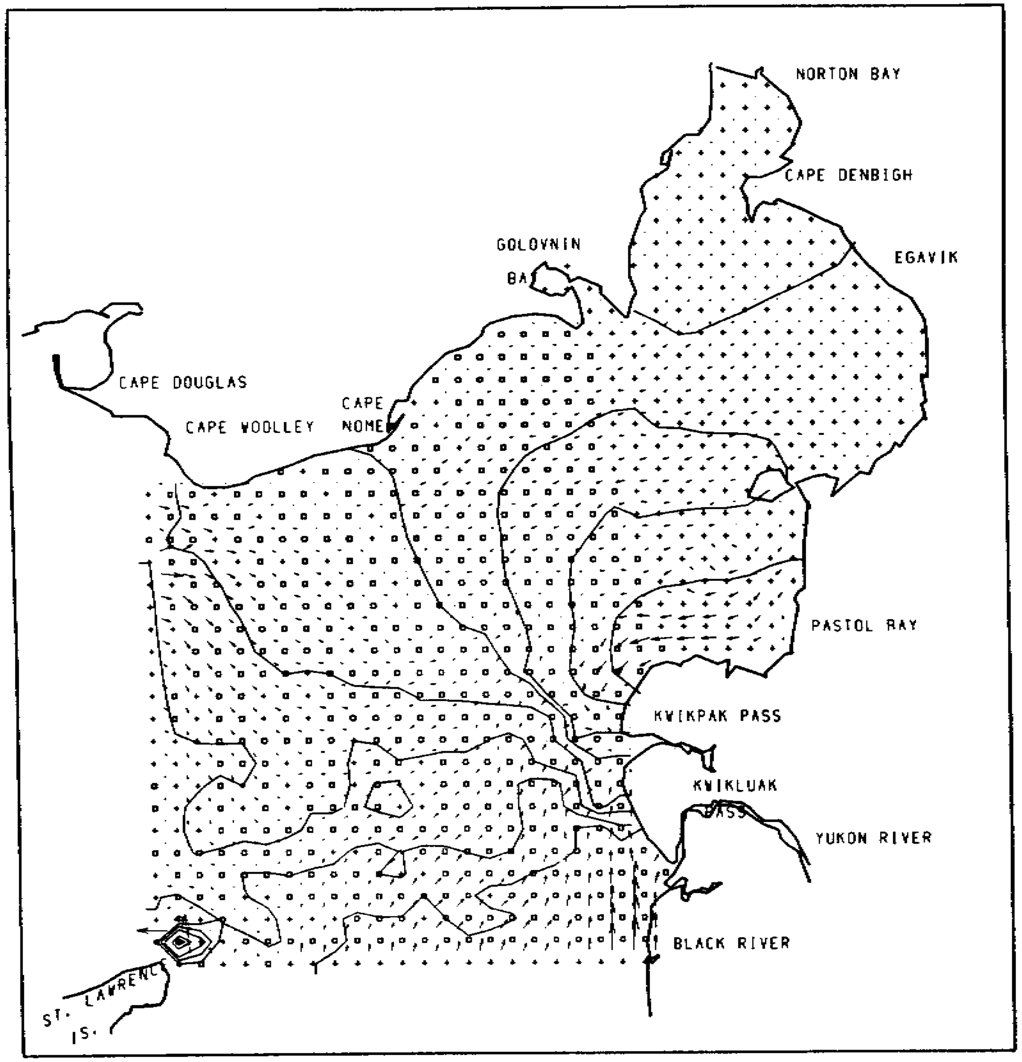
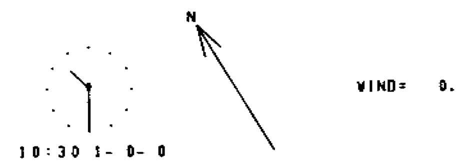


Fig. B-6--Computed subgridscale energy at 8.2 m in the Norton Sound model





NORTON SOUND ALASKA STEP = 315

WATER LEVEL
Grid size = 10000 m
Velocity vector grid size = 60.0 cm/sec
Isolines at $-0.400\times10^{+02}$, $-0.300\times10^{+02}$, $-0.200\times10^{+02}$, $-0.100\times10^{+02}$, 0.000, $0.100\times10^{+02}$, $0.200\times10^{+02}$, $0.300\times10^{+02}$, $0.400\times10^{+02}$
NORTON SOUND ALASKA JULY 1977 RAND CORP
08/02/77 15.11.54 o + show surface rise, fall
Contour values can be determined from the order indicated above, counting inward from land boundaries.

Fig. B-7--Computed water levels and rise or fall of the tide at a particular time in the Norton Sound model

Table B-1

PARAMETERS USED IN THE NORTON SOUND SIMULATION

Item	Parameter
Number of horizontal grid points	39 x 43
Maximum number of layers	7
Integration time step size	120 seconds
Horizontal grid size	10 km
Vertical grid size	3 fathoms
Fixed portion of the horizontal momentum and constituents diffusion coefficient	10^7
Bottom shear stress coefficient	550 $cm^{\frac{1}{2}}$/sec
Initial value of salinity	32 gr/kg
Initial value of temperature	5 degrees C
Initial value of turbulent energy density	1 erg/unit mass

Table B-2

WATER LEVEL AND CURRENT STATIONS IN THE NORTON SOUND MODEL

Grid Location M	N	Type	NOS Station Name or Other Designation	NOS Station Number if Applicable
3	3	Water level	North Cape	2079
24	6	Water level	Kwickluak Pass	2117
29	16	Water level	Appon Mouth	2121
32	24	Water level	St. Michael	2125
24	29	Water level	Carolyn Island	2129
12	5	Water level		--
13	15	Water level		--
4	18	Water level		--
21	22	Water level		--
17	26	Water level		--
32	30	Water level		--
27	34	Water level		--
29	40	Water level		--
4	4	Current	NS1	--
12	5	Current	NS2	--
19	5	Current	NS3	--
15	7	Current	NS4	--
8	8	Current	NS5	--
18	9	Current	NS6	--
12	10	Current	NS7	--
6	11	Current	NS8	--
7	15	Current	NS9	--
13	15	Current	NS10	--
22	17	Current	NS11	--
4	8	Current	NS12	--
11	18	Current	NS13	--
18	19	Current	NS14	--
26	19	Current	NS15	--
11	21	Current	NS16	--
5	22	Current	NS17	--
21	22	Current	NS18	--
27	22	Current	NS19	--
14	24	Current	NS20	--
22	25	Current	NS21	--
24	25	Current	NS22	--
17	26	Current	NS23	--
29	28	Current	NS24	--
24	29	Current	NS25	--
32	30	Current	NS26	--
27	34	Current	NS27	--
28	38	Current	NS28	--
29	40	Current	NS29	--

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RU #499

NO REPORT WAS RECEIVED

QUARTERLY REPORT

Contract: 03-5-022-67T011
Research Unit: 519
Reporting Period: 1 July - Sept. 30, 1977
Number of pages:

COASTAL METEOROLOGY OF THE ALASKAN ARCTIC COAST

Frank Carsey
Research Scientist
Polar Research Center
Division of Marine Resources
University of Washington
Seattle, Washington 98195

1 October 1977

I. Task Objectives

The objectives of this research are to compare local wind and pressure field data from the Oliktok-Umiat-Deadhorse "triangle", with NWS regional analysis. Data will be examined for anomalies due to orography, thermal gradients and chart resolution. The underlying purpose of the work is to model nearshore winds and atmospheric stability as a means for estimating air stress forcing on surface currents and sea ice.

II. Field and Laboratory Activities

A. Field Trip Schedule

A field trip was taken from 22 July to 2 Sept. 1977.

B. Scientific Party

The scientific party was composed of T. L. Kozo and R. Andersen. One week was spent at the Prudhoe Bay OCS billet and the rest of the time was spent on Pingok Island, in Simpson Lagoon.

C. Methods and D. Sample Localities

1. Atmospheric pressure and instrument space temperature were recorded at Prudhoe Bay, Oliktok, Umiat and Pingok Island, Alaska from July 28 to September 1, 1977. Atmospheric pressure was measured to .25 millibar with Weather Measure Ball microbargraphs.

2. Winds and temperature at 10 m height were measured at Cross Island (N.E. of Prudhoe Bay), Cottle Island (Simpson Lagoon) and Pingok Island (Simpson Lagoon) with MRI model 701 weather stations. A CIMST weather station was installed on Pingok Island also.

3. Pilot balloon data consisting of wind velocity vs. height were taken on Pingok on only 50% of the days due to fog conditions. The 30 gram helium filled balloons were tracked by two theodolites.

4. Radiosonde data consisting of relative humidity and temperature vs. elevation were taken on days of wind speed less than 15 knots. A total of 36 profiles were obtained with one third of them tracked by theodolite for simultaneous wind profile data.

E. Data Collected, 22 July - 1 September, 1977

1. Atmospheric pressure - four sites

2. Wind speed and direction at 10 meters, - three sites (see D. 2 above)

3. Temperature and relative humidity atmospheric soundings at Pingok Island, altitude ~5000 meters.

4. Wind speed vs. height to 1000 meters at Pingok Island.

III. Results

1. The atmospheric data is now being reduced.

2. Observations as part of a secondary study with LGL (Canada) people (Dr. Richard Robarts and Lew Haldorson):

   a. Two temperature and salinity profiles were obtained during wind regimes off the north coast of Pingok Island in shallow water of 0 to 14 meter depth. Profile 1 was taken August 2, 1977 after four days of 4.5 m/s, 090° winds accompanied by very clear and relatively warm weather (4.4° C). Profile 2 was taken August 7, 1977, nine hours after "relaxation" of the 090° wind and establishment of 315°, 3 m/s winds.

   Profile 1 indicated an apparent "upwelling" region within 200 meters of shore with 34‰ of salinity and 0.5° C temperature at the surface. This upwelling is consistent with a mass transport away from shore due to Coriolis influence.

   This profile also indicated a surface layer from 3500 to 8000 meters from shore (end of profile) about 1 meter thick with temperatures of 3.5° - 4.5° C, increasing seaward, and salinities of 29.0‰ to 27.5‰, decreasing seaward, due to ice melt influence. The nearshore 200 meter segment was an area of intense biological activity involving shore birds.

   Profile 2, taken nine hours after the wind reversal, showed that the "upwelling" region had disappeared along with the bird activity. A low salinity surface layer of 20.5‰ and 4° C about 1/2 to 1 meter thick was above a 30‰ and 2° C layer from near shore to 6500 meters (end of profile).

   In addition, we observed a feather covered water wedge of 28‰ salinity, 4° C temperature, relatively rough surface texture, which appeared to "move" at a speed of .1 m/s from East to West along the shore. This was probably due to the low salinity lens flowing over the entire area.

IV. Preliminary Interpretation of Results

1. None for major atmospheric data.

2. The above observations indicate the plausibility of applying synoptic scale wind and pressure data to prediction of some mesoscale biological-oceanographic events in the Simpson Lagoon area.

V. Problems Encountered and Recommended Changes

1. OCS-Coordinator Barrow - Should maintain radio communications with field sites on weekends due to lack of Coast Guard support.

2. NOAA helicopter and Barrow aircraft support cannot be relied upon even with a one time per week frequency. Due to data loss, alternate private transportation must be made available during critical situations.

3. Over water flights with aircraft having no floats or unreliable pop-out floats were necessary to perform the most basic parts of this study. The "savings" to OCS in this type of support are minor compared to the loss of human lives.

VI. Estimate of Funds Expended

As of 1 July 1977, expenditures under this contract will come to $13,428.90 out of an allocation of $30,147.00.

Quarterly Report

Contract # 03-5-022-56
Research Unit # 526-77
Task Order # 13
Reporting Period: 7/1/77-9/30/77
Number of Pages: 7

CHARACTERIZATION OF THE NEARSHORE HYDRODYNAMICS OF AN ARCTIC BARRIER ISLAND-LAGOON SYSTEM

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University of Alaska
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September 30, 1977

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending September 30, 1977

Project Title: Characterization of the Nearshore Hydrodynamics of an Arctic Barrier Island-Lagoon System.

Contract Number: 03-5-022-56

Task Order Number: 13

Principal Investigator: J. B. Matthews

I. Task Objectives:

A. To review estuarine lagoon hydrodynamics.

B. Summarize knowledge of Simpson Lagoon.

C. Produce numerical predictions of Simpson Lagoon circulation under various environmental conditions.

D. Plan and execute a field program to verify the numerical model computations.

E. Produce circulation, flow and water quality estimates for use by ecological modeling group.

II. Field or Laboratory Activities:

A. Ship or Field Trip Schedule.

29 July - 7 August Naval Arctic Research Laboratory
7 August - 13 August R. V. Alumiak
5 August, 7 August, 8 August DeHavilland Twin Otter N127RL
6 September - 13 September NARL
20 September - ? NARL, VECAMP, Boston Whaler

B. Scientific Party.

J. B. Matthews	Geophysical Institute, University of Alaska, Fairbanks, Alaska.
29 July - 15 August	Principal Investigator
Bill Kopplin	Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
29 July - 13 August	Chief Marine Technician
6 September - 13 September	Chief Marine Technician and Chief Scientist
20 September - 24 September	Chief Marine Technician and Chief Scientist
D. F. Paskausky	Ocean Science Division, Office of Naval Research, NORDA, Bay St. Louis, Mississippi
29 July - 8 August	Chief Scientist Surface Drifter Program

C. Methods.

1. Field Sampling.

Three In Situ recording current meters were set in the lagoon on specially designed mounts.

One In Situ recording tide gauge was placed on the same frame as one of the above current meters. Reversing thermometer samples were taken at 5 stations shown in Figure 1. Mean currents at 0.5 m above the bottom were taken at 5 stations using a Hydro products profiling savonious rotor analog read-out current meter. Woodhead surface drifters were air-dropped at 21 sites on 7 August and relocated later the same date. Recoveries were made by other scientific parties in the field.

2. A bibliographic search has been initiated on lagoon circulation with special reference to Arctic lagoons. The methods employ the facilities of the Institute for Scientific Information which has computer access to current journal articles. These data are used to up-date data from the standard reference Indexes such as Oceanographic Index, Oceanographic Abstracts, etc. The information is computer accessible at the University of Alaska.

3. Theoretical.

Three different numerical models have been implemented on the time share system of the University of Alaska Honeywell 66/20 computer. The models will be used to make Landsats and forecasts of currents, sea land and temperature and salinity distributions to be verified against the field data. Graphical techniques will be used to display the large quantities of data generated by the models and compare these with field data.

D. Sample Localities.

These are shown on the attached figures.

E. Data Collected or Analysed.

1. Number and type of data collected from <u>in situ</u> instruments is not known until instruments have been recovered and data decoded, one current meter lost. 2 current meters and 1 tidegauge recovered.

2. 5 Nansen bottle readings.

3. 2 miles of trackline recorded.

4. Woodhead-type surface drifters (500) were relased in packs of 25 on a line from 70°29'N, 149°48'W to 70°35'N, 150°00'W

(Sta. 1-19) and at 70°34'N, 149°12'W (Sta. 20) and 70°31'N, 149°13'W (Sta. 21) from the NARL Twin Otter N127RL on 7 August 1977 as described in Table 1 (see Fig. 2). The deployment began at 1504 after landing on Pingok Island to deliver supplies and was complete at 1656. The western end of Simpson's Lagoon was chosen since the wind was from the west and the wind-driven drift was expected to be to the east. During the two hours of release we noted very little movement of the drifters. They were plainly visible from the Otter at 200 ft. Upon returning to Deadhorse we noted the wind was from the east; this explained why the drifters were stalled, the wind had shifted at the eastern end of the Lagoon. Upon returning to observe at 2000 we observed one drifter on the beach at A in Fig. 2 at 2012 and several strung along the edge of the river plume at B in Fig. 2 at 2016. (This suggests that spilled oil would concentrate at the turbulent interface between the river plume and sea water). We then proceeded east in a rectangular search pattern looking for drifters until we came to the fog bank 10 miles eastward. We proceeded back to Oliktok Point and observed numerous ($\sim$ 12) at C on the west shoal spit off the Dew Line Station. Now suspicious that they went west, we went west in a rectangular search pattern until we approached the Coleville River Delta and no success in finding them. We returned to Oliktok Point just ahead of the westward moving fog bank at 2110 and spend the night camping in the Otter.

III. Results:

Nansen bottle temperatures and spot current meter results only available at this time; temperatures to $\pm$0.01°C, currents $\pm$ sem/s.

Time ADT	Date	Station	Temp °C	Depth (m)	Spot Current W Component	N Component
1240	8/8/77	SIM 118B	9.46°C	2	-9.7 cm/s	-3.5 cm/s
1350	8/8/77	SIM 118D	4.75°C		8.5	5.0 cm/s
1430	8/8/77	SIM 118F	6.21°C		16.0	12.0
1500	8/8/77	SIM 118H	5.25°C		29.0	-0.8

Two Aanderaa current meter data tapes and one Aanderaa tide gauge tape been recovered and are being analysed. No results are yet available.

The bibliographic data search on lagoon systems is turning up interesting and useful data on lagoon circulation and both field and laboratory studies. The search is not yet complete so that a full analysis has not been completed.

The numerical models have been put into operational state and appear to work satisfactorily on the University of Alaska's Honeywell 66/20 Computers. Further work will continue with the implementation of graphical technique after the field data are analysed.

IV. Preliminary Interpretation of Results:

Temperatures fall steadily from shore to midway across lagoon.

Westerly currents build as the ENE wind increased from 0 to 30 kts.

The surface drifters will work well to simulate an oil spill and observe where the oil will go; they can be seen from an aircraft, but the fog which is very frequent over the lagoon is a major problem. The major observation is that the shallow lagoon is very responsive (response time of hours) to the wind and any spill will move down wind. One improvement would be to launch some larger drifters (with drogues) with radar reflectors so they can be located by radar (from plane or small boat) in addition to the inexpensive plastic floats. Some of the numbered drifters were found by birdwatchers, and this data will be included and analyzed in the final report.

V. Problems Encountered/Recommended Changes:

We had not achieved good model runs of anticipated currents before the field season. Thus we did not have the model data to help shape the field program. THis can be easily remedied for the next season.

The field program was heavily dependent on logistics provided by NARL. Though the Alumiak is a vessel well-suited to physical oceanographic work in shallow lagoons its unreliability caused us to completely modify our field program while in the field. We did achieve our primary objective of installing current meters and tide gauge in the lagoon but only after repeated delays due to physical equipment failures on the vessel. When the Alumiak finally failed we were unable to use the vessel to recover the instruments and all our data with the ship. It was only after considerable 'arctic heroism' displayed by Ray Dronenberg (Captain), Ned Manning (Chief Engineer) and Bill Kopplin (Chief Marine Technician) that 2 of our 3 moorings were recovered from a Boston Whaler late in the season. Without the sophisticated electronic positon-finding equipment of the Alumiak nor the heavy duty lifting gear it was impossible to find the exact location of the mooring most distant from landmarks. We used iron pipe frames to mount our instruments. Considerable corrosion resulted. Also the plastic bouys may not have been sufficient to relocate the positions without the Alumiak's navigation equipment.

For the drifter program we had anticipated using a float plane but none was available. We used a Twin Otter quite successfully but weather interfered with the observation of released drifters.

A major problem with all the field operations was the lack of communications between groups. Thus sections of our work parties were isolated by lack of radio contact from each other. This was both frustrating and, at times, dangerous. It was also a problem to write a renewal proposal before the first field season was begun.

An improved research platform needs to be found. R. V. Alumiak is satisfactory but only if it can be made to operate reliably and radio communication is secured between the vessel and shore. Good communications between all groups in the field and major laboratories should be provided and maintained.

We shall use the new pipe frame mounting method again if a suitable launching and recovery platform is available. However, we recommend using underwater locator beacons on all moorings and having locator sets for both diver and deck use. We recommend using large sacrifical zinc anodes on our future moorings. While we had such anodes on the instruments, the mounting frames suffered from the high corrosion activity.

We recommend considering using radio-tracked drifters rather than visually tracked drifters since fog is frequent in the open water season.

VI. Estimate of Funds Expended:

Approximately $90,000 expended of a total authorized $111,608. A request to carry forward unexpeded sums to the next FY has been approved.

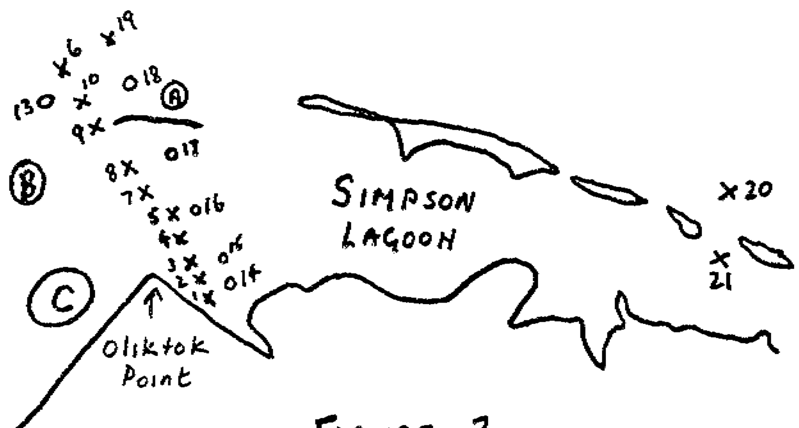
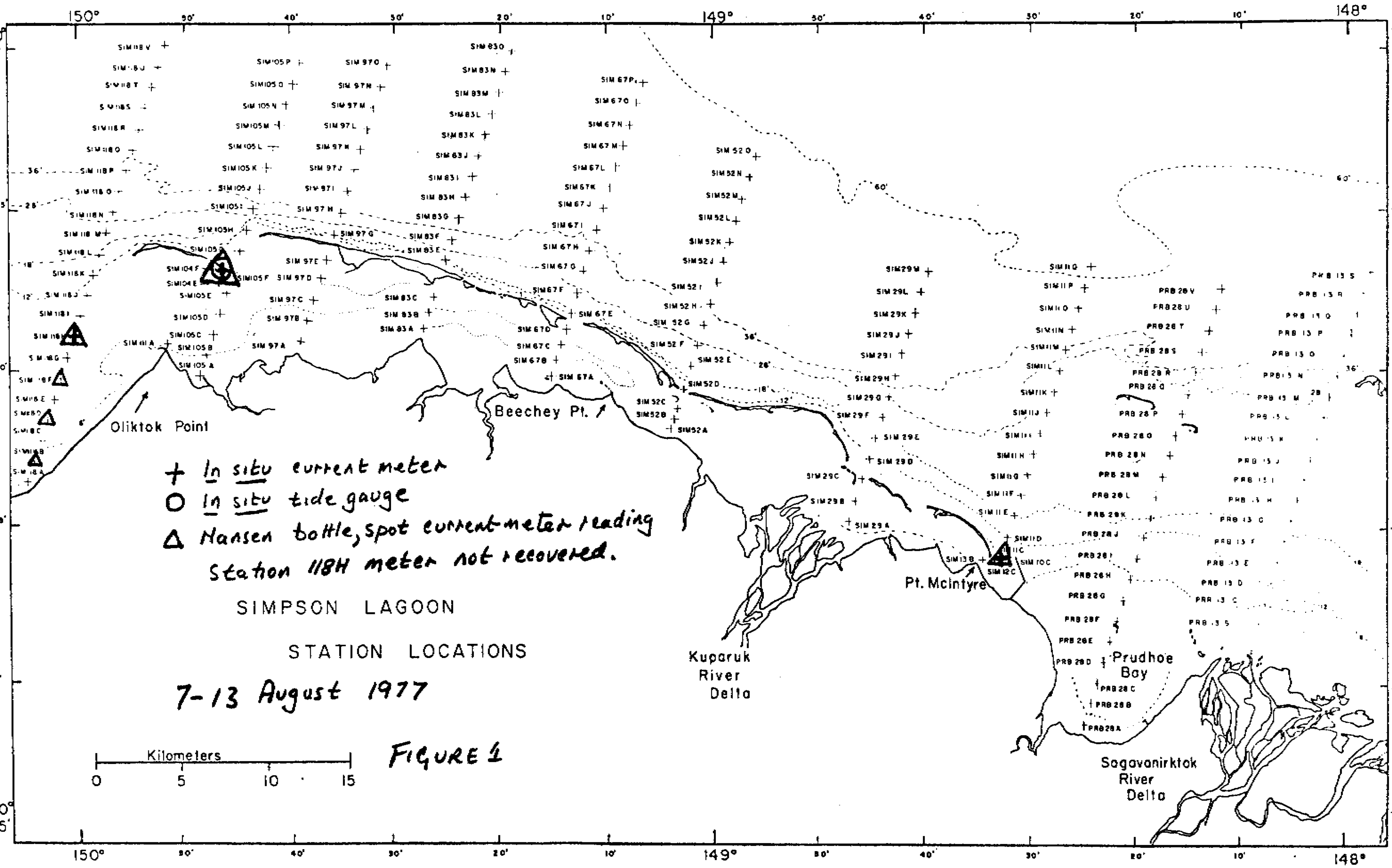


FIGURE 2
SURFACE DRIFTER RELEASE LOCATIONS
7 AUGUST 1977

Table 1

Release Number	Drifter Numbers	Alaska Daylight Time
1	950 - 926	1504
2	925 - 901	
3	1000 - 976	
4	975 - 976	
5	900 - 876	
6	875 - 851	
7	826 - 850	1506
8	825 - 801	1530
9	800 - 776	
10	775 - 751	
11	750 - 726	
12	725 - 701	1532
13	700 - 676	1557
14	675 - 651	1636
15	653 - 636	
16	625 - 601	
17	600 - 576	
18	575 - 551	
19	550 - 501	1641
20	500 - 476	1655
21	475 - 451	1656



SIMPSON LAGOON

STATION LOCATIONS

7-13 August 1977

FIGURE 1

QUARTERLY REPORT

Contract 03-5-022-56
Research Unit #529-77
Reporting Period 7/1/77-10/1/77
Number of Pages: 4

SEDIMENT CHARACTERISTICS, STABILITY, AND ORIGIN OF THE BARRIER ISLAND-LAGOON COMPLEX, NORTH ARCTIC ALASKA

A. S. Naidu
Principal Investigator
Assistant Professor in Marine Science

Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

October 1, 1977

I. TASK OBJECTIVES

The primary objective of this program is to collect all basic data on the size distribution, mineralogy, and certain biologically "critical" chemical attributes of sediments of the barrier island-lagoon complex of north arctic Alaska. In addition, research will be directed to assess the long-term directions and net volumes of alongshore transport of sandy sediments, as well as the stability and origin of the barrier islands along the Beaufort Sea coast. The additional objective of this program is to collect lithological and chemical baseline data from the contiguous area of the continental shelf of the Beaufort Sea. The chief purpose of this latter effort will be to fill in the small data gaps that exist on shelf sediments, principally between Barter Island and Demarkation Point.

II. FIELD AND LABORATORY ACTIVITIES

Field Work

About five weeks, extending from August 1 to September 6, 1977 were devoted to collecting sediment samples from the Simpson Lagoon, all the major barrier islands extending from the Demarkation Point to Point Barrow, and from a few points on the coastal beaches of the North Slope of Alaska. To understand the nature of the terrigenous sediment debris of the Beaufort Sea and the adjacent continental margin the bed-load of the Colville, Canning, Putuligayuk, Sakonowyak, Ugnuravik, Kadleroshilik and Shaviovik rivers were sampled. In addition, our field program consisted of collecting bottom surface and gravity core sediment samples from the Beaufort Sea shelf, onboard the ice-breaker USCGC *Glacier*. The chief objective of our participation in the above cruise was to fill in the sediment sample gaps between the Barter Island and Demarkation point in the Beaufort Sea.

A separate report will be submitted to the OCSEAP office by October 6, 1977 enumerating the details of the field work accomplished and the kind of geological samples collected during the USCGC *Glacier* cruise at the various stations. It may suffice to say, however, that 80% of the projected field work for the summer of 1977 has been satisfactorily accomplished. Field observations would seem to suggest that the Pingok, Bertoncini, Bodfish and Flaxman Islands, constituted of well-established tundra surface, are most likely relict mainland coasts. However, the islands with sand and/or gravel substrates are probably resultants of contemporary marine constructive processes. It would seem that the large boulders, characteristically associated with tundra-topped islands, are paleomorainic debris associated with pre-Wisconsian glaciation in the North Slope.

Laboratory Activities

Satisfactory but limited progress has been accomplished since June 2, 1977 when the formal approval of the funding came through. Most of June was spent on procuring supplies and equipments, and preparing for the summer field work. Laboratory analysis since July has included the grain size distributions of short core samples that were taken off the Colville Delta and provided to us by Dr. Peter W. Barnes of the U.S. Geological Survey. To date pipette size analysis on approximately 60-70 sections of cores have been completed. This number (60-70) includes 7 complete, or nearly complete, cores. The coarse fractions of each sample have been labelled and saved for dry sieving at a later date. The weight percentages (of each phi size) for some of the samples are in the process of being computed.

Within the next week the Simpson Lagoon sediment samples will be taken up for chemical and clay mineral analyses.

On September 12, 1977 Dr. Naidu participated in a meeting at Fairbanks to discuss with other OCSEAP investigators of the barrier island-lagoon ecosystem study and the Arctic Project Office, the highlights of the summer 1977 field investigations. In addition, discussion was also initiated on the logistic requirements and plan of work for the 1978 summer.

Methods

Grain-size distributions of sediments are being analyzed by the usual combined sieving-pipetting method.

III. RESULTS

As mentioned earlier, weight percentages of the phi sizes for some samples are being computed. Therefore, at this point in time no complete data have been obtained.

IV. PRELIMINARY INTERPRETATION OF RESULTS

Not applicable at this point of time.

V. PROBLEMS ENCOUNTERED/RECOMMENDED CHANGES

Although most of the field work that we had projected for this summer was accomplished satisfactorily, we are not particularly happy with the sediment core samples that were collected by us onboard the USCGC *Glacier* off the Colville Delta. The core samples that were retrieved by us were short (i.e., 50 cm maximum) and may not include continental margin lithologic sequences during the last glacial sea-level regression. I understand that

Dr. Peter W. Barnes of the USGS has successfully retrieved this summer relatively longer cores (about 2 m lengths) from the North Slope lagoon areas. Hopefully, we will be able to procure splits of these cores, and that stratigraphic studies of these cores will be of eventual help in the understanding of the origin of the barrier islands adjacent to the lagoons.

Owing to inclement weather continuously for a week, we were unable to collect this summer a suite of sediment samples from some of the inter-barrier island inlets in the North Slope area. We hope to fullfill this sample gap next year.

We are facing some problems in recruiting suitable graduate students to work on a thesis project. To avoid any further delay, and to fullfill our contractual commitments, vigorous attempts are now being made to hire one or two part-time students/student aide rather than a graduate student.

Quarterly Report

Contract #03-5-022-56
Research Unit #530
Task Order #34
Reporting Period 7/1 - 9/30/77

THE ENVIROMENTAL GEOLOGY AND GEOMORPHOLOGY OF THE BARRIER ISLAND - LAGOON SYSTEM ALONG THE BEAUFORT SEA COASTAL PLAIN FROM PRUDHOE BAY TO THE COLVILLE RIVER

Dr. P. J. Cannon
Solid Earth Science
University of Alaska
Fairbanks, Alaska 99701

October 1, 1977

QUARTERLY REPORT FOR QUARTER ENDING SEPTEMBER 30, 1977

Project Title: The Environmental Geology and Geomorphology of the Barrier Island - Lagoon System Along the Beaufort Sea Coastal Plain from Prudhoe Bay to the Coville River

Principal Investigator: Dr. P. Jan Cannon

I. Task Objectives

1. To determine the origin and evolution (geomorphic history) of the barrier islands and the coastal lagoons.

2. To determine the source(s) of the gravel size materials that make up the barrier islands.

3. To determine the stability of the barrier island - lagoon system in respect to natural processes and man induced effects.

4. To determine the magnitude of the geomorphological relationships between the barrier island - lagoon system and the landforms of the coastal plane such as the various streams, dune fields, ground patterns, thermokarst features, deltas, pingos, lugs, and lakes.

5. To construct a spatial and temporal model of the environmental geology of the region.

II. Activities

1. Preliminary field investigation made in July.

2. Secondary field investigation made in August.

3. Aerial reconnaissance made of part of area in August.

4. Collected beach samples and documented various features with photographs.

5. Performed intensive literature search.

6. Began to compose map of area.

7. Started work on a realistic island-lagoon model.

8. Attended LGL-NOAA post-field debriefing.

9. Investigated six theories as to the origin of the materials of the islands. Those theories include:

a. Longshore transport by currents
b. Ice rafting
c. Ice shove
d. Overflow of rivers at breakup
e. Coastal Plain remnant
f. Eolian transport

III. Results

A. Samples and Lithologies

Initial sieving of gravel samples from four locations shows a possible trend in the abundance of quartz-chert sandstone eastward. The relative amounts of quartz-chert sandstone in random samples are as follows: Spy Island, 6%; Pingok Island, 6.9%; Bodfish Island, 9.7%; Cottle Island, 11.8%. The above percentages were calculated from over 500 grains from each sample.

The quartz-chert sandstone consists of angular and subangular grains, indicative of minimal fluvial transport.

The same types of chert composing the quartz-chert sandstone are found on the coastal islands.

Initial observations suggest that the source of most of the gravel on and composing the islands is from the tundra and from the underlying silts and sands. Gravel, cobbles, and boulders were noted weathering from the silt, sand, and tundra mat.

Frost heave has brought gravel to the surface in dry tundra areas.

Material eroding from the tundra includes all sizes from sand to boulders. The fine fractions are considerably more common.

The introduction of coarse clastic material to the islands from coastal and inland tundra areas cannot be excluded with available data.

Lithologies of cobbles and boulders include: arkosic sandstone, gabbro, diorite, alkali granite porphyry, and 2-mica alkali granite. Lithologies of the gravels include chert of various colors, dolomite and limestone, schists, plutonics, and argillites.

Glacial striations and polished surfaces occur on several of the larger boulders.

Large boulders were noted only on tundra covered islands. The majority of the boulders are found on the lagoon side of the islands with only a few noted on the seaward side. Greater sand and gravel buildup on the seaward (upwind) side probably covers many boulders.

About 7.8% of the random gravel samples from the tundra covered islands is dolomite or limestone of Carboniferous age. The percentage is slightly lower (4.6) on the non-tundra covered island. The carbonates are black limestone and light brown dolomite. Corals and crinoid columnals are indicative of the age.

Large areas of Carboniferous deposits are presently exposed in the Brooks Range, northern Alaska. The greater portions within the north slope drainage occur in the northeastern part of the range; lesser amounts occur all along the crest of the Brooks Range.

B. Dunes

Dunes consisting of medium to coarse sand and granule size clasts develop where the beach is wide enough to provide the material, and where there is an elevated tundra mat to stop the transported sand. The lateral extent of the dune ridge varies with the width of the beach. On Pingok Island extensive dune buildup occurs on the northeast end. Here, the beach is wide. The dune buildup is less on the northwest end of the island where the beach is narrow.

The dunes occur only on the seaward side of the islands. This is the upwind direction.

There is a specific vegetation type on the dunes and on areas extensively covered with sand. This provides a distinct color change for the purpose of landform mapping.

C. Storm Action

Storms have a high impact on the islands and coastal areas. On the coasts, driftwood and 55 gallon drums are observed several hundred meters inland. The low areas on the islands and coast are apparently filled with water during some storms. The bottoms of drained lakes are covered with a thick layer of organic material. During storms and consequent filling with water the drained lakes could be a source of organics into the system.

Some islands without tundra cover become completely awash during storms as evidenced by the position of driftwood on the islands.

Dras'ic modifications of beach features during a single storm occurred on the seaward side of Pingok Island. Ice shoved mounds were partially destroyed and a sinusoidal beach developed. The sinusoidal beach shape probably resulted from wave interference.

D. Ice Shove

Ice shove features are most prominant on the seaward side of the islands, however, should not be excluded from the lagoonal side. Very large boulders aligned by ice movement. On Spy Island an ice shoved mound is located in the center of the island. The shoved side of these mounds is often concave, the opposite side being steep and often convex. The concave side of the large mound on Spy Island faces the lagoon.

E. Nutrient Input

Organic material on the beach consists of clumps of tundra and fiber-like tundra material. The latter probably contributes more nutrients to the system. The lagoonal beaches along tundra capped cliffs often have buildups of organic material extending from the base of the cliff to, and often past, the waters edge. These buildups range from 0.01 to 0.5 m in thickness.

Summer input of nutrients into the system is relatively small. The majority of the input occurs just before and during ice breakup. Organics spilled onto ice covers are dropped at the time of breakup and through strudel holes prior to breakup.

The Colville River drainage cannot be excluded as a source of nutrient introduction. Tags dropped at the mouth of the Colville Delta were noted east of Oliktok Point.

F. Lakes

The lakes form in areas bounded by ridges. This central area is depressed by thawing. The source of the water may be from thawing of underlying ice and/or from precipitation. The ridges seem to be cored with ice wedges and generally have a depression and/or fracture along the crest. If a depression is present, there is often a newly formed fracture along the trough. The depressions (often water filled) result from thawing along the initial and subsequent fractures.

Some of the lakes on the coastal plain and the offshore islands are drained by coastal erosion, while others appear to drain from evaporation or as ground water.

G. Remnant Features

The tundra covered offshore islands are definitely not true barrier islands, but are remnant coastline. Indicators of this are: morphology of surface lakes and drained lakes, similar stratigraphy, and similar lithologies. The gravel islands are, in part, remnant coastline; the tundra covers having been completely removed leaving the constituent gravel as lag. As constructional features, the non-tundra covered islands receive material eroded from tundra covered islands. The islands, of course, are constantly being modified by geologic agents (ice shove, wind, wave action, etc.).

IV. Preliminary Interpretation of Results

The material composing the coastal plain and the offshore islands may represent a ground moraine from Pleistocene glaciation which has been reworked by fluvial processes. Evidence supporting this are:

- Large numbers of lithologies, some with little resistance to fluvial and/or marine transport
- Angular clasts
- Surface striations (oriented) and polished surfaces on boulders
- Clast sizes from sand to boulders
- The fact that ice rafted material contributes little in terms of deposition
- Presently streams entering the area are of such low relief, that transportation of coarse material is unlikely

V. Problems Encountered

None

Contract # 03-7-022-35182
Research Unit # 531
Reporting Period: 1 July-30 September 1977
Number of Pages: 5 pages + 4 figures

Oceanographic Processes in a Beaufort Sea Barrier Island-Lagoon System: Numerical Modeling and Current Measurements

Principal Investigator: J. C. H. Mungall

Department of Oceanography
Texas A&M University
College Station, Texas 77843
(713)845-1443

28 September 1977

I. Task Objectives

Study the hydrography and circulation of Simpson Lagoon, so as to aid in the understanding and prediction of physical, chemical, biological and geomorphological conditions in similar barrier island lagoons along the Arctic coast of Alaska.

II. Field and Laboratory Activities

A1. Field Activities

Based at VE Construction Camp, Prudhoe Bay, Alaska, from 7 August to 25 August 1977, inclusive.

Boston Whaler available 12 August to 25 August 1977.

NOAA helicopter survey 15 August 1977

Post field season meeting at Geophysical Institute, University of Alaska, 12 September 1977

A2. Laboratory Activities

One month has been devoted to setting up a 3-D hydrodynamic model of Simpson Lagoon. The grid coincides with that used by C. Mungall and J. B. Matthews at the two modeling workshops (held in Vancouver). Initial runs will be made with a spacing of 1 km x 2 km, islands will (when appropriate) be represented by infinitely thin barriers, and 5 levels will be used (3', 6', 12', 25', 40'). Steady state wind conditions will be modeled using $\partial u/\partial x = 0$, $\partial v/\partial y = 0$ on open boundaries.

B. Personnel

J. C. H. Mungall, P.I.

R. E. Whitaker, 3-D modeling

D. Horne, Graduate Research Assistant

C. Methods

Conductivity, salinity, temperature measurements using Beckman RS5-3 portable salinometer modified for use at -2°C.

Depth measurements

Current measurements using 2 Hydroproducts deck read-out current meters (with Savonius rotors and direction sensors), and occasionally a General Oceanics, Inc. flowmeter.

D. Sample Locations (see Figure 1)

East Dock

West Dock (east and west sides at middle, end of causeway)

Between Stump Island and Pt. McIntyre

Entrances between Stump Island, Egg Island, Long Island

Current meter location between end of causeway and Stump Island

E. Data Collected or Analyzed

East Dock	16 visits
West Dock	15 visits
Stump Isl./Pt. McIntyre	10 visits
Stump Isl./Egg Is.	4 visits
Egg Isl. Long Isl.	3 visits
Current meter location	9 visits

III. Results

A. Temperature and salinity measurements.

Curves of temperature and salinity are shown in Figures 2 and 3 for the following locations: East Dock, West Dock (causeway) - end, east side of center, west side of center, Stump Isl./Pt. McIntyre entrance, current meter location. The wind speeds and directions given were measured by unsophisticated instruments and should only be used until better data becomes available. Tide heights were not recorded but will be obtained for the NOAA tide gauge at the eastern side of the causeway center.

B. NOAA Helicopter Survey

Although the planned axial surveys of Simpson Lagoon could not be carried out due to the lack of a float plane, we were fortunate in obtaining a helicopter flight permitting us to make observations around the perimeter of Simpson Lagoon. Salinities and temperatures were measured at 23 locations - these quantities being shown in Figure 4. As would be expected, salinities are lower, and temperatures are higher on the landward side of the lagoon.

In addition to water quality measurements, the survey enabled us to estimate the relative significance of the entrances as to flow into and out of Simpson Lagoon. Besides the obvious entrances on either side of Spy Isl., significant entrances were found at the east end of Cottle Island and at the west end of Egg Isl. The latter entrance has depths of at least 16 ft., being deepest towards the west. The remaining two entrances towards the east - at either end of Stump Isl. - are probably still significant but of decreasing importance. Maximum depths are of the order of 6 ft. and 5 ft., respectively.

Eight water samples were collected from the current meter site. Their salinities have been determined and given to Dr. J. B. Matthews. The salinities thus found have helped to calibrate the Beckman portable salinometer.

C. Current Measurements

The full amount of current measurements scheduled - in particular measurements in the presence of waves - was not possible owing to manufacturing delays and the lack of freight flights. The measurements that were made were not considered reliable in winds of greater than, say, 15 mph due to boat movement and wave-induced rectification errors. Those measurements taken at lower wind speeds were generally of the order of .3 knots between Stump Isl. and Pt. McIntyre, .5 knots between Stump Isl. and Egg Isl., and .2 knots west of Egg Isl. Problems were encountered with sticking of the compasses of both deck read-out current meters -- perhaps a consequence of the high angle of dip.

IV. Preliminary Interpretation of Results

A. Salinity/Temperature Measurements

A preliminary inspection indicates considerable differences between measurements taken at the East Dock and the eastern side of the causeway on the one hand, and those taken at the other points. This suggests that the causeway has obviously had an effect on the water quality of the region. How far this effect can be said to extend, and whether the effect of the salinity and temperature changes on the local biota is of consequence, remains to be determined. It should be noted that significant changes in salinity and temperatures can occur in less than a day -- a fact that ought to be taken into account when planning data collection.

B. Entrance Conditions

As a result of the helicopter survey, it seems reasonable for the purposes of numerical modeling to ignore those entrances between Pingok Isl. and Cottle Isl.

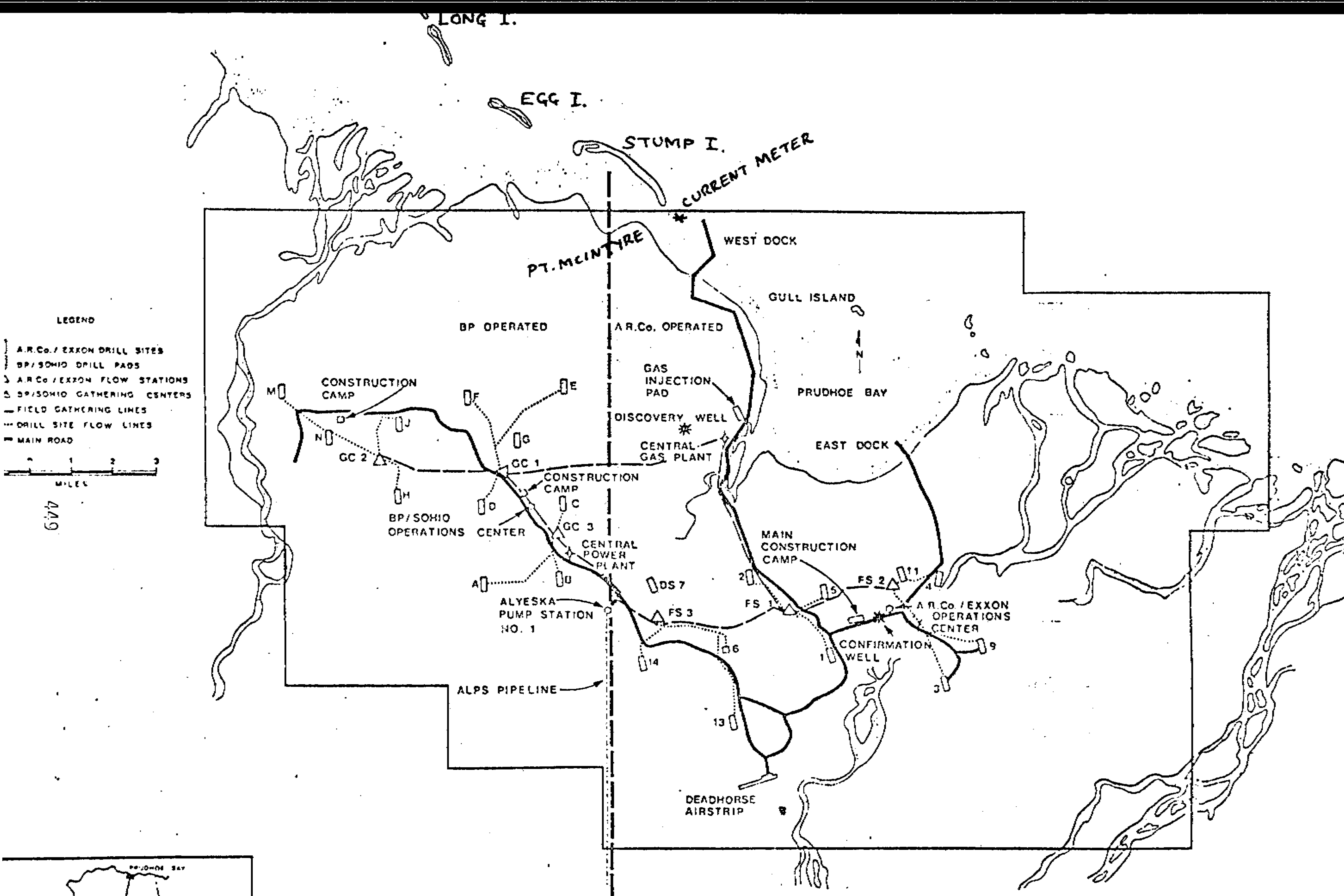
V. Problems Encountered

Such problems as were encountered were mostly due to weather (fog, working in open boats exposed to spray) and to logistics. The lack of a float plane was a serious blow to the first year of the project.

A certain amount of time was needlessly spent every day in truck maintenance and scheduling, and in phoning for freight or contacting the N.A.R.L. for logistical support. The lack of lab space caused a certain amount of discomfort in that electrical repairs frequently had to be performed outdoors. Lastly, the lack of planned radio communications added an unnecessary element of danger to the small boat operations.

VI. Estimate of Funds Expended

To date: $13,483.99



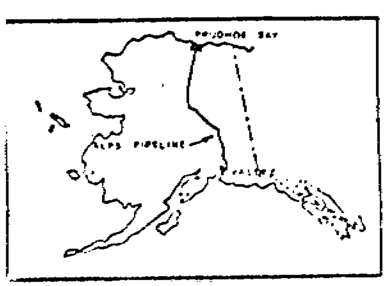


FIGURE 1. Location Map.

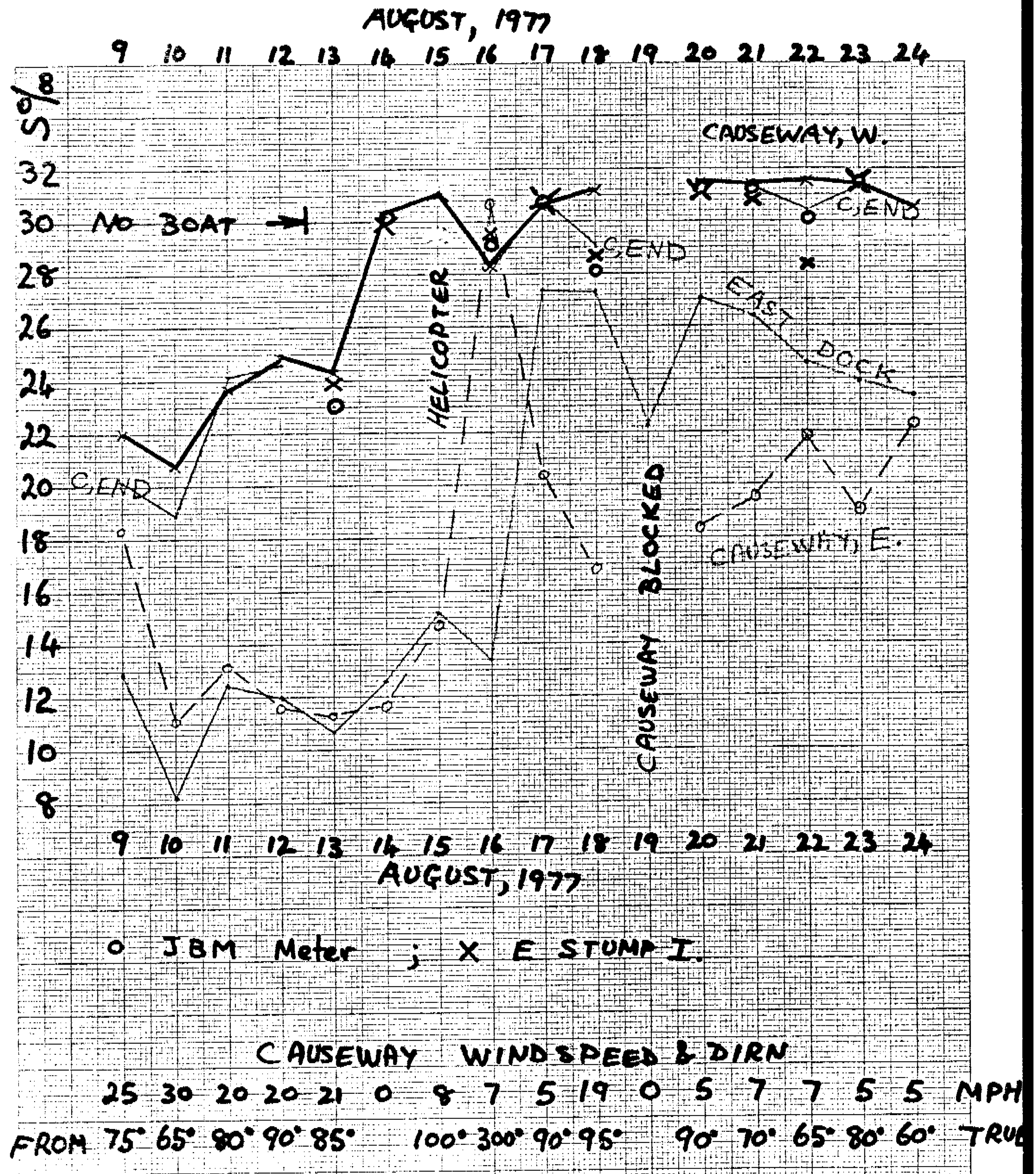


FIGURE 2. Salinity Measurements

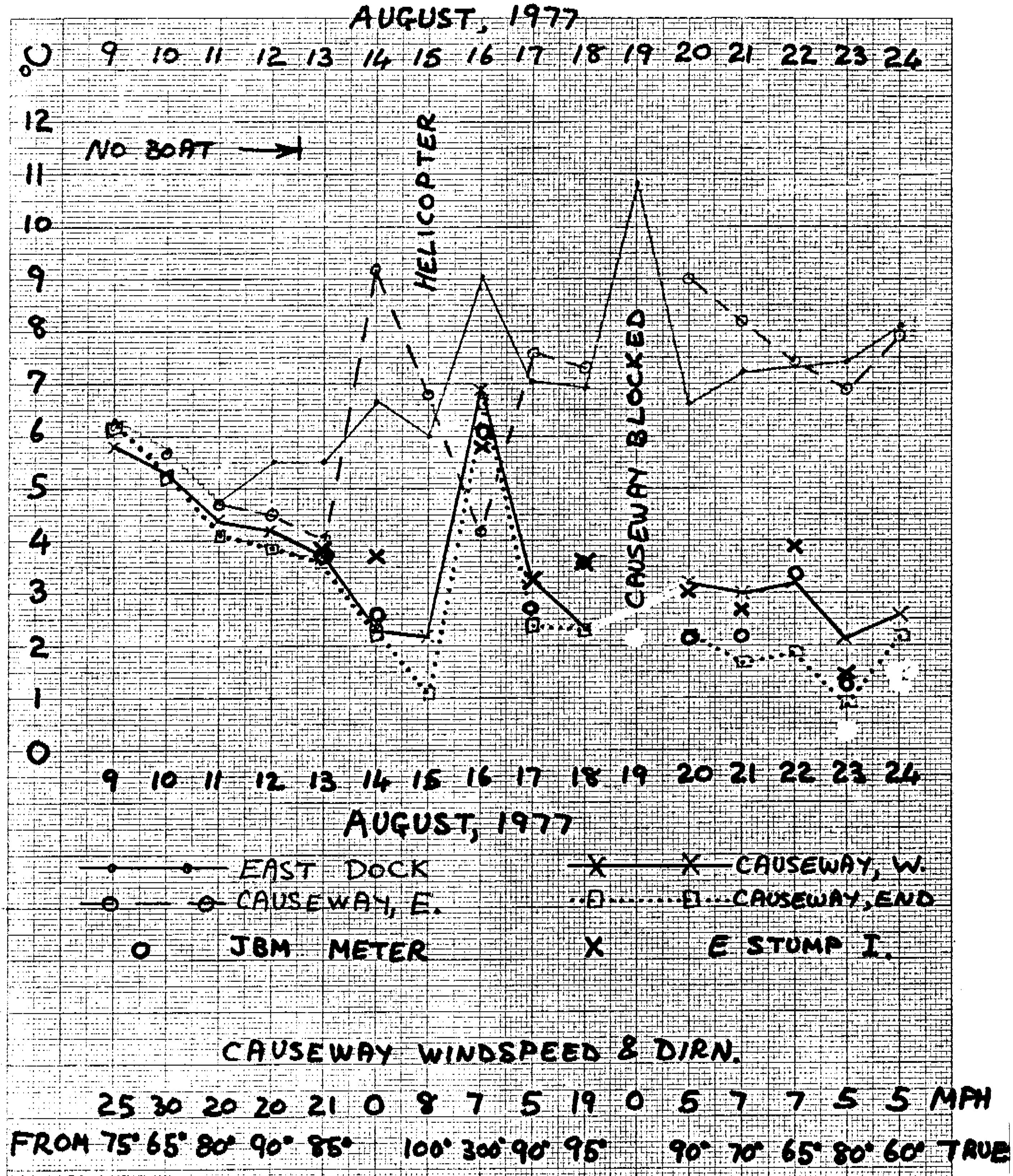


FIGURE 3. Temperature Measurements

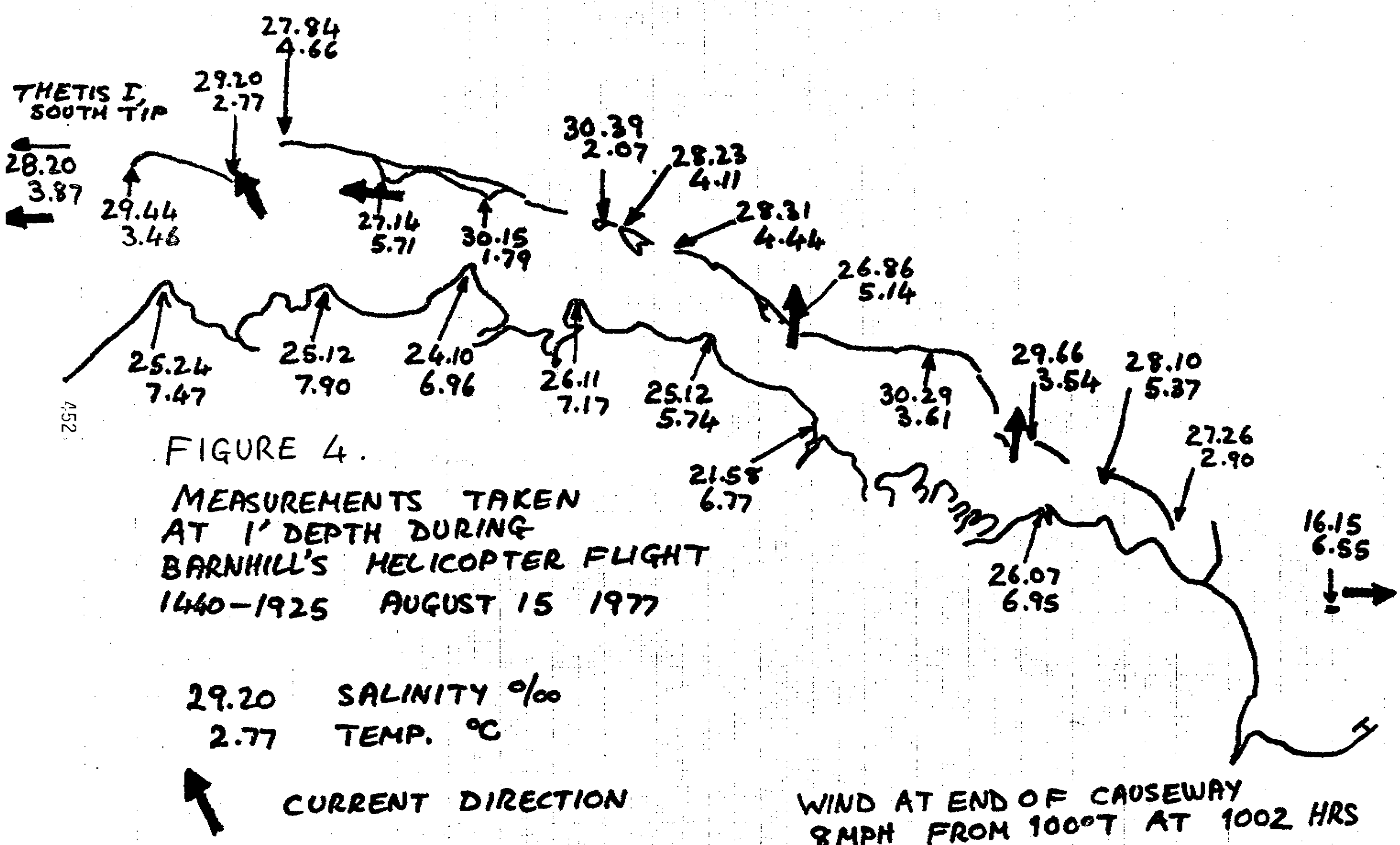


FIGURE 4.

MEASUREMENTS TAKEN AT 1' DEPTH DURING BARNHILL'S HELICOPTER FLIGHT 1440–1925 AUGUST 15 1977

RU # 536

NO REPORT WAS RECEIVED

QUARTERLY REPORT

RESEARCH UNIT #: 540
REPORTING PERIOD: July 1, 1977 to
September 1, 1977
NUMBER OF PAGES: 6

OIL SPILL VULNERABILITY OF THE BEAUFORT SEA COAST

Principal Investigator: Dag Nummedal
Co-Investigators: Ian A. Fischer, Jeffrey S. Knoth
University of South Carolina, Columbia, South Carolina

October 1, 1977

I. Highlights of Quarter's Accomplishment

The field work in the Beaufort Sea commenced on August 3, 1977. The first week involved data collection at the Geophysical Institute of the University of Alaska, while the Principal Investigator, Dag Nummedal, worked with Dave Hopkins in the Prudhoe Bay area. On August 6, 1977, the field party commenced work in Point Barrow. Despite severe logistical problems, approximately 70 - 80% of the shoreline between Demarcation Bay and Pt. Barrow was photographed, sampled and profiled.

II. Task Objectives

(1) To characterize the mainland and barrier shoreline of the Beaufort Sea between Barrow and Demarcation Bay with respect to geomorphology and sedimentary environments.

(2) To assess the retention potential for spilled hydrocarbons within the coastal environments.

(3) To develop testable hypotheses on the initiation and development of the barrier island systems. These working hypotheses will include data on morphologic trends, grain size trends and lithologic variability.

(4) To do a preliminary reconnaissance of the braided streams on the eastern slope, to assess their present transport regime and the significance of fluvial sediment supply to the littoral zone.

III. Field or Laboratory Activities

A. Field trip Schedule:

Aircraft support was in the form of a Bell 206 helicopter charted from ERA helicopters of Prudhoe Bay. Flight time was approximately 25 hours between August 18 and August 26.

B. Scientific Party:

The field crew consisted of Dag Nummedal, the Principal Investigator, Ian A. Fischer and Jeffrey S. Knoth serving as Research Scientists. All were from the University of South Carolina, Columbia, S. C. In addition, R. K. Fahnestock from the State University of New York at Fredonia served as a consultant on braided stream morphology.

C. Methodology:

The morphologic characterization of the shoreline is based on the following observations.

1. Description, on tape, of all features seen from aerial overflight at about 200 '.

2. Oblique aerial photography of all features of special interest.

3. Landing at predetermined sample sites spaced roughly 5 NM apart along the coast. Prior to landing, each study site was photographed and described in detail from the air.

4. At each sample site, a detailed beach profile was run from the landward side of the highest high-water mark to a water depth about 1 foot below MSL. All major breaks in slope were recorded on the profile.

5. The sample site was sketched from a vantage point about 50' up the beach from the profile line. Photographs up and down the beach were taken from the same vantage point.

6. The standard sampling prodedure consisted of three samples per profile: one at the water line, one at the first well-defined berm crest, and one generally at the washover terrace or other active sedimentation unit landward of the berm. If the active beach was backed by aeolian dunes, cliffs or other "unusual" deposits, these were generally sampled too.

7. One of two close-up photographs of the sediments were generally taken. The samples obtained will be analyzed in the laboratory for size, mineralogy of the sand fraction, lithology of the rock fragments and sand grain size shape characteristics. These data may provide clues to the provenance of the sediments found on many of the islands.

During a northeast storm in the Beaufort Sea between August 8 and 11, we also measured littoral processes along the shores of Pt. Barrow and Plover Pt., to permit an estimation of sediment transport rates. At a total of 11 stations, wave height, period and angle of incidence were recorded, as well as the wind velocity and direction.

The river reconnaissance consisted of the following steps:

1. Aerial photographic overflight to describe the flow pattern and bar morphologies. Observations were tape recorded while in flight.

2. Landing and sampling of selected river bars spaced roughly 6 NM apart upstream.

3. At each sample site, the coarse upstream end (apex) of a mid-channel bar was selected. The bar was photographed, and the general distribution of bedforms and clast sizes noted.

4. The 30 largest clasts within the apex area of the bar were chosen for measurements of long and intermediate axes. This provides (perhaps) a rough measure of the competency of the stream of that site.

5. One hundred clasts in the size range of 3 to 5 cm were sampled and brought back to camp for determination of lithologies.

D&E. Sample Extent:

Between Demarcation Bay and Lonely, we sampled 72 stations, via ERA helicopter support, between August 18 and 26. The stations cover both the barrier island chain and the mainland shore and are spaced roughly 5-6 NM apart with a somewhat greater spacing to the east of Barter Island.

In Prudhoe Bay, between Heald Pt. to the east and Pt. McIntyre to the west, 12 stations were sampled (with the help of David Hopkins and Roger Hartz of the U.S.G.S.) on August 4 through 6. At the Barrow and Plover Spits, 11 stations were measured 3 times between August 7 and 28. Due to inadequate logistics, we did not gain access to the shoreline between Plover Pt. and Lonely.

A total of 95 coastal stations were sampled between Barrow and Demarcation Bay.

River sampling was limited to the Sagavanirktok, the Ivishak and the Canning Rivers to the east and south of Prudhoe Bay. Most of the Sagavanirktok was sampled by driving the Alyeska haul-road, the other streams as well as the eastern distributary of the Sag downstream of Franklin Bluffs were sampled by helicopter. The distribution of river stations is as follows:

16 stations on the Sagavanirktok from Prudhoe Bay to Happy Valley camp on the first glacial moraine.

5 stations on the Ivishak from its junction with the Sag to the foothills of the Brooks Range,

2 stations on the Canning from about 5 to 15 miles upstream, and

4 stations at the Sag river delta. A total of 27 river stations were sampled.

IV. Does not apply

V. Does not apply

VI. Does not apply

VII. Problems Encountered/Recommend Changes

A brief review of some of the logistics problems encountered this season are included here, as it is felt that by bringing these to the attention of NOAA and BLM personnel at this early stage, changes to the benefit of all OCS investigators might be implemented by the summer of '78.

The Bell 206 helicopter rented from ERA proved to be ideal for the job. It carried three passengers plus light scientific gear, was equipped with floats for over-water flying and wasted no time on landings and take-offs. About 90 percent of our field work was done by this helicopter. The remainder was accomplished on foot along the shores of Prudhoe Bay and by truck up the Alyeska haul-road and from Barrow to Plover Pt. Besides Nana fuel service at Deadhorse and NARL at Barrow, fuel was purchased at the Barter Island DEW-line station and ferried by ERA helicopter to Pt. Thompson and by NARL aircraft to Lonely and Helmericks.

What did not work out includes the following: (1) NARL's Cessna 180 floatplane sustained minor damage during a small storm and remained out of commission for the remainder of our field season. No other aircraft capable of general beach landings exist at NARL, (2) The NOAA UH1H helicopter was down for boost-pump replacement and maintenance during msot of our field season. We got no working time on this helicopter. There is no back-up available.

Since our project was totally dependent on the support of aircraft capable of beach landings, it would not have been carried out without the helicopter support obtained. We are very appreciative of the expeditious handling of this problem at the OCS offices in Fairbanks and Juneau.

The following recommendations for OCS logistics for 1978 may be of some value:

1. Let those OCS investigators who require a fair amount of aircraft support arrange their own logistics, if they so desire. Include logistics funds in the contracts for these PIs.

2. Make two Bell-206-sized helicopters available rather than one large one. Having the only NOAA helicopter grounded because of mechanical reasons during the few short time periods of good flying weather leads to an enormous waste of time on the part of the investigators and to an enormous waste of money for OCS when subsistence cost on the North Slope is taken into consideration.

3. Perhaps not a major problem, but definitely an item of considerable irritation, is the refusal of NARL staff, particularly the pilots, to work on Sundays. We can appreciate the need for one day off per week; however, weather con-

ditions at Barrow usually provide such off days at very frequent intervals. During the short summer field season at Barrow, OCS and other investigators try to maximize their data-collecting efficiency. This would be greatly facilitated by a slight shift in attitude on the part of some elements of the NARL staff.

4. The OCS "headquarters" at Prudhoe Bay should be upgraded to include, at a very minimum:

(a) Reliable phone answering service.

(b) Storage area.

(c) Basic tools and perhaps a full-time expediter during the peak of the field season.

HAZARDS

HAZARDS

HAZARDS

Research Unit	Proposer	Title	Page
212	P. R. Carlson B. F. Molnia USGS	Faulting, Instability, Erosion and Deposition of Shelf Sediments, Eastern Gulf of Alaska	556
251	J. Kienle H. Pulpan U. of Alaska	Seismic and Volcanic Risk Studies - Western Gulf of Alaska	557
253	T. E. Osterkamp W. D. Harrison U. of Alaska	Subsea Permafrost: Probing, Thermal Regime and Data Analysis	609
271	J. C. Rogers J. L. Morack U. of Alaska	Beaufort Seacoast Permafrost Studies	617
290	C. M. Hoskin IMS/U. of Alaska	Benthos-Sedimentary Substrate Interactions	621
327	M. A. Hampton A. H. Bouma USGS	Shallow Faulting, Bottom Instability, and Movement of Sediments in Lower Cook Inlet and Western Gulf of Alaska	627
429	D. R. Thor H. Nelson USGS	Faulting, Sediment Instability, Erosion and Deposition Hazards of Norton Basin Sea Floor	628
430	D. A. Cacchione D. E. Drake USGS	Bottom and Near-Bottom Sediment Dynamics in Norton Basin	650
431	A. H. Sallenger et al. USGS	Coastal Processes and Morphology of the Alaska Bering Sea Coast	655
473	D. M. Hopkins et al. USGS	Shoreline History of Chukchi and Beaufort Seas as an Aid to Predicting Offshore Permafrost Conditions	659
483	N. N. Biswas L. Gedney USGS	Evaluation of Earthquake Activity Around Norton and Kotzebue Sounds	669
516	M. Vigdorchik U. of Colorado	A Geographic Based Information Management System for Permafrost in the Beaufort and Chukchi Seas	672

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A SEISMOTECTONIC ANALYSIS OF THE SEISMIC AND VOLCANIC HAZARDS IN THE PRIBILOF ISLAND-EASTERN ALEUTIAN ISLANDS REGION OF THE BERING SEA

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TABLE OF CONTENTS

I. SUMMARY

In conjunction with an ERDA sponsored seismotectonic study, L-DGO is collecting seismic data to evaluate the earthquake hazard to the exploration for and development of oil resources in the SE Bering Sea, E Aleutian Islands, and Alaska Peninsula regions of Alaska. These data, and other geophysical and geological data, are used in several seismic hazards studies. These studies include assessment of seismic risk, investigation of active faults, and monitoring of certain active volcanoes.

Most seismic activity in the Shumagin seismic gap is confined to a well-defined Benioff zone. There are no obvious linear alignments of the shallow hypocenters above this Benioff zone to indicate any clearly active crustal faults. However, detailed geologic and seismic work remain to be done to evaluate the risk due to active crustal faulting in this area. The historical record for the Aleutian arc, in general, and the Shumagin seismic gap, in particular, indicates that an event of magnitude $M_b \geq 7$ is likely within a decade, and one of magnitude $M_b \geq 8$ is likely within a century. However, the spatio-temporal sequence of great earthquakes in the Aleutian and SE regions of Alaska may imply that a $M_b \geq 8$ event will occur sooner, perhaps within one or two decades. This may constitute a major threat for development of potential oil resources in the Shumagin section of the Aleutian arc.

Activity on Saint Paul Island is very low (about 10 detectable events per year). During the last eleven-month sample, 8 events were detected in the vicinity of Saint Paul. Several events with S-P times consistent with the distance to the NW Saint George Basin were recorded at Saint Paul. Paul.

Pavlof and Akutan volcanoes continue to be the most active of those in the vicinity of the Shumagin seismic gap.

Although any portion of the Aleutian arc could generate a great earthquake, several lines of evidence indicate that one of the most probable locations for the next $M_b \geq 8$ event is the Shumagin seismic gap. Such an earthquake is likely to be accompanied by vertical displacements of several meters over hundreds of kilometers of coastline. This magnitude of displacement would generate a significant tsunami. If structures with design lifetimes of decades are to be built in the vicinity of the Shumagin gap, they should be expected to experience a $M_b \geq 8$ earthquake and associated major tsunami.

There appears to be little earthquake risk to structures on Saint Paul Island. A remote but finite chance exists for volcanic activity on the continental shelf in the vicinity of Pribilof Islands. The few events recorded at Saint Paul which are most likely from the St. George Basin region, along with several which have been reported by NEIC for this region suggest that this basin may be bound by active faults. This possibility should be evaluated before any major development of this basin takes place.

II. INTRODUCTION

This study, "A Seismotectonic Analysis of the Seismic and Volcanic Hazards in the Pribilof Islands - Eastern Aleutian Islands Region of the Bering Sea," is being carried out by Lamont-Doherty Geological Observatory of Columbia University in the City of New York (L-DGO) in conjunction with a study supported by the Energy Research and Development Administration (ERDA) entitled, "A Comprehensive Study of the Seismotectonics of the Aleutian Arc". The NOAA-sponsored study can be considered a logical subset of the ERDA study. To avoid duplication, NOAA supports a clearly delineated portion of the seismic work: logistic support for the maintenance of the short-period seismic network and salary and related support for the reduction of data from this network to accelerate hazard evaluation.

The objective of this study is to evaluate the earthquake hazard to petroleum exploration and development. To make this evaluation, basic seismic data are collected which are used in studies of V_p/V_s ratios, b-values, seismicity patterns, and volcanic activity. Of particular concern is the evaluation of the level of activity of faults in the study area.

The Shumagin seismic gap stands out on maps of Aleutian seismicity (Barazangi and Dorman, 1969) as a region in which relatively few earthquakes are occurring when compared with the rest of the arc. Sykes (1971) pointed out that this region is bounded on the east and west, respectively, by the aftershock zones of the 1964 Great Alaskan and the 1957 Andreanof-Fox Islands earthquakes. Sykes also noted that the last $M_b \geq 8$ earthquake in this region occurred in 1938 and that its aftershock zone may not have extended into the western portion of the gap. Kelleher (1970) showed that the Shumagin region appears as a clear gap on a space-time plot of Aleutian seismicity. He also noted that there may exist a westerly progression of great earthquakes along the northern edge of the Pacific plate which would imply that the next great earthquakes in the Aleutians should occur in the Shumagin region within a deacde or two. A statistical examination of the historic data for the Aleutian arc by Davies _et al_. (1976) suggests that a $M_b \geq 7$ earthquake is likely to occur within the Shumagin gap within a decade and $M_b \geq 8$ is likely within a century. Archambeau (1976) reports that stress drop calculations for recent earthquakes indicates that the Shumagin gap is probably at a higher stress level than any other portion of the Alaska-Aleutian arc. If a great earthquake does occur, it is likely to be accompanied by vertical displacements of several meters over hundreds of kilometers of coastline (see, e.g., Plafker, 1965). This magnitude of displacement would generate a significant tsunami. The above statements regarding the timing of the next great earthquake within the Shumagin gap must be taken with error limits on the order of decades to centuries; however, the likelihood of such an occurrence during the lifetime of an oil field is significant enough that petroleum development in this region must design for the occurrence of at least a $M_b = 8$ earthquake and accompanying tsunami.

In the Pribilof Islands region, the earthquake hazard is much less than in the Shumagin gap. It is an apparent intraplate region with no known history of destructive earthquakes (Meyers, 1976). This does not, however, exclude the possibility of destructive earthquakes. A more quantitative risk estimate will be given after another year of monitoring seismicity. Hopkins (1976) suggests that there may be a set of NW trending faults between St. Paul and St. George Islands. These faults may extend along the NE edge of the St. George Basin. During the last eleven-month sample (Nov. 1976-Sep. 1977) of seismicity recorded at St. Paul, events with S-P times consistent with an epicenter within the St. George Basin were recorded. Because the only known active area around the Pribilofs is the St. George Basin (Davies *et al.*, 1976), these events probably occurred there. This seismic activity may imply that the St. George Basin is bounded by active faults. This possibility needs to be evaluated further before any significant structures are built in support of petroleum development in the St. George Basin. This situation is potentially troublesome, particularly if pipelines are to be laid from the basin to the Pribilof Islands.

III. CURRENT STATE OF KNOWLEDGE

The state of knowledge of the seismotectonics of the study area has been reviewed in the introduction. Geodetic levelling measurements, although not sensitive enough to reveal the expected long-term tilt rates, do show that abnormally high tilt rates did not occur over the past few years (Davies *et al.*, 1976). The existence of a double-sheet Benioff zone has been discovered in Japan (Hasegawa *et al.*, 1976), the Kuriles (Sykes, 1966; Veith, 1974; Stauder and Mualchin, 1976) and the central Aleutians (Engdahl and Scholz, 1977). Current work in the Shumagin gap on this topic may improve our understanding of the mechanics of subduction and hence earthquake risk. In a recent paper, Geller and Kanamori (1977) have revised the magnitudes assigned to some great earthquakes. This revision is based on an accounting of the energy released at longer periods than are normally recorded by long-period seismographs. Strain and tiltmeter records have provided much of the longer-period data and may be regarded as a necessary extension of seismograph records in the future. A direct mechanical coupling between the Pacific plate subduction and the Aleutian volcanoes was demonstrated by inferring tectonic stress from volcanic structures (Nakamura et al., 1977). This result and others relating the occurrence of earthquakes to volcanic eruptions (Nakamura, 1969, 1977; Kimura, 1976; Berg et al., 1977; Blot, 1977) suggest that seismic and geodetic monitoring of volcanoes may be a good way to measure the increasing stress prior to a great earthquake.

IV. STUDY AREA

The general region of study for this work is the SE Bering Sea from the Pribilof Islands to the eastern Aleutians. Short-period stations are maintained as follows: one on St. Paul Island, two near Dutch Harbor, one on Akutan Island, six around Cold Bay, twelve on Pavlof volcano, and nine around Sand Point. With a single station on St. Paul, only general levels of seismicity can be measured; no epicenters can be located. The three stations in the Dutch Harbor-Akutan vicinity allow rough determinations of epicenters. The Cold Bay and Sand Point arrays allow relatively precise determination of hypocenters in the center of the Shumagin seismic gap which is the principal focus of the seismotectonic study. The dense array on Pavlof volcano is intended to provide data with which to search for a magma chamber beneath the volcano. This Pavlof array may also provide data with which to study the transport of magma within the root zone of the volcano and perhaps to study the relation of this activity to earthquakes.

V. DATA COLLECTION

To carry out studies of seismicity patterns, V_p/V_s ratios and b-values it is necessary to obtain as uniform a record as is possible of the locations and magnitudes of earthquakes which occur in the study area. This requires a geographically well-distributed network of stations which operate year-round. Since much of the study area is uninhabited and since it is useful to record as many stations as possible on a common time base, most of the stations operate unmanned on battery power and continuously radio-telemeter data to a central recording station. Recording stations are located at St. Paul, Dutch Harbor, Sand Point and Port Moller. These central stations record the seismic signal in continuous analog form on 16 mm film, 1" magnetic tape and/or heat-sensitive helicorder paper. The records are mailed to L-DGO where they are read, analyzed and archived. Punched cards containing hypocenter parameters for the located earthquakes are sent quarterly to the National Geophysical and Solar-Terrestrial Data Center (NGSTDC).

VI. RESULTS

The principal direct results of this study are the locations, origin times and magnitudes of earthquakes which occur within the study area. These data are sent on punched cards to NGSTDC along with maps and cross-sections of the hypocenters. L-DGO is currently compiling all the information of these maps and cross-sections into a catalog of the seismicity of the Shumagin Islands. Hypocenter cross-sections of recent data are included in this report. Copies of the catalog will be forwarded upon its completion.

Figures 1 through 9 show the most recent set of hypocenters, covering the period July-December 1976. These figures do not show any unusual migration patterns, as so far analyzed. Most of the events continue to occur within the less than twenty kilometers thick Benioff zone. An epicenter map of all the events located to date which are shallower than twenty kilometers (see Figure 10) shows no obvious linear alignments which might indicate an active fault. However, this data set is small and detailed geological work has not yet been done to identify possible active faults.

Magnitude Scale for Shumagin Vicinity

A preliminary coda-length magnitude scale for the Shumagin region has been established. For many events it is impossible to compute a magnitude from the amplitude of the signal because the record is clipped; that is, the largest amplitudes exceed the dynamic range of the telemetry system and are limited to some maximum cutoff value. It is desirable, therefore, to devise a magnitude scale based on the duration or coda length of the record. We selected all events which had been well-recorded without clipping and plotted the average-amplitude magnitude against the average coda-length for each event. This plot is shown in Figure 11. Error bars represent one standard deviation about the average. The straight line is plotted from the linear regression of the magnitudes against the coda lengths, the equation of which is given in the upper left-hand corner of the figure. The curved lines are three standard deviation limits (98.4% confidence level) about the regression line. The relation thus determined

$$M = 1.69 \log \tau + 0.04$$

is now being used to compute magnitudes for all of the events so far recorded. This uniformly determined set of magnitudes will be used in b-value calculations and extrapolation for estimates of occurrence of larger events for hazard evaluation.

Saint Paul Seismic Records

Short-period records from Saint Paul Island covering 11 months in the period November 1976 through September 1977 have been read. These readings are summarized in Table I. When classified by S-P time, as recorded at St. Paul, the events naturally fall into five categories. The first, 1-2 seconds, consisted of two questionable events whose source region would be on St. Paul Island, itself. The second, 8-23 seconds, consisted of six events (2?) which occurred 68-191 kilometers from St. Paul, assuming a surface focus. Since the only known active area at this distance range from St. Paul is the general vicinity of the St. George Basin (Davies *et al.*, 1976), these events are tentatively assigned to the NE St. George Basin. The third category, 50-81 seconds, consisted of 12 events in the distance range 450-774 kilometers. This range implies that these events most probably occurred in the Andreanoff Islands or on the Alaska Peninsula. The fourth category, 103-130 seconds, consisted of 13 events in the range 996-1247 kilometers. Ten of these events occurred on September 4, near Amchitka Island. For the other three events, the distance range is consistent with an origin in Cook Inlet or the Near and Rat Islands. The fifth category consists of 13 events (3?) which are clearly teleseismic and have no obvious S-phase.

VII. DISCUSSION

Shumagin seismic gap. While the data from the Shumagin vicinity show no obvious change indicative of an impending earthquake, all of the reasons for classifying this region as a seismic gap remain in force. Therefore the data collected to date continue to be a valuable and growing baseline data set against which to measure possible future change. Additional uses for this data set will be discussed in Section IV, Needs for Further Study.

Pribilof Islands-St. George Basin seismicity. As stated above, only two questionable events were recorded local to St. Paul Island and only 4-6 with S-P times appropriate for events in the St. George Basin area. It should be noted that the St. Paul seismograph must be run at very low magnification due to the extremely high level of surf noise present at the site. The surf noise level is especially high because of the proximity of the shore and the fact that the station is located on unconsolidated volcanic sand and gravel. The dominant period of this noise is approximately two to three seconds. It was necessary to strongly high-pass filter against this noise. Therefore the low-frequency response of the seismic system is especially low in sensitivity. Figure 12 shows the system magnification vs. frequency. It shows a 1 Hz magnification of 20 and a peak value of just under 2000 (at 25 Hz). Typical values for interior Alaska stations would be 100,000 and 1,000,000, respectively.

VIII. CONCLUSIONS

We have continued to collect basic seismic data from the southeast Bering Sea and western Gulf of Alaska. In particular, we have concentrated on the Pribilof Islands and eastern Aleutians - western Alaska Peninsula regions. The data show a very low but consistent level of activity on the Pribilof Islands. There is a suggestion that the St. George Basin may be moderately active. The Shumagin Islands vicinity continues to be quite active but less so than adjacent portions of the Aleutian arc, consistent with the identification of this area as a seismic gap.

IX. NEEDS FOR FURTHER STUDY

Pribilof Islands - St. George Basin. The low magnification of the St. Paul seismograph station has been emphasized above. An important contributing factor is the location of the station. If the station were to be relocated from its present site on unconsolidated sands and gravels to an outcropping of volcanic bedrock, it is possible that considerably higher magnifications could be achieved. If several such improved sites could be located (possibly even on St. George Island), then a telemetered array could be considered. The obvious advantage of the array is that events could be located. This would be of considerable interest in the case of the St. George Basin. We have recorded a number of earthquakes at St. Paul which have S-P times consistent with an origin in the St. George Basin. An alternative origin might be deep beneath St. Paul. There is a small but finite possibility that these earthquakes could be associated with the motion of magma at depth under St. Paul (see Nakamura et al., 1977 and Hopkins, 1976). An array in the Pribilofs would allow a determination of the exact location of these events and hence a discrimination between the above alternatives.

Shumagin seismic gap. If the data being collected from the Shumagin array are to be of maximum use in actually predicting a major earthquake, they need to be as uniform as possible. Studies of changes in V_p/V_s ratios, seismicity patterns and simple rates of seismicity all require consistent operation of most of the array. One of the major problems in obtaining a complete record from a remote region such as the Shumagin Islands is the recording system and its maintenance. It is difficult to find in this thinly settled region, an operator skilled and reliable enough to keep a Develocorder running 365 days a year. Therefore it would be highly desireable to replace the film recording system with a modern digital tape system. These systems require less operator attention than the film recorders. Two additional advantages of these systems result from the fact that they are computer compatible. This means that fewer personnel are required in data reduction and the results can be obtained much more quickly. The latter advantage is critical if a close-to real-time prediction program is desired.

X. SUMMARY OF 4TH QUARTER OPERATIONS

The fourth quarter was spent mostly in routine reduction of seismicity data and technical and logistic preparation for the field work.

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TABLE 1

Saint Paul Seismograph Readings

November 1976 - September 1977

(11 months)

S-P Range (seconds)	Distance Range* (kilometers)	Probable Source Region	Number of Events
1 - 2	8 - 17	Saint Paul Island	2?
8 - 23	68 - 191	Saint George Island to NE Saint George Basin	4 + 2?
50 - 81	460 - 774	Andreanoff Island or Alaska Peninsula	12
103 - 130	996 - 1247	Near and Rat Islands or Cook Inlet	13
> 200?	?	Teleseismic	10 + 3?

*Assuming surface focus.

FIGURE CAPTIONS

Figure 1. Western hypocenter cross-section, July through September 1976. Distances and depths are in kilometers. The projected location of the seismograph stations and the trend-line of the Aleutian volcanoes are shown along the top of the figure. The surface projection of the volume from which these hypocenters were plotted is shown by the box labeled "W" on the map given in Figure 10.

Figure 2. Western hypocenter cross-section, October through December 1976. Details same as Figure 1.

Figure 3. Western hypocenter cross-section, July through December 1976. Details same as Figure 1.

Figure 4. Central hypocenter cross-sections, July through September 1976. Details same as Figure 1, except that this section corresponds to box "C" in Figure 10.

Figure 5. Central hypocenter cross-sections, October through December 1976. Details same as Figure 4.

Figure 6. Central hypocenter cross-section, July through December 1976. Details same as Figure 4.

Figure 7. Eastern hypocenter cross-section, July through September 1976. Details same as Figure 1, except that this section corresponds to box "E" in Figure 10.

Figure 8. Eastern hypocenter cross-section, October through December 1976. Details same as Figure 7.

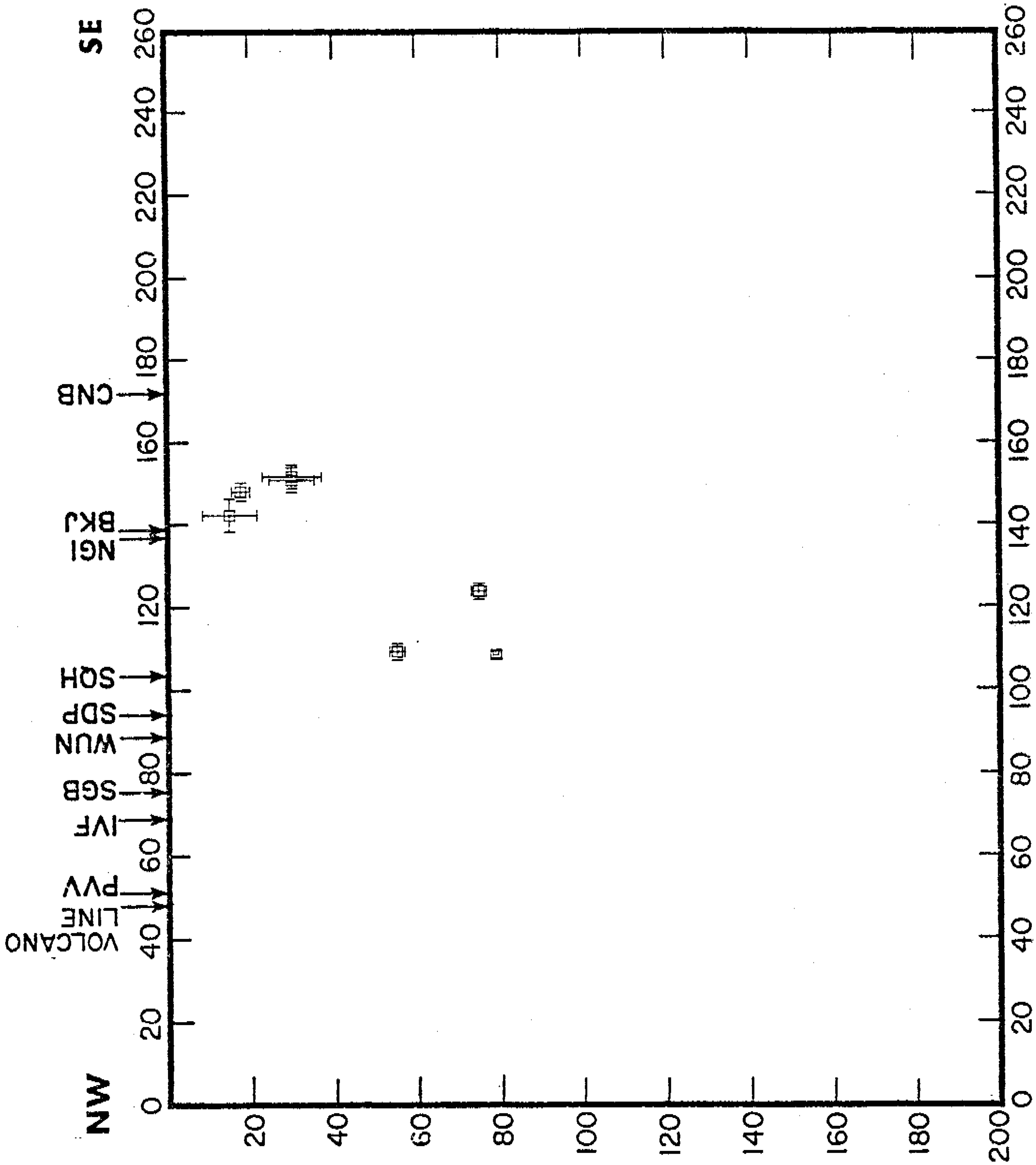
Figure 9. Eastern hypocenter cross-section, July through December 1976. Details same as Figure 7.

Figure 10. Shumagin Islands seismicity map, July 1975 through December 1976. The small boxes mark the epicenters of all of the shallow ($0 \leq H \leq 20$) earthquakes recorded during the above period. The number contained in the box represents the depth of the hypocenter in kilometers. The dashed boxes labeled "W", "C", and "E" correspond respectively to the western, central, and eastern hypocenter cross-sections shown in Figures 1 through 9.

Figure 11. "Richter" (local) magnitude vs. coda length for Shumagin Island earthquakes. Coda lengths were measured for a set of well-recorded earthquakes whose Richter (local) magnitudes could be calculated.

The heavy straight line shown was determined by linear regression of the average magnitudes for each earthquake against the average of the logarithm of the coda lengths. These average values are plotted as solid dots. The light crosses through each dot represent one-sigma estimates of the standard deviation of the average. The heavy curved lines represent the three-sigma estimates (98.4% confidence level) of the standard deviation of the average values from the regression line.

Figure 12. Frequency-dependent displacement magnification of the Saint Paul short-period seismograph, 6 October 1975. Note that sensitivity at the low frequency end is cut off sharply to suppress surf noise.



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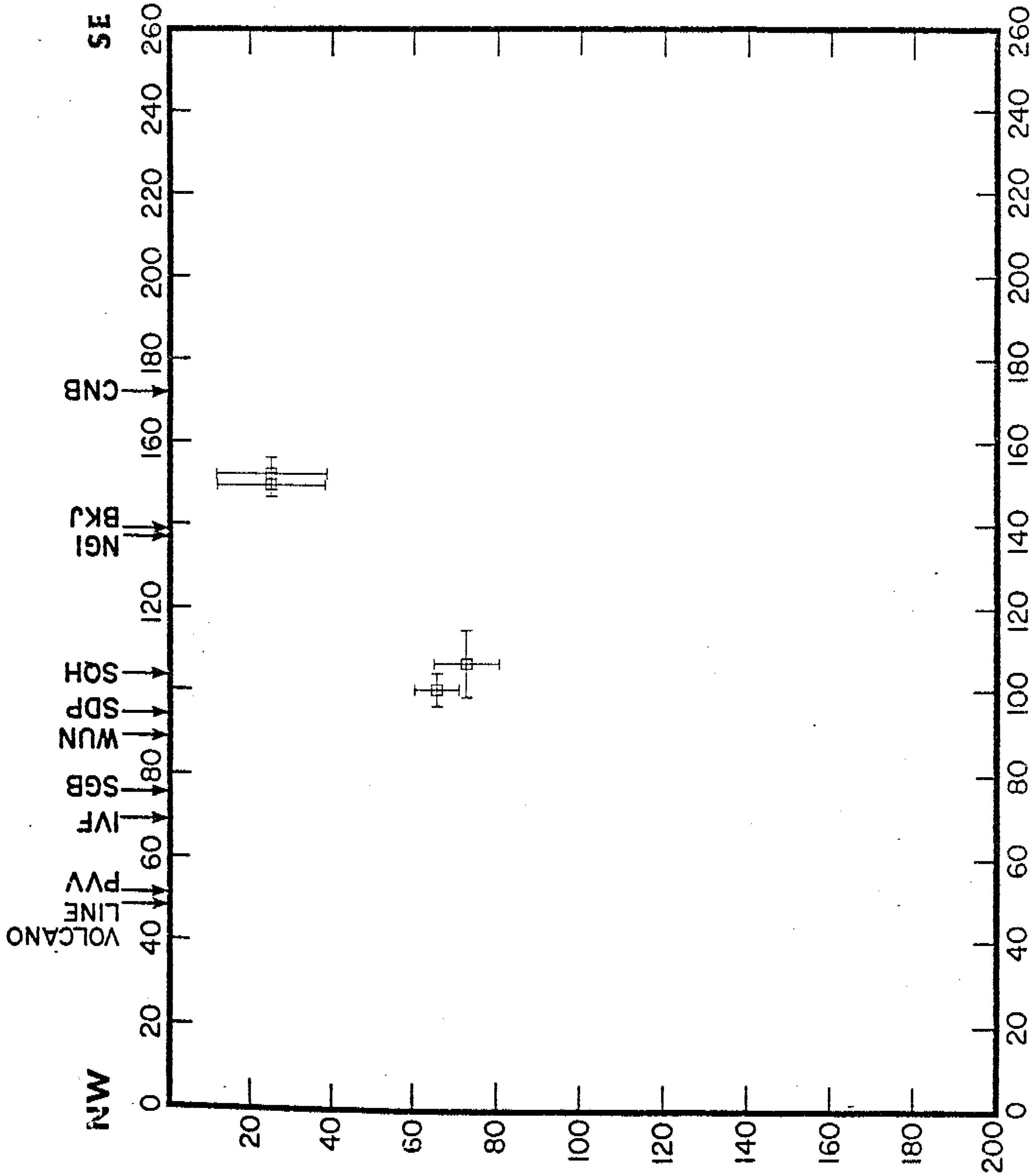
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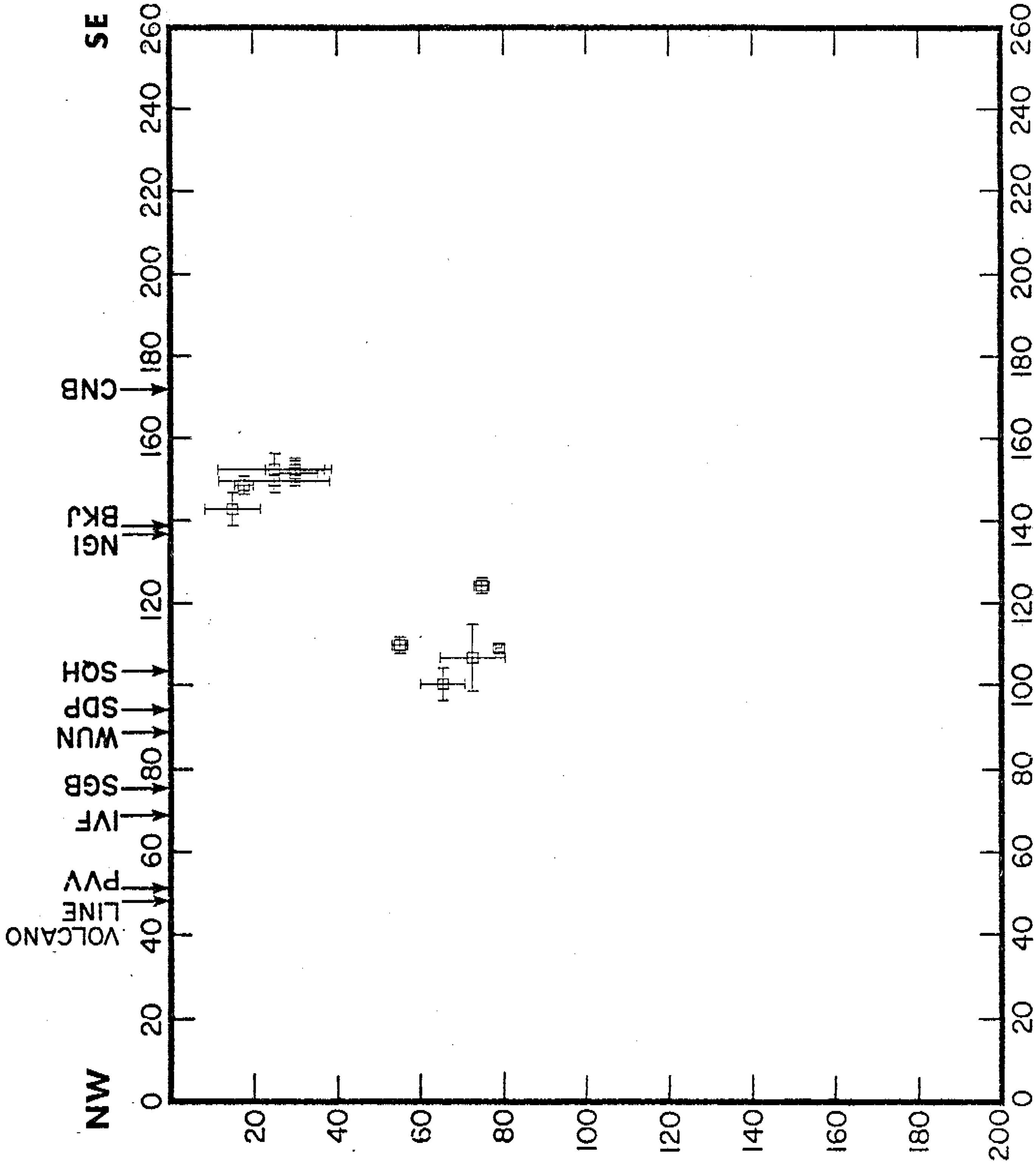

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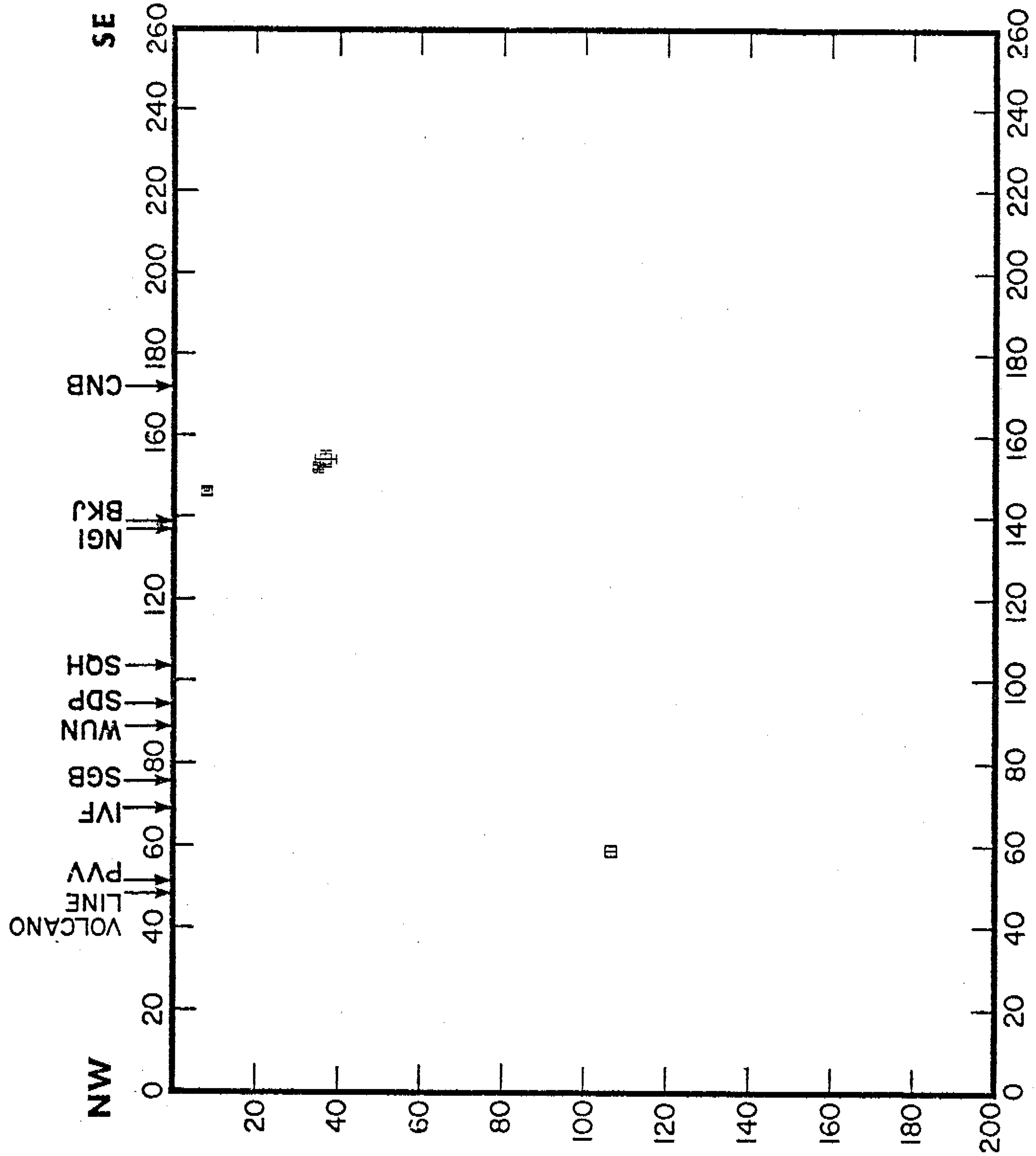

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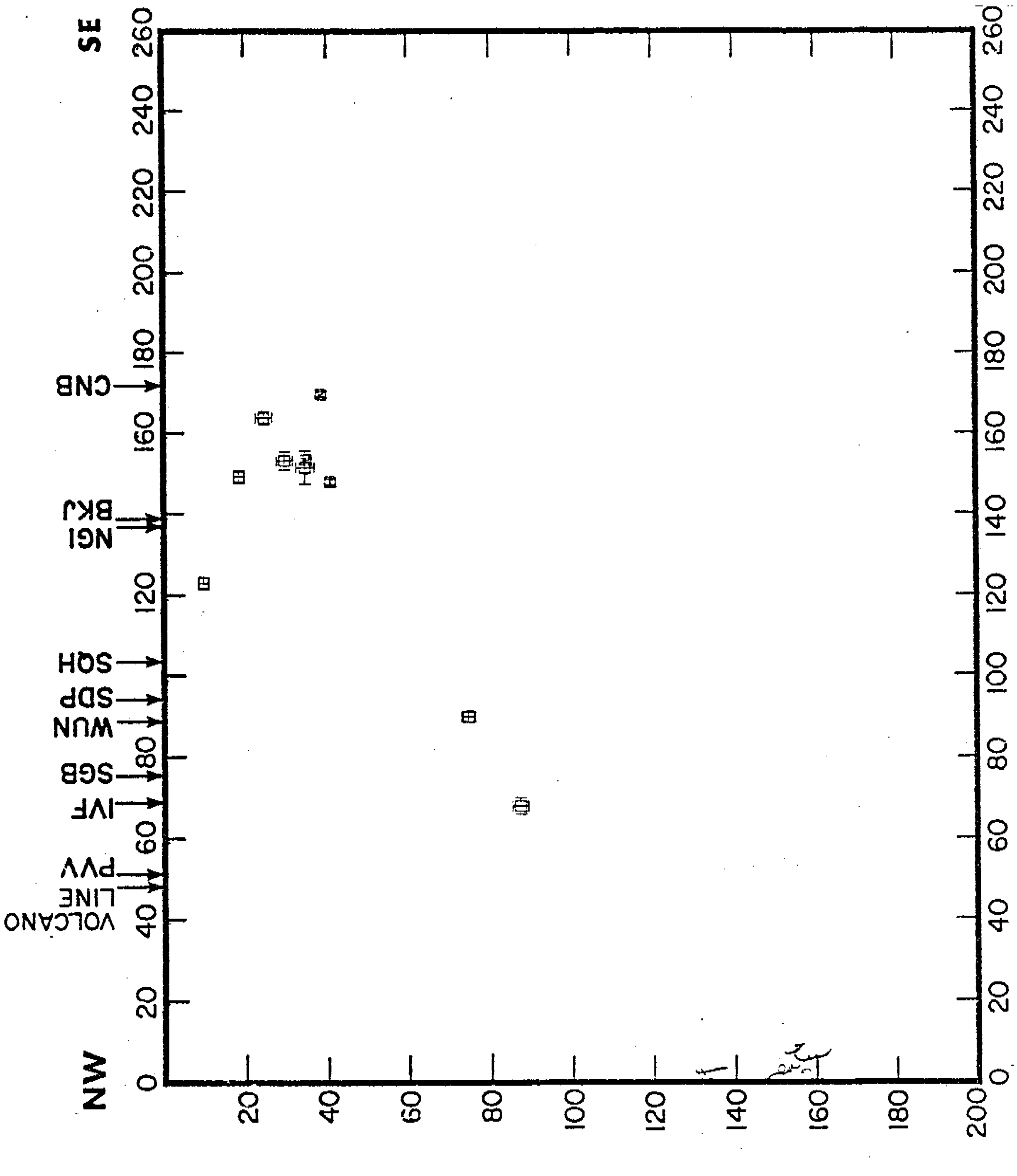

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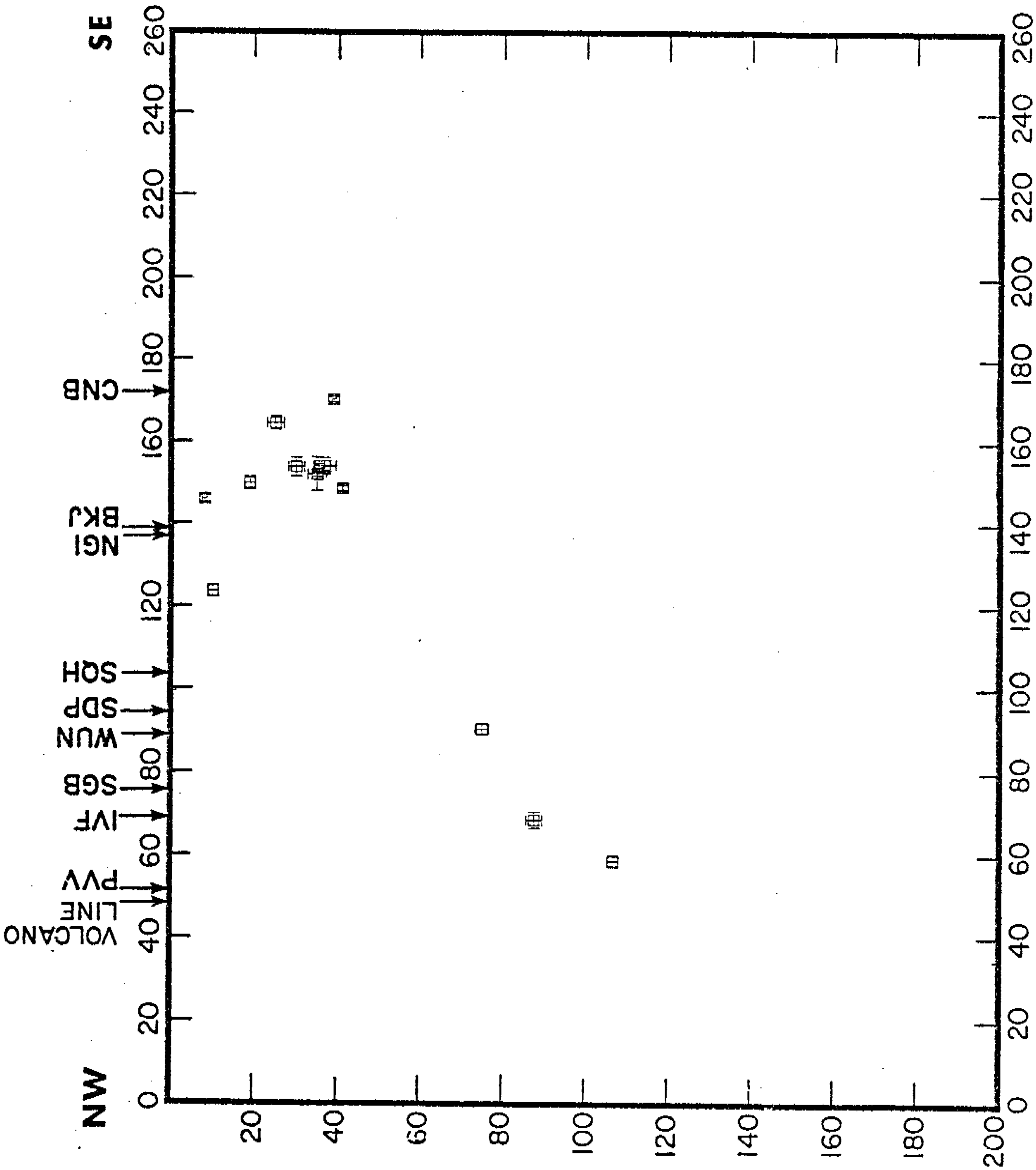

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Figure 6

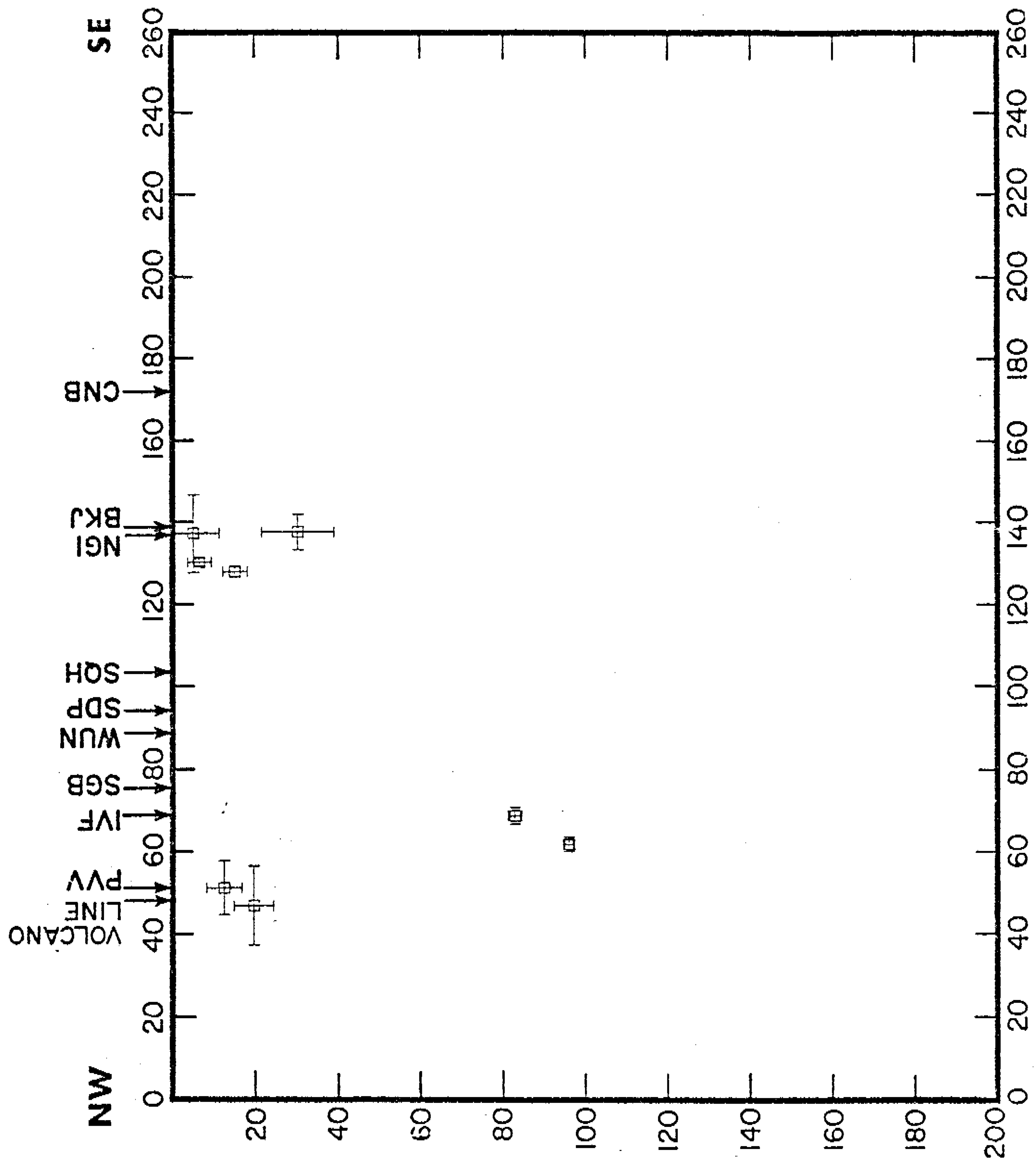
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Figure 7

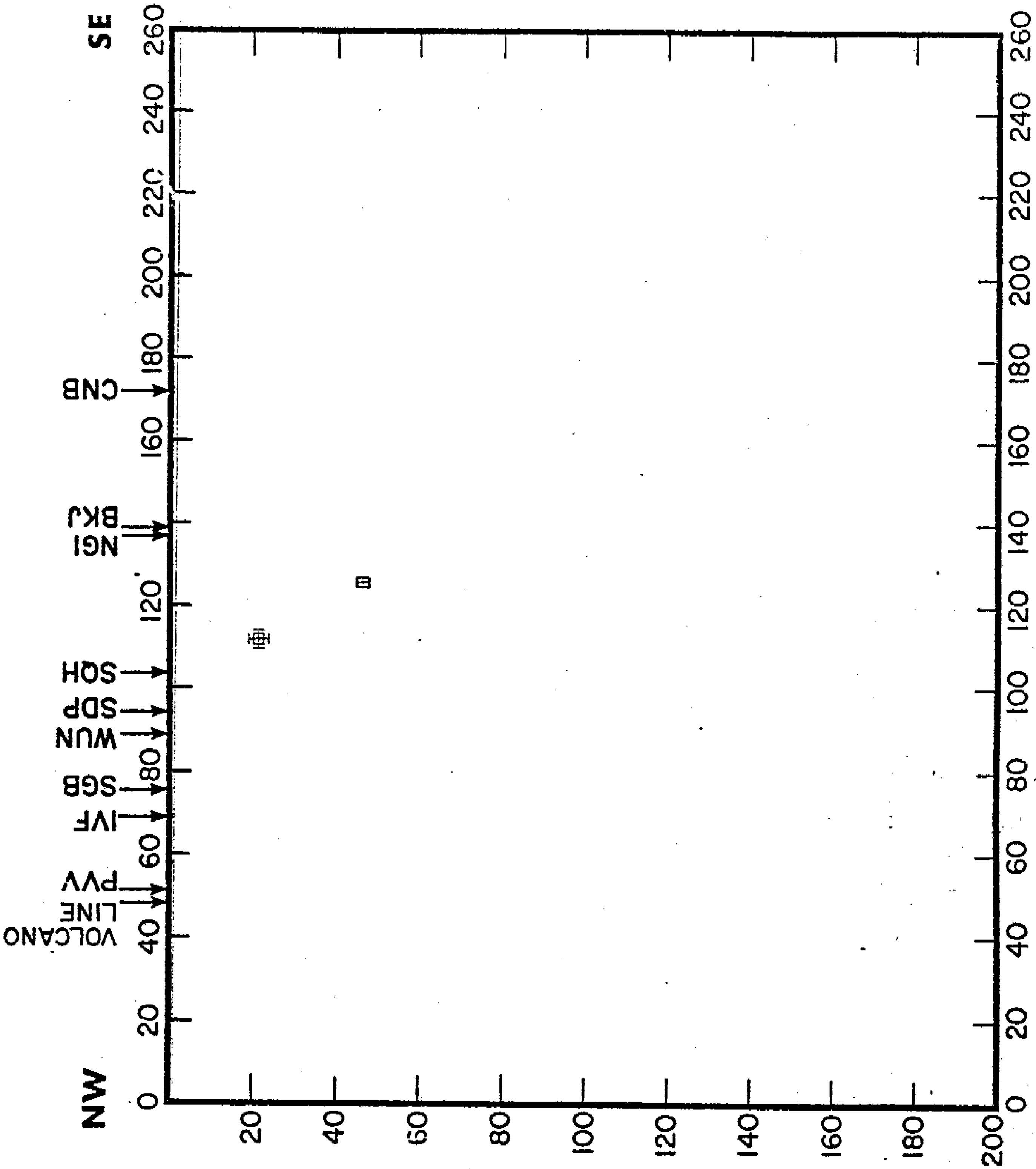
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Figure 8

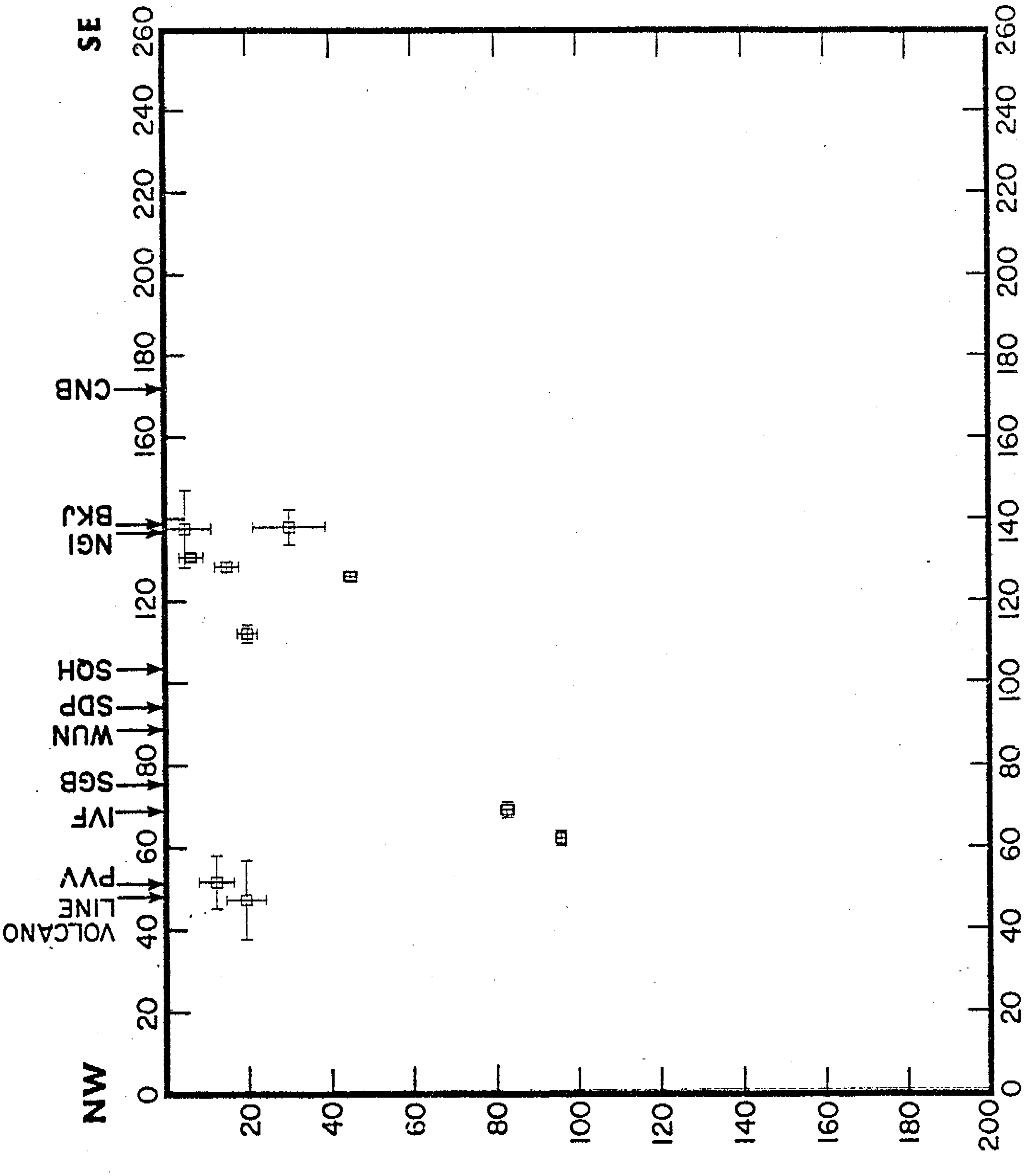


Figure 9

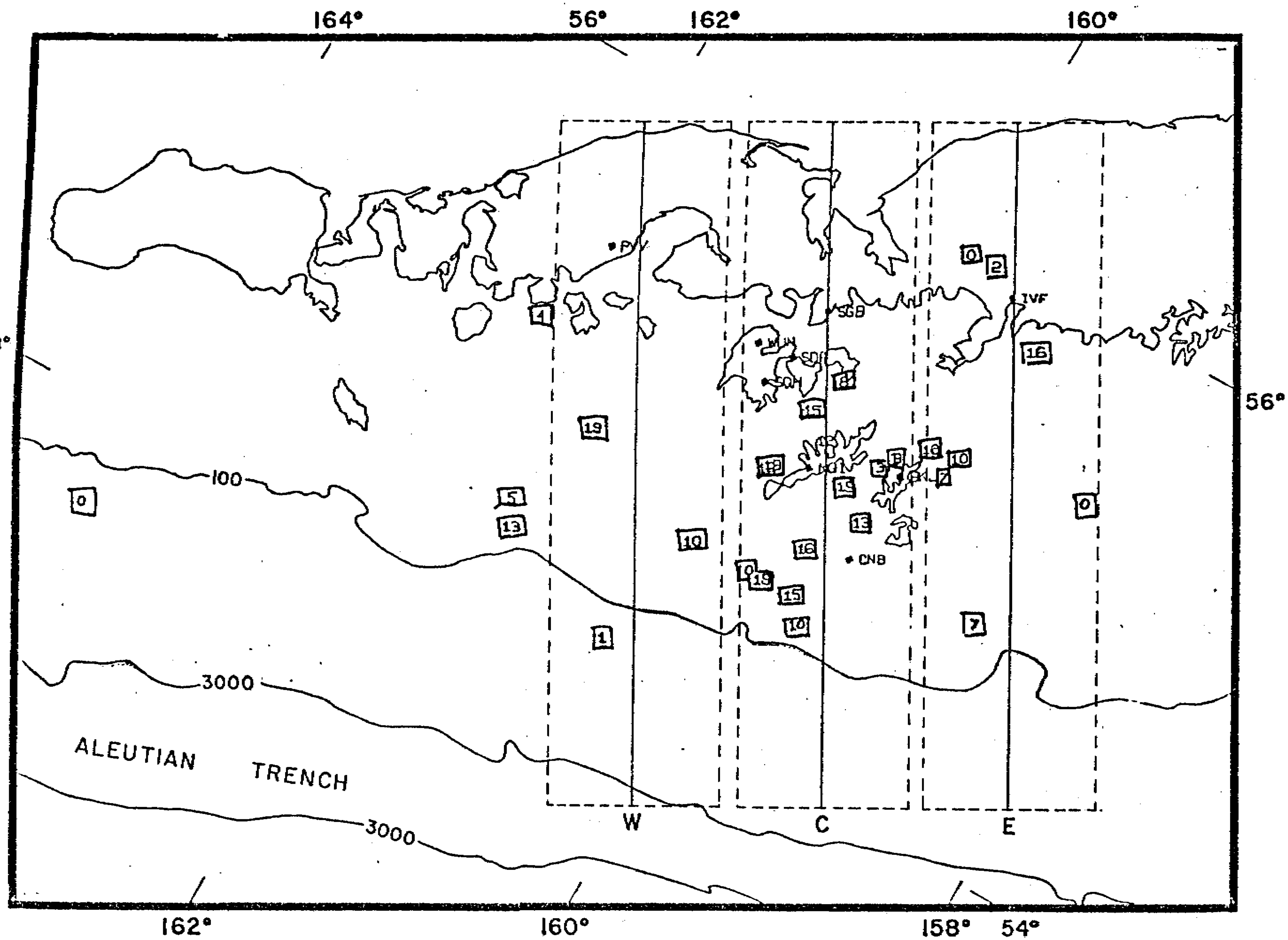

164°
56°
162°
160°
54°
56°
100
3000
ALEUTIAN TRENCH
3000
SGB
IVF
CNB
W
C
E
162°
160°
158°
54°

Figure 10

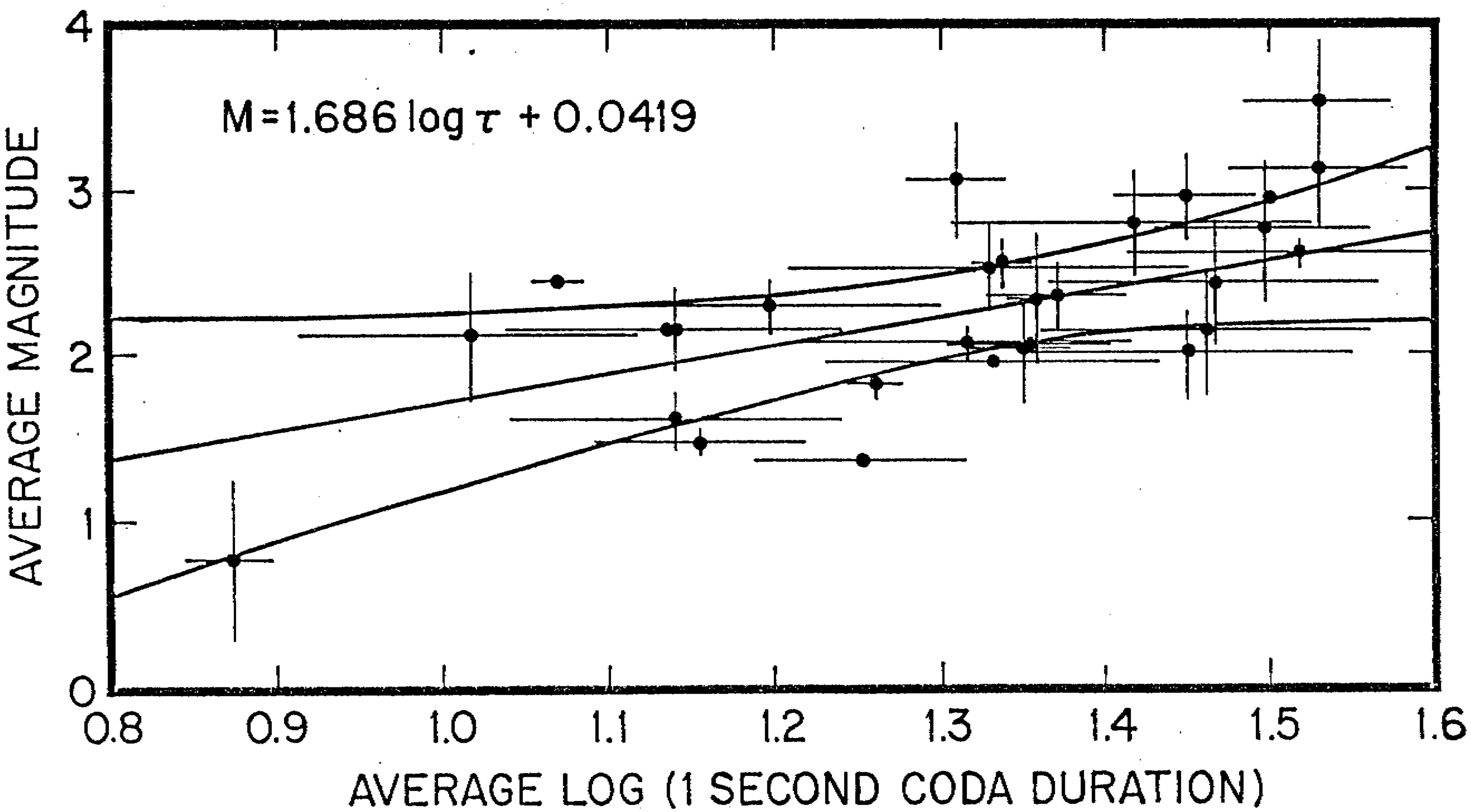

M=1.686 log τ + 0.0419
AVERAGE MAGNITUDE
AVERAGE LOG (1 SECOND CODA DURATION)
0
1
2
3
4
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6

Figure 11

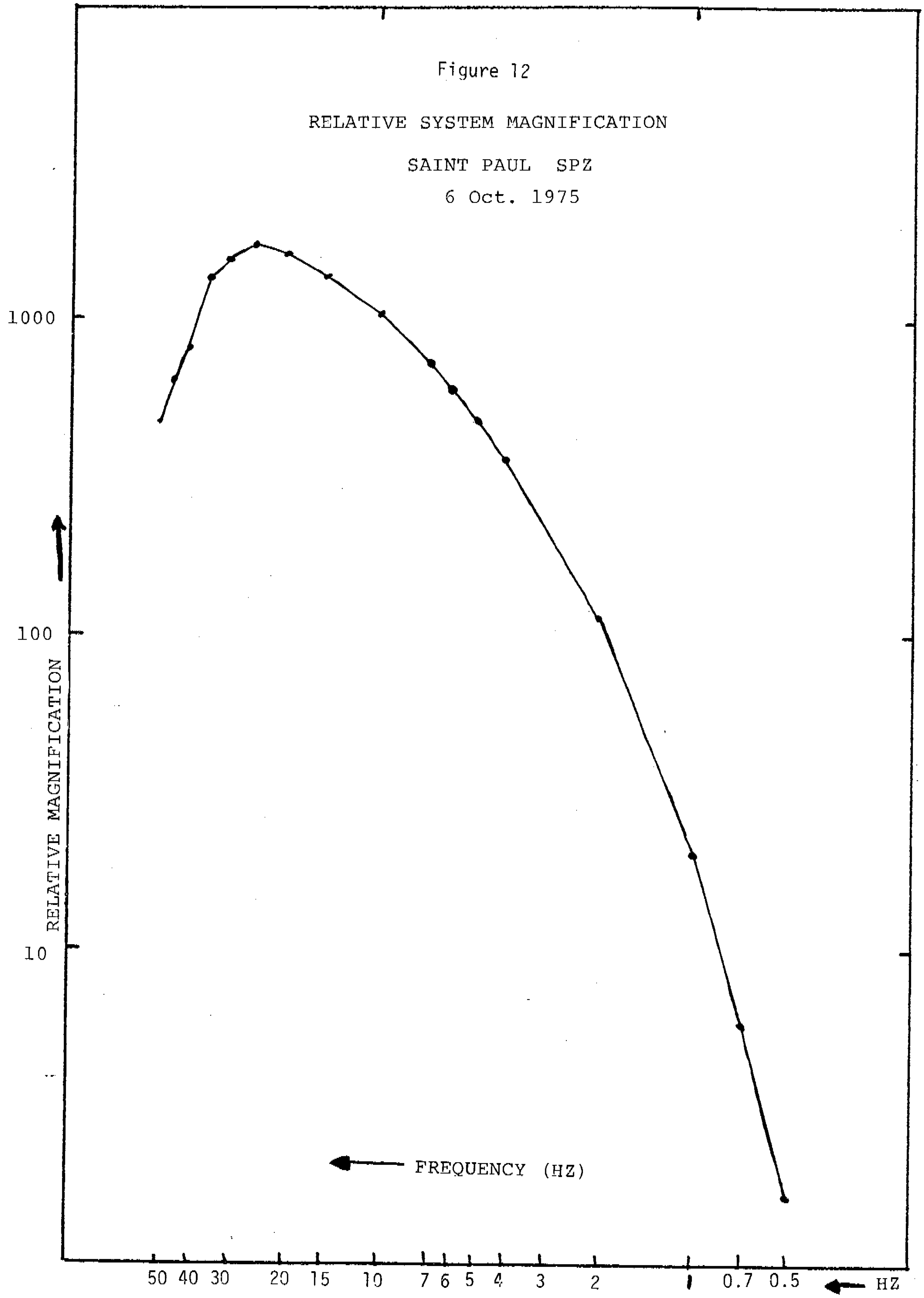


Figure 12
RELATIVE SYSTEM MAGNIFICATION
SAINT PAUL SPZ
6 Oct. 1975
1000
100
10
RELATIVE MAGNIFICATION
FREQUENCY (HZ)
50 40 30 20 15 10 7 6 5 4 3 2 1 0.7 0.5
HZ

QUARTERLY REPORT

Research Unit #59

COASTAL MORPHOLOGY, OIL SPILL VULNERABILITY AND SEDIMENTOLOGY OF THE NORTHERN GULF OF ALASKA

Miles O. Hayes - Principal Investigator

Christopher Ruby - Co- Investigator

Coastal Research Division
Department of Geology
University of South Carolina

Contract No. 03-5-022-82

October 1, 1977

I. Quarter's Accomplishments:

This quarter's primary activities were field oriented in the Beaufort Sea (see Quarterly Report submitted by Dag Nummedal to Fairbanks office).

Final completion of the NODC magnetic tape data submission was accomplished. Magnetic tapes containing complete beach profiles and complete grain size analysis of the Gulf of Alaska samples are enclosed. Data documentation forms are also included.

The "de-bugging" and final format corrections to our "in-house" programs has been completed and, hopefully, this will considerably reduce the time required for future submission of magnetic tape data sets.

Present activities are aimed at a detailed morphologic breakdown of our study area in Kotzebue Sound. An application of our oil spill vulnerability is also well underway and to be submitted in the next Quarterly Report.

II. Task Objectives:

The major emphasis of this project falls under task D4, which is to: evaluate present rates of change in coastal morphology, with particular emphasis on rates and patterns of man-induced changes, and locate areas where coastal morphology is likely to be changed by man's activities and evaluate the effect of these changes, if any. The relative susceptibility of different coastal areas will be evaluated especially as they relate to potential oil spill impacts.

III. Field and Laboratory Activities:

No field work was done in the Gulf of Alaska. Laboratory activity concentrated on the completion of computer programs to convert our programs to NODC guidelines.

Quarterly Report Continued

IV. Results

The results have been summarized under section I of this report.

V. Interpretation of Results

This data has been previously submitted in earlier progress reports and annual reports.

Enclosed please find:

1. One magnetic tape containing beach profile and grain size data.
2. Data documentation forms.
3. A partial listing of the information on the mag tapes.

QUARTERLY REPORT

Contract # 03-5-22-67, Task Order 6
Research Unit #87
Reporting Period: 1 July 1977 - 30 September 1977
Number of Pages: 2

THE INTERACTION OF OIL WITH SEA ICE IN THE BEAUFORT SEA

Seelye Martin

Department of Oceanography, WB-10

University of Washington

Seattle, Washington 98195

October 1, 1977

I. Task Objectives:

To understand the small scale interaction of petroleum and sea ice in the Beaufort Sea. Our eventual aim is to predict how an oil spill or well blow-out would interact with the mobile pack ice of the Arctic Ocean.

II. Laboratory Activities:

During the past quarter, we ran two experiments on the interaction of oil with sea ice. The first concerned the way in which ice entrains a pool of oil under a sheet of pack ice; the second modeled some of the processes which occur when oily sea ice is deformed into a pressure ridge.

In the oil entrainment under pack ice experiment, we released oil under a uniform columnar ice sheet, and then recorded both photographically and with a thermistor chain, the growth of ice around a 10 mm thick oil pool. The data is still being analyzed; briefly, because the oil is a thermal insulator, the ice crystals grew down below the oil surface, then grew in laterally from the sides.

For the pressure ridge model, we wanted to see if the thermal shock caused by submerging an ice block in which oil was entrained below the water surface, would open up the brine channels and allow oil to flow to the surface. In this experiment we submerged a 0.1 m thick block of ice which was instrumented with thermistors to a depth of about 0.1 m in sea water at $-2^{o}C$. The results were somewhat inconclusive; the interior temperature only reached $-3^{o}C$ before the water above the block refroze, and less than 1 ml of the 500 ml of oil in the block was released. We did find however, when the ridge was illuminated with simulated solar radiation, that the oil rapidly came to surface and formed oily melt ponds, where the oil on the surface absorbed heat preferentially over the surrounding white ice and caused the rapid growth of the ponds. Again, the data from this experiment is still being worked on and will be presented in a later report.

III. Estimate of Funds Expended:

As of this date, we are 99% expended.

QUARTERLY REPORT

R.U. #88: Dynamics of Near-Shore Ice
P.O.: 01-5-022-1651
Reporting Period: July 1977-Sept 77
Number of Pages: 8

DYNAMICS OF NEAR - SHORE ICE

Principal Investigators: A. Kovacs
and W. F. Weeks

Cold Regions Research and Engineering Laboratory

Hanover, New Hampshire 03755

October 1, 1977

I. Task Objectives

1. Narwhal Island

a. Collect quantitative information on the movements (velocities, directions, accelerations, and deformation rates) of the near-shore pack ice and the fast ice along the southern coast of the Beaufort Sea.

b. Make observations on major ice deformation features that occur near the edge of the fast/pack ice boundary.

c. Utilize an air-borne radar system for measuring variations in the thickness of sea ice.

d. Document the nature of the internal crystal structure of the fast ice in the vicinity of Narwhal Island.

2. Bering Strait

Obtain time-lapse photographs of an X-band radar display of sea ice movement through the Bering Straits.

3. Remote Sensing

Continue analysis of SLAR imagery and laser profiles of the near-coastal sea ice.

II. Field and/or Laboratory Activities

1. Narwhal Island

During the time period covered by this report no field observations were made and all project personnel were involved in data analysis and report writing. All ice motion data as well as standard meteorological observations made at Narwhal Island have been edited and are on file in our computer. A preliminary analysis of the orientation of c-axes has taken place. The orientations have been plotted on local maps of the area. Impulse radar data has provided surface dielectric constants for different ice types. Further analysis correlating radar attenuation with ice crystal c-axis orientation has taken place. Project personnel during this reporting period were A. Gow, A. Kovacs, W. B. Tucker, and W. F. Weeks.

2. Bering Strait

A cursory analysis of the data collected by the system has taken place in order to determine modifications that will improve imagery quality. A new time lapse camera has been acquired and timing circuits are being constructed at present. In addition, electronic filters and a voltage stabilizer to help overcome the somewhat erratic power situation at the site have been purchased. Installation of this equipment is expected in late October. Project personnel for this reporting period were M. Frank and W. F. Weeks.

3. Remote Sensing

Reduction of the laser profiles in the form of ridge counts (height and spacing) has been completed. Analysis of the winter and spring data is complete, and the remainder of the data is presently being analyzed.

III. Results

1. Published reports

a. Kovacs, A. (1977) Sea ice thickness profiling and under-ice oil entrapment. Proceedings of the Offshore Technology Conference, May 2-5, 1977.

b. Sodhi, D. S. (1977) Ice arching and the drift of pack ice through restricted channels CRREL Report 77-18.

c. Tucker, W. B., Weeks, W.F., Kovacs, A., and Gow, A.J. (1977) Nearshore ice motion at Prudhoe Bay, Alaska. Preprints of ICSI/AIDJEX Symposium on Sea Ice.

Processes and Models, Sept. 6-9, 1977.

d. Weeks, W.F., Tucker, W.B., Frank, M., and Fungcharoen, S., (1977) Characterization of the surface roughness and floe geometry of the sea ice over the continental shelves of the Beaufort and Chukchi Seas. Preprints of ICSI/AIDJEX Symposium on Sea Ice Processes and Models, Sept. 6-9, 1977.

2. Reports Completed and In Press

a. Gow, A.J. and Weeks, W.F. (1977) The internal structure of fast ice near Narwhal Island, Beaufort Sea, Alaska, CRREL Report 77- .

b. Kovacs, A., (1977) Iceberg thickness profiling, 4th International Conference on Port and Ocean Engineering under Arctic Conditions, St. Johns, Newfoundland.

c. Kovacs, A. (1977) Iceberg thickness and crack detection, 1st International Conference on Iceberg Utilization for Fresh Water Production, Weather Modification and Other Applications, Iowa State University, Ames, Iowa.

3. Reports in Preparation

a. Kovacs, A. (1977) The origin of rock debris found on sea ice North of Narwhal Island, Alaska, CRREL Report.

b. Weeks, W. F. and Gow, A. J. (1977) Preferred crystal orientations in the fast ice along the margins of the Arctic Ocean. CRREL Report.

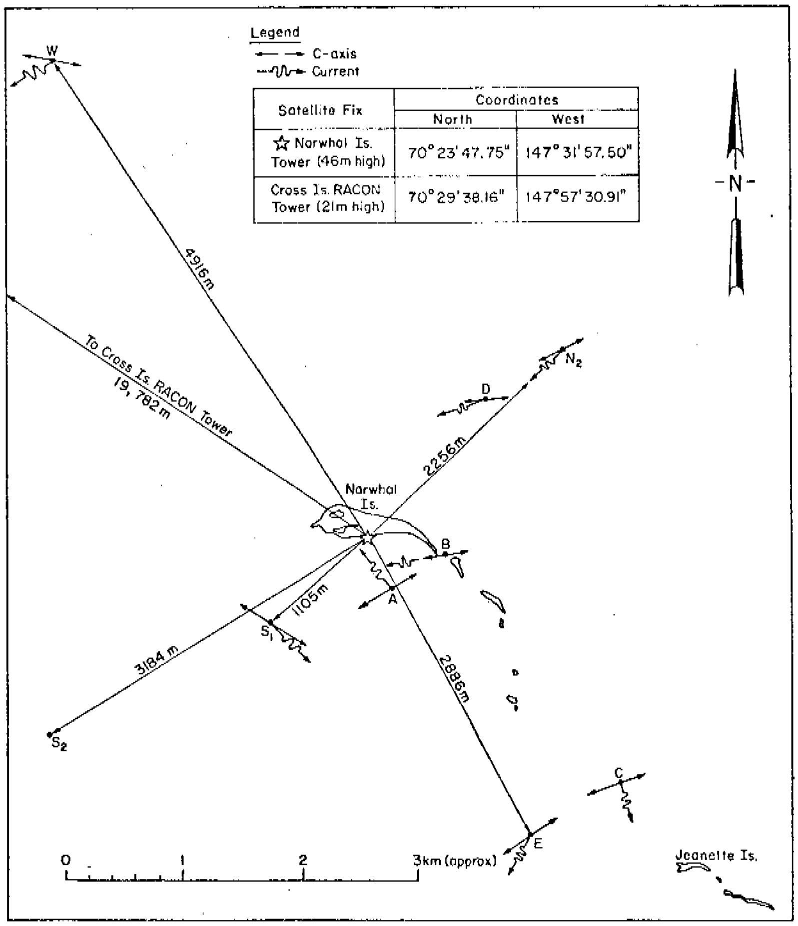
IV. New Results

1. Narwhal Island

a. The two field seasons of ice motion data near Narwhal Island provided no evidence of Beaufort Gyre movement (East to West) in this area as we and others had expected. Significant motions (>100 m) occurred only after periods of sustained wind. In general the nature of the motions indicate a large stress being exerted on this nearshore ice by the pack further offshore. The fast ice out for approximately 5 km North of the islands is relatively stable. Thermal expansion seems to dominate spring movements ($\sim$1.5 m) shoreward of the islands while stress cracking with larger movements ($\sim$5 m) can occur on the seaward smooth fast ice. Grounded ice in the shear zone helps to stabilize the ice in this area. The increase in movement during the 1977 season as compared to 1976 is attributed primarily to the fact that there was significantly less grounded ice in 1977.

b. The strong orientation of the c-axes in fast ice crystals seems to be aligned with prevalent current direction. In situ current measurements have shown agreement in most cases (see figure). Some disagreement is expected because the currents in this area are weak and variable and an instantaneous measurement may not reflect the long term current direction during the ice growing process. Industry seems quite concerned over these results as models of ice crushing strength only consider horizontally isotropic sea ice.

c. The surface dielectric constants of first year and multi-year sea ice were determined from impulse radar studies. It was also found that attenuation in first year sea ice was a function of c-axis orientation. The thickness of an ice island near Flaxman Island was determined with impulse radar profiles.



d. Ten ice islands were observed during the field season. One was located northeast of Cross Island and eight were found off Flaxman Island. Another was located off Herschel Island. All were within the fast ice and those along the Alaskan coast were believed to be grounded.

2. Bering Strait

a. The data from the first year has been examined to aid in proper modifications to the system to improve quality and resolution of the imagery for the coming year. While precise measurements of ice dynamics in the Strait have been difficult to obtain from this data, large ice velocities have been observed.

b. Physical modifications to the radar system at Tin City are due to take place in October.

V. Estimate of Funds Expended

a. FY 77 Funds

1. Narwhal Island

TOTAL	$161,930.00
SPENT	135,370.00
REMAINDER	$ 26,560.00

2. Bering Strait

TOTAL	$ 75,335.00
SPENT	58,826.00
REMAINDER	$ 16,509.00

3. Grant to Memorial University

TOTAL REMAINDER (1 & 2)	$43,069.00
SPENT	19,367.00
REMAINDER	$23,702.00

4. Funds for Fort Huachuka Remote Sensing

REMAINDER FROM (3)	$23,702.00
SPENT	10,000.00
REMAINDER	$13,702.00

5. Reduction of FY 77 Funds by NOAA

REMAINDER FROM (4)	$13,702.00
REDUCTION BY NOAA	13,702.00
REMAINDER	$00,000.00

QUARTERLY REPORT

Contract: 03-5-022-67
Research Unit: 98
Reporting Period: 1 June - 30 Sept 1977
Number of Pages: 3

DYNAMICS OF NEAR SHORE ICE

Norbert Untersteiner
Professor of Atmospheric Sciences and Geophysics
AIDJEX Project Director

Max D. Coon
AIDJEX Research Coordinator

Division of Marine Resources
University of Washington
Seattle, Washington 98195

I. TASK OBJECTIVES

The University of Washington under Task Order No. 5 of NOAA Contract 03-5-022-67 agreed to deploy ice buoys to gather data on ice movement and atmospheric conditions in the nearshore areas of the Beaufort and Chukchi Seas. In addition to this field program, the University agreed to process data and do model calculations.

II. FIELD AND LABORATORY ACTIVITIES

A. Field Trips Scheduled

None.

B. Scientific Party

None.

C. Methods

1. All buoys mentioned in this report are sampled by the Random Access Measurement System on board Nimbus VI satellite.

D. Sample Locations

The sites of the buoys at deployment and after drifting are as follows:

Buoy	Date	Lat.	Long.	Date	Lat.	Long.
1064	3/2	67.08°N	168,00°W	4/25*	67.12°N	168.16°W
1035	3/2	68.83°N	168.98°W	7/17*	71.84°N	171.48°W
1052	3/2	70.67°N	165.67°W	7/13*	72.94°N	174.57°W
1617	3/7	72.33°N	166.00°W	9/4	76.98°N	172.43°W
1023	3/13	69.67°N	173.67°W	7/10*	71.63°N	176.22°W
1305	3/13	70.92°N	173.75°W	5/3*	71.16°N	174.36°W
0632	3/22	70.62°N	147.25°W	5/30*	70.74°N	146.91°W

*Date expired.

E. Data Collected or Analyzed

1. The buoys mentioned in D above were tracked during this quarter.
2. Data from the first quarter of 1977 has been forwarded to the NOAA data bank.

III. RESULTS

A data report on the time history of the buoy positions is being prepared.

IV. PRELIMINARY INTERPRETATION OF THE RESULTS

None.

V. PROBLEMS ENCOUNTERED AND RECOMMENDED CHANGES

There have been no problems encountered during this quarter.

VI. ESTIMATE OF FUNDS EXPENDED

As of September 30, 1977, actual expenditures under this contract totalled $222,736. The estimated obligations for October are anticipated to be approximately $5,500.

I. TASK OBJECTIVES

The University of Washington under Task Order No. 5 of NOAA Contract 03-5-022-67 agreed to deploy ice buoys to gather data on ice movement and atmospheric conditions in the nearshore areas of the Beaufort and Chukchi Seas. In addition to this field program, the University agreed to process data and do model calculations.

II. FIELD AND LABORATORY ACTIVITIES

A. Field Trips Scheduled

None.

B. Scientific Party

None.

C. Methods

1. All buoys mentioned in this report are sampled by the Random Access Measurement System on board Nimbus VI satellite.

D. Sample Locations

The sites of the buoys at deployment and after drifting are as follows:

Buoy	Date	Lat.	Long	Date
1064	3/2	67.08°N	168.00°W	4/25*

Quarterly Report

Contract #03-5-022-56
Research Unit #99
Task Order #6
Reporting Period 7/1 - 9/30/77

THE ENVIRONMENTAL GEOLOGY AND GEOMORPHOLOGY OF THE COASTAL ZONE OF KOTZEBUE SOUND

Dr. P. J. Cannon
Solid Earth Science
University of Alaska
Fairbanks, Alaska 99701

October 1, 1977

QUARTERLY REPORT FOR QUARTER ENDING SEPTEMBER 30, 1977

Project Title:	The Environmental Geology and Geomorphology of the Coastal Zone of Kotzebue Sound
Contract Number:	03-5022-56
Task Order Number:	6
Principal Investigator:	Dr. P. Jan Cannon

I. Task Objectives

A. To produce three maps, with explanations, which will display certain baseline data necessary for an environmental assessment of the regions. The maps will be constructed from various types of remote sensing data.

1. Environmental geologic map of the entire forelands from Cape Prince of Wales to Cape Lisburne which will include the lowlands of the Kobuk Delta, the Noatak Delta, and the Kotzebue Moraine.

2. A coastal landforms map of the region identifying and describing important geomorphic features.

3. A map which indicates potential tectonic and geomorphic hazards.

B. To produce a report on the unique geologic setting of the Kobuk Delta indicating the possible effects (beneficial and adverse) of petroleum related development in the area.

C. Direct the acquisition of remote sensing data of the area for Cannon, Hayes and other investigators.

D. Construct a mosaic of the area of sequential LANDSAT data for Cannon, Hayes, and other investigators.

E. Construct an annotated mosaic of the area from SLAR imagery.

II. Activities

A. Performed photointerpretation of areas having questionable map units.

B. Continued compilation of maps.

C. Attempted reconnaissance of Noatak area in August.

III. Results

The continued photointerpretation has provided information which indicates that the large lakes in the Seward Peninsula are talik lakes and there are no geomorphic indicators which support the existence of volcanic maars.

IV. Preliminary Interpretation of Results

The model for the origin of talik lakes has been modified to exclude the postulated effects of prevailing winds.

V. Problems Encountered

Field work and reconnaissance were hindered during August by smoke from the many fires in the area. Visibility was often less than 200 meters. It is hoped that remote sensing data will provide enough information to complete the mapping of areas that couldn't be visited because of the smoke.

Contract no. - 01-50-22-2313
Research Unit no. - 105
Reporting period - 30 June 1977 - 30 September 1977
Number of pages - 3

Quarterly Report
to

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Arctic Projects Office
Fairbanks, Alaska

DELINEATION AND ENGINEERING CHARACTERISTICS OF PERMAFROST BENEATH THE BEAUFORT SEA

Principal Investigator:
P.V. Sellmann

Associate Investigators:
J. Brown
S. Blouin
E. Chamberlain
I. Iskandar
H. Ueda

October 1, 1977

CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

I. TASK OBJECTIVES

The emphasis of this program is on quantifying the engineering characteristics of permafrost beneath the Beaufort Sea, and determining their relationship to temperature, sediment type, ice content and chemical composition. These data will be used in conjunction with those from the other OCSEAP marine and subsea permafrost projects to develop a map portraying the occurrence and depth of permafrost under the Beaufort Sea. The drilling program is providing subsurface samples and other controls for the other programs. It is also designed to test drilling, sampling, and in-situ measurement techniques in this offshore setting where material types and ice conditions make acquisition of undisturbed samples extremely difficult.

Our current activities are being jointly undertaken with the USGS program RU204, and Dr. Robert Lewellen's ongoing ONR project that was previously based at Barrow. We are also working closely with the University of Alaska OCS projects.

II. FIELD OR LABORATORY ACTIVITIES

A. Ship or Field Trip Schedule:

No field work during quarter.

B. Scientific Party:

No field work during quarter.

C. Methods:

See previous reports.

D. Sample Localities:

See last quarter's report for details.

E. Data Collected or Analyzed:

Engineering Properties

The laboratory program for determining the engineering properties of the samples obtained this past field season continued throughout the quarter. Samples were processed for water content, density, compressive strength, grain size, Atterberg limits, specific gravity, organic content, and consolidation characteristics.

The range of material properties determined to date for each drill site is given in Table I. The general range of values are similar to those obtained during previous sampling programs.

TABLE I. Preliminary Index and Engineering Property Results from 1977 Field Program.

Site	Water content (%)	Dry density (mg/m^3)	Specific gravity	Liquid limit (%)	Plastic limit (%)	Grain size class	Comp. strength (kPa)	Overconsolidation stress (kPc)	Overconsolidation ratio
PB-5	31-37	1.35-1.44	-	-	-	-	70-100	-	-
PB-6	18	1.80	-	-	-	-	80	-	-
PB-7	-	-	-	-	-	-	-	-	-
PB-8	20-39	1.33-1.74	2.70-2.75	23-28	18-27	OL-ML	50-185	170-600	2-14

Preliminary analysis of the results for site PB-8, which is shoreward of Reindeer Island, indicate that the fine-grained sediments (clays) that overlie the coarser grained section are lightly overconsolidated. This is in contrast to the very highly overconsolidated clays found last year at site PB-2, seaward of Reindeer Island. These new data still support our earlier ideas concerning the mechanism for the overconsolidation of the sediments found seaward of Reindeer Island; this overconsolidated being attributed to freezing and thawing during shoreward transgression of the offshore islands.

Probe Data

Continuous printout of load/depth for the static probe provides data that correlated with the lithology and engineering properties from the drill holes. Data on penetration resistance was also useful in determining occurrence of ice-rich sediment, usually found near the seabed in water depths of less than 2 meters. These results will be used for interpretation of geologic and engineering properties between drill holes.

Shallow temperature data obtained with the probe is providing valuable thermal information for areas between the deeper bore holes which were logged by the USGS. For instance, anomalies of very low temperatures in the region of the Sagavanirktok River were found.

Chemical Properties

During the previous quarter, approximately 100 sediment samples and 200 water samples were collected from Prudhoe Bay, Alaska. Initial processing of these samples were carried out at the CRREL Office in Fairbanks, During this quarter, the chemical analysis of the interstitial water and sediment samples were completed. Analyses of water sample include the determination of the sodium, potassium, calcium and magnesium concentrations by atomic absorption spectrophotometry, and the determination of chloride and sulfate ion concentrations by titrametric methods. Preliminary results show that these analyses are in good agreement with last year's analyses. Sediment analyses included the determination of the organic carbon content by wet chemical oxidation and the determination of calcium carbonate content. Again, results were in good agreement with last year's data.

III and IV. RESULTS AND DISCUSSION

Two papers were accepted for publication in the Third International Conference on Permafrost:

1. Chamberlain, E.J., P.V. Sellmann, S.E. Blouin, D.M. Hopkins, and R.I. Lewellen, Engineering Properties of Subsea Permafrost in the Prudhoe Bay Region of the Beaufort Sea.

2. Iskandar, I.K., T.E. Osterkamp, and W.D. Harrison, Chemistry of Interstitial Water from Subsea Permafrost, Prudhoe Bay, Alaska.

A paper is being presented by P.V. Sellmann at the Symposium on Permafrost Field Methods and Permafrost Geophysics, Saskatoon, 3-4 October 1977, entitled "Results of Offshore Permafrost Drilling in the Beaufort Sea, Alaska."

An annual CRREL report entitled "Operational Report - 1977 USACRREL-USGS Subsea Permafrost Program, Beaufort Sea, Alaska," has been prepared and is being reviewed.

V. PROBLEMS ENCOUNTERED/RECOMMENDED CHANGES

None

VI. ESTIMATE OF FUNDS EXPENDED

It is projected that as of 30 September 1977 all FY 77 funding at CRREL were obligated.

QUARTERLY REPORT

RESEARCH UNIT #: 204
REPORTING PERIOD: July 1, 1977 to September 1, 1977
NUMBER OF PAGES: 11

OFFSHORE PERMAFROST STUDIES, BEAUFORT SEA

Scientific Staff: D. M. Hopkins
R. E. Lewellen
V. Marshall
J. Blueford
P. A. Smith

October 1, 1977

Research Unit #204: Quarterly Report, July-August-September, 1977

OFFSHORE PERMAFROST STUDIES, BEAUFORT SEA

I. Abstract of Highlights

Equilibrium temperatures have been calculated for the four 1977 offshore boreholes, and the data are presented in this report.

A fossil marine amphipod has been collected from an organic horizon at a depth of 13.6 m in borehole PB-7. This horizon has previously been dated as 22,300 $\pm$ 1,300 years old, but a new radiocarbon sample associated with the fossil suggests that the horizon may, in fact, be 40,000 years or older.

II. Task Objective: D-9

III. Field and Laboratory Activities:

A. Field Activities: None

B. Scientific Party:

D. M. Hopkins, geologist and P.I.
R. E. Lewellen, geologist and chief driller
Vaughn Marshall, geophysicist, geothermal studies
Joyce Blueford, technician, prepare microfossil samples
Peggy A. Smith, technician, pick radiocarbon samples

C. Methods of Analysis: One radiocarbon date in progess.

D. Sample Localities

As in previous Quarterly Reports (seven offshore and one onshore boreholes in the Prudhoe Bay area).

E. Data Collected or Analyzed:

All microfossil samples washed and picked.
One radiocarbon date in progress.
Calculation of geothermal profiles completed.

IV. and V. Results and Interpretation:

A. Borehole temperatures in our 1977 boreholes were observed on the following dates:

PB-5 4/20/77
PB-6a 4/17/77; 4/22/77; 4/30/77; 5/29/77
PB-7 4/24/77; 4/29/77; 5/04/77; 5/31/77
PB-8 5/02/77; 5/06/77; 6/02/77.

The single log of PB-5 was made 18 days after drilling was completed and is essentially an equilibrium profile for this briefly occupied borehole. The temperature measurements are tabulated and plotted as part of Appendix I. Equilibrium profiles for

PB-6a, PB-7, and PB-8 have been calculated and are also tabulated and plotted as part of Appendix I. The individual observed thermal logs for PB-6a, PB-7, and PB-8 are omitted but will be furnished to interested investigators upon request.

B. The posterior part of a small marine amphipod, probably Onisimus affinis, was found in a wash sample recovered between depths of 13.3 and 13.6 m below sea level in borehole PB-7. The amphipod was identified by Dr. Charlotte Holmquist of the Swedish Museum of Natural History, Stockholm, who reports that the animal is presently distributed in shallow water on the continental shelf and in bays and estuaries of the Beaufort Sea but not in fresh-water bodies (written commun., 8/77).

The fossil marine amphipod was recovered from a widespread organic horizon that seems to be represented in most of the offshore boreholes and also possibly in some of the deeper gravel pits onshore at Prudhoe Bay. A small sample of wood, recovered at a depth of 13.7 m below sea level in Osterkamp and Harrison's borehole 3370, located within a few tens of meters of our borehole PB-7, has yielded a radiocarbon age of 22,300 ± 1,300 years (AU-115, T. E. Harrison and W. D. Osterkamp, University of Alaska Geophysical Institute Report UAG R-245). However, organic material directly associated with the amphipod is now being dated in the Menlo Park radiocarbon laboratory of the Geological Survey and appears to be near or possibly older than the limit of radiocarbon dating (i.e. near or older than 40,000 years).

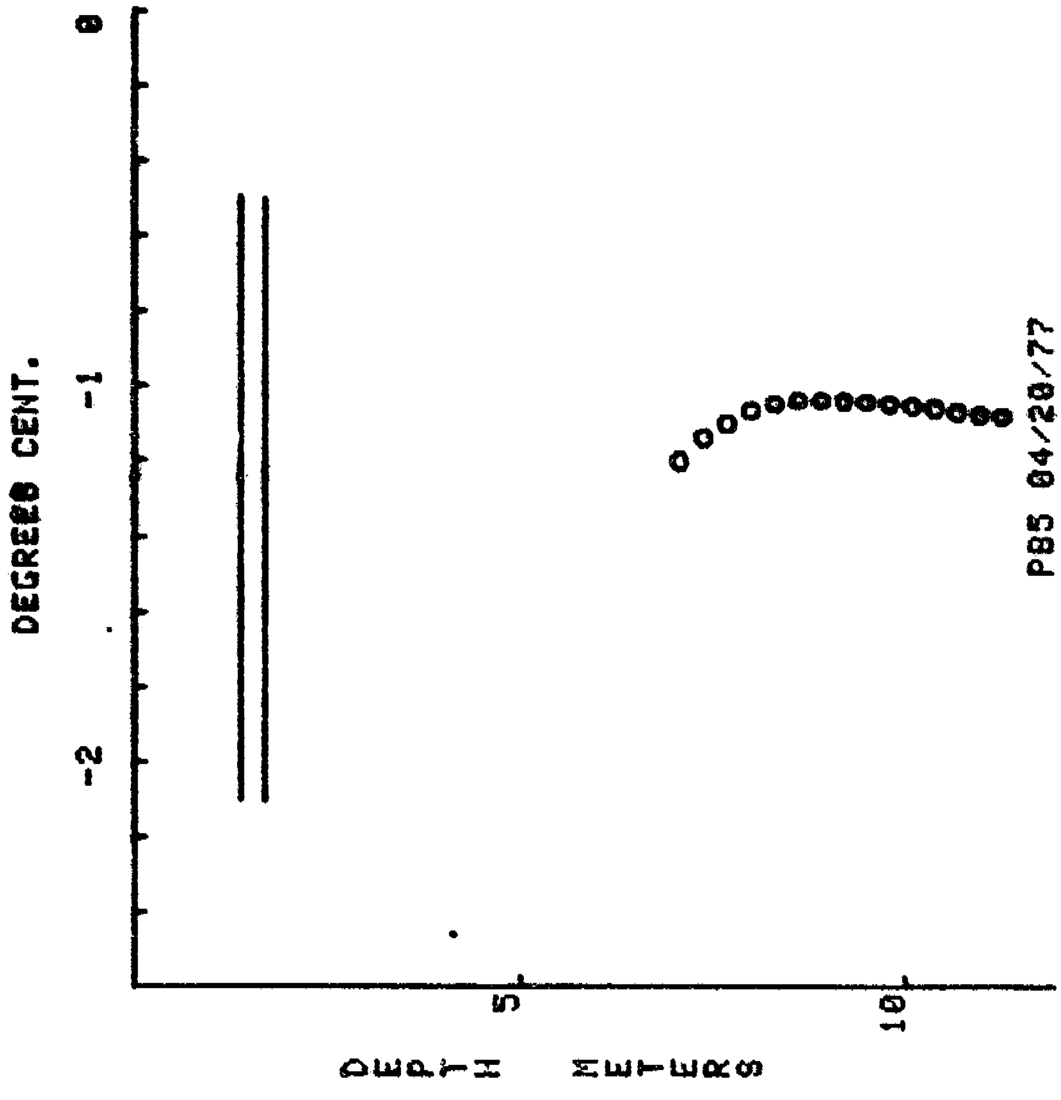
The deposit of sand, gravel, and detrital peat in PB-7 appears to be a non-marine fluvial deposit, but the presence of the fossil marine amphipod suggests that it may have been so near to the coast as to lie occasionally within the zone flooded during storm surges. The shoreline must have lain very nearby. Thus, a more refined dating of this peaty horizon will provide valuable information on long-term sea-level history in the Prudhoe Bay area.

VI. Problems encountered and recommended changes: None.

VII. Estimate of funds expended to date: All.

VIII. Bibliography: None.

Appendix I. Thermal Data.

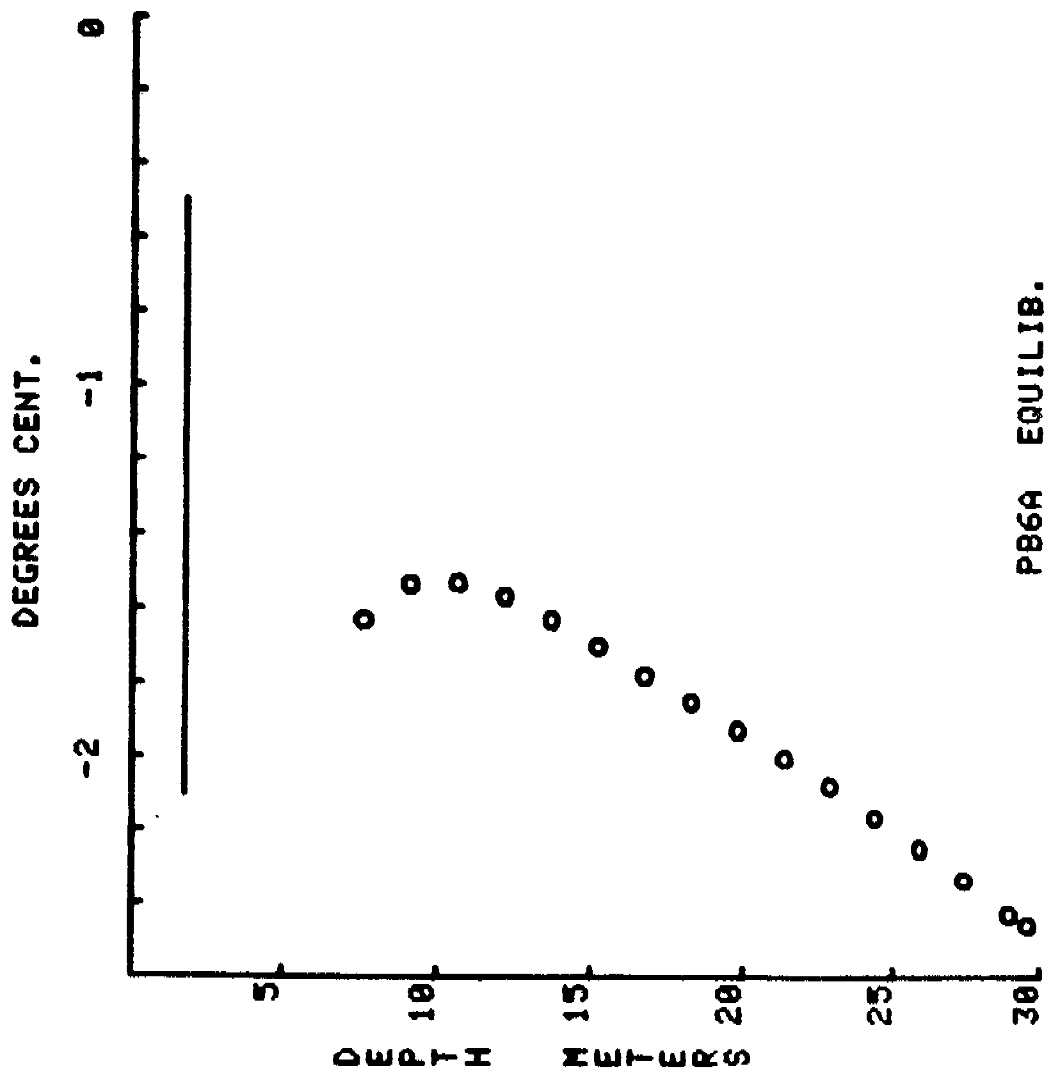


Appendix I. Thermal Data.

PB5

DEPTH(M)	TEMP(C)
-7.04	-1.2025
-7.35	-1.1399
-7.65	-1.1008
-7.96	-1.0686
-8.26	-1.0476
-8.56	-1.0399
-8.87	-1.0406
-9.17	-1.0420
-9.48	-1.0441
-9.78	-1.0497
-10.09	-1.0546
-10.39	-1.0616
-10.70	-1.0707
-11.00	-1.0885
-11.31	-1.0826

Appendix I. Thermal Data.

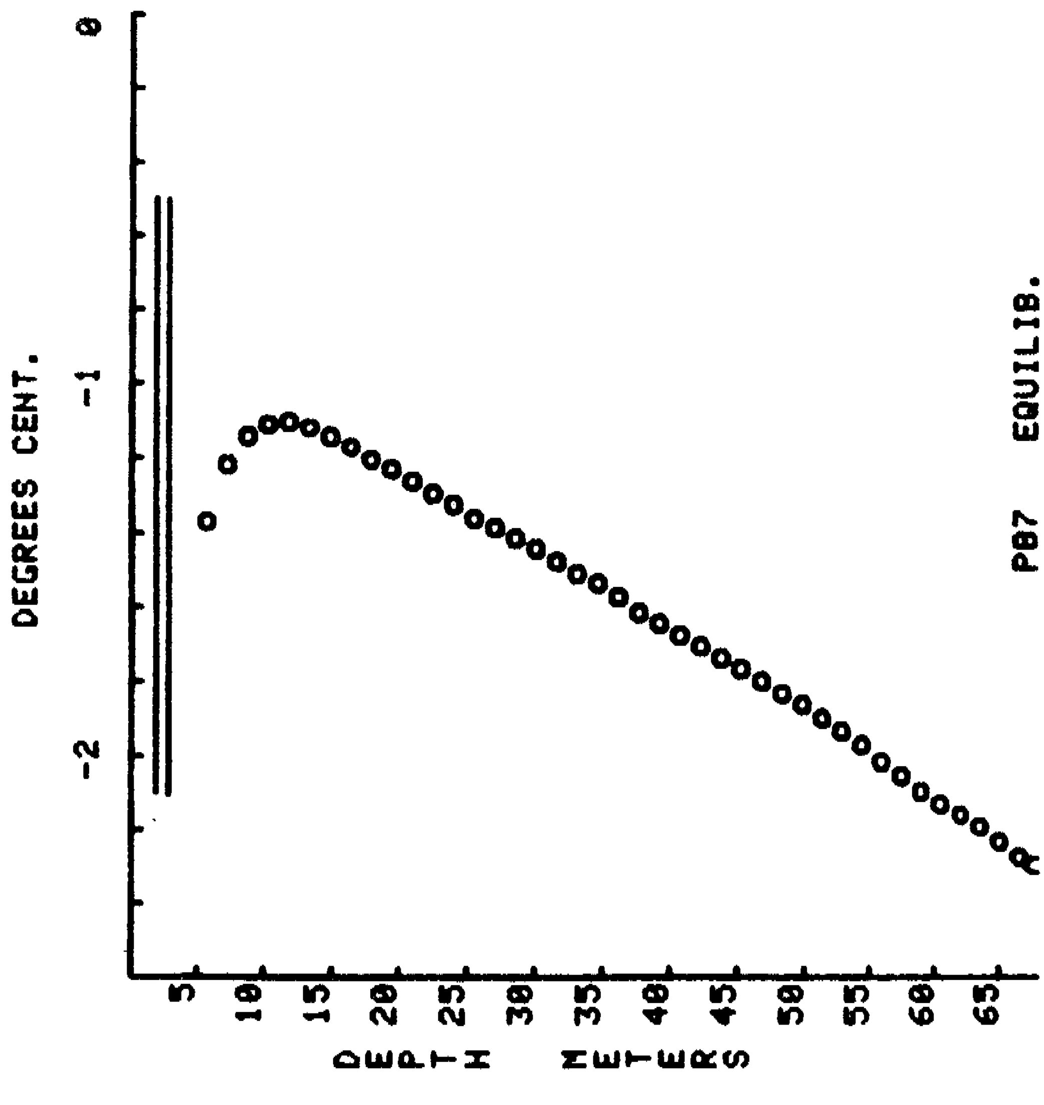


DATA

X	Y
-1.631	-7.62
-1.536	-9.14
-1.534	-10.67
-1.57	-12.19
-1.632	-13.72
-1.703	-15.24
-1.781	-16.76
-1.852	-18.29
-1.93	-19.81
-2.009	-21.34
-2.083	-22.86
-2.168	-24.38
-2.255	-25.91
-2.338	-27.43
-2.433	-28.96
-2.46	-29.6

PB6A - EQ. TEMPS.

Appendix I. Thermal Data.



Appendix I. Thermal Data.

DATA

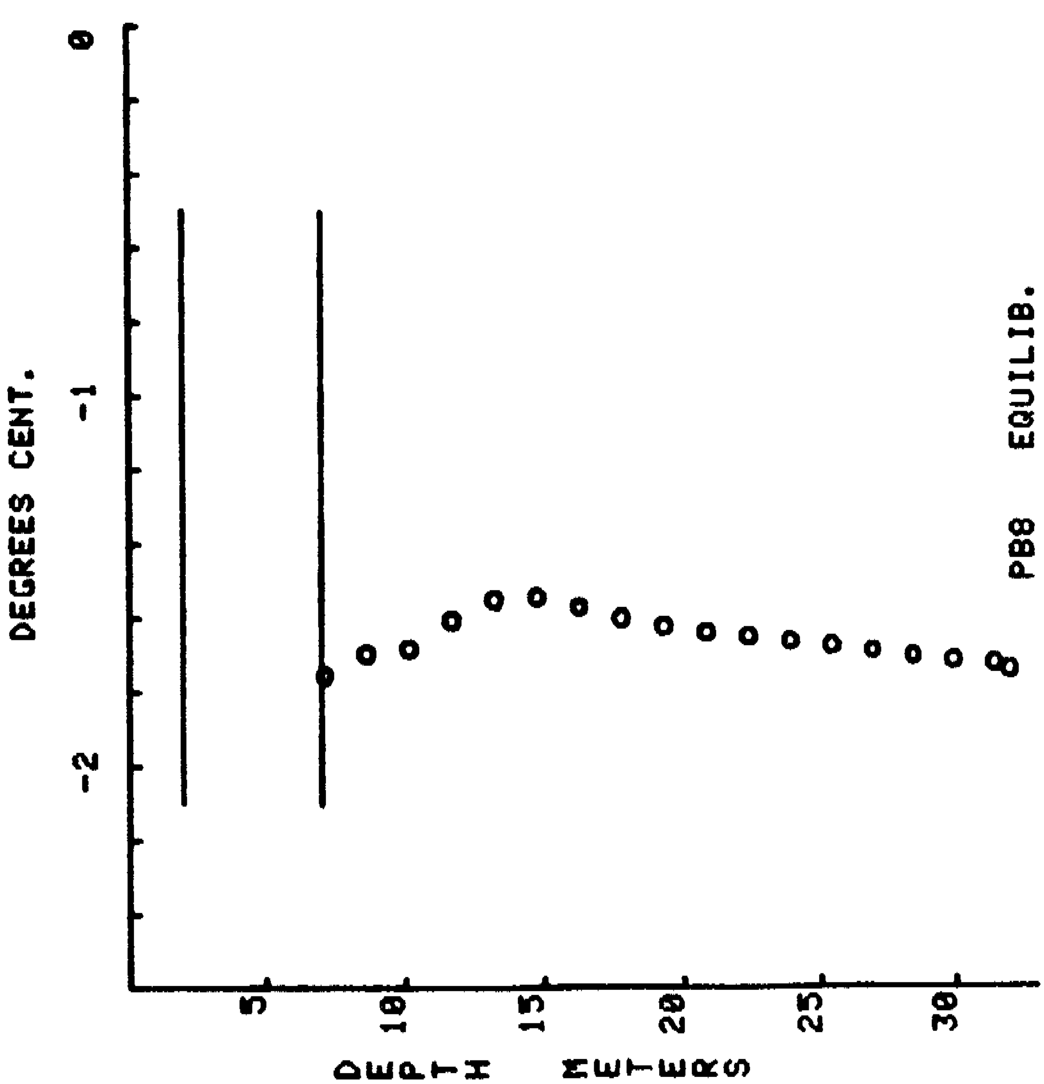
X	Y
-1.371	-5.7
-1.217	-7.22
-1.142	-8.75
-1.109	-10.27
-1.1	-11.8
-1.116	-13.32
-1.143	-14.84
-1.169	-16.37
-1.203	-17.89
-1.229	-19.42
-1.262	-20.94
-1.295	-22.46
-1.326	-23.99
-1.361	-25.51
-1.388	-27.04
-1.416	-28.56
-1.445	-30.08
-1.478	-31.61
-1.511	-33.13
-1.536	-34.66
-1.575	-36.18
-1.615	-37.7
-1.646	-39.23
-1.679	-40.75
-1.71	-42.28
-1.743	-43.8
-1.771	-45.32
-1.804	-46.85
-1.837	-48.37
-1.868	-49.9
-1.905	-51.42
-1.938	-52.94

PB7 EQUILIBRIUM TEMPERATURES

-1.976	-54.47
-2.018	-55.99
-2.056	-57.52
-2.1	-59.04
-2.132	-60.56
-2.16	-62.09
-2.195	-63.61
-2.235	-65.14
-2.277	-66.66
-2.3	-67.76

. PB7 EQUILIBRUIM TEMPERATURES

Appendix I. Thermal Data.



DATA

X	Y
-1.757	-7.11
-1.7	-8.63
-1.686	-10.16
-1.609	-11.68
-1.553	-13.21
-1.547	-14.73
-1.572	-16.25
-1.602	-17.78
-1.624	-19.3
-1.641	-20.83
-1.655	-22.35
-1.667	-23.87
-1.68	-25.4
-1.693	-26.92
-1.71	-28.45
-1.721	-29.97
-1.728	-31.49
-1.747	-32.07

PB8 -- EQUIL. TEMPS.

QUARTERLY REPORT

Contract: RK6-6074
Research Unit: 205
Reporting Period: July through September 1977
Number of Pages: 9

GEOLOGIC PROCESSES AND HAZARDS OF THE BEAUFORT SEA SHELF AND COASTAL REGIONS

Peter Barnes

Erk Reimnitz

David Drake

Pacific-Arctic Branch of Marine Geology
345 Middlefield Road
Menlo Park, California 94025

October 1, 1977

QUARTERLY REPORT - RU 205

I. Task Objectives

The primary goal of this project is to study the nature, distribution, stability and thickness of Holocene and older sediments, and their relationship to sources, dispersal mechanisms and bottom processes. Emphasis is placed on processes that are unique to the arctic environment where ice plays a dominant role. More detailed objectives are given in previous reports and in the report of Field Activities (II).

II. Field and Laboratory Activities

A. Ship and field trip schedule;
Four field efforts were carred out during the report period.

1. A skiff study was conducted in early July on the eastern and central portions of the Colville River Delta front platform.

2. Leg I on the R/V Karluk in late July and August continued studies on the inner Beaufort sea shelf between Narwhal Island and Smith Bay, emphasizing repetitive observations from previous years.

3. Leg II on the R/V Karluk from late August continuing into October stressing site specific observations of topical problems, working from Pole Island to Harrison Bay with some data extending along the coast to Nome.

4. A skiff operation was carried out west of Barrow in early September in the area of intense ice ridging and ice gouging along the coast.

B. Scientific Party:

1.	L. Toimil	U. S. Geological Survey
	P. Barnes	" " "
	G. Gattung	" " "
2.	P. Barnes	" " "
	D. McDowell	" " "
	H. Hill	" " "
	G. Gattung	" " "
	J. Nicholson	" " "
	R. Novac	" " "
	J. Rogers	University of Alaska
	J. Morack	" " "
3.	E. Reimnitz	U. S. Geological Survey
	L. Toimil	" " "
	H. Hill	" " "
	D. Maurer	" " "
	D. Thor	" " "
	D. Scholl	" " "

4. P. Barnes U. S. Geological Survey
   D. McDowell " " "
   R. Metzner University of Alsaka

C. Methods:

1. Helmericks camp on the Colville river was used as the primary base of operations for the delta front platform studies in early July. A 16' Whaler was outfitted with precision navigation, bathymetric, sub-bottom seismic equipment along with coring, temperature and salinity sensors and water sampling bottles. Work on the western delta front was not accomplished due to the presence of ice.

2 & 3. Geologic studies from the R/V KARLUK were conducted using Prudhoe Bay as the prime operational base. The observational methods and equipment utilized for gathering data include; precision fathometer, side-scanning sonar, precision navigation system and data logger, towed temperature, salinity and transmissivity sensors, current meter moorings, vibrocoring, diving observations, in-situ and sample observations of sediment salinity, and sediment strength, water samples, sediment profiling sparkers, air guns, and transducers, bottom plow, aerial photography and water level recorders.

4. The Naval Arctic Research Lab at Barrow was used as the base of operations for a skiff survey in early September. A 16' Whaler was outfitted with side-scanning sonar and precision fathometer with navigation control from shore based radar and range makers on the beach.

D. Data Collected or Analyzed - (see also Figure 1)

Only limited data has been analyzed during the reporting period. A partial list of the data collected to date follows.

Bathymetry - precision	650 km of track line
Side scan sonar	415 km of track line
Seismic reflection	260 km of track line
Seismic refraction	115 km of track line
Core samples	36
Thermoprobe stations	10
Water samples	40
Sediment samples	60

In addition one of five current meters implanted in the fall of 1976 was recovered and considerable time was spent searching for the remaining four meters. Additional data includes, aerial photographs, outcrop descriptions, underway salinity and temperature observations, diving observations and time lapse camera data.

E. Scientific Laboratory Group

Peter Barnes	Project Chief	U.S.G.S. Office of Marine Geology
Erk Reimnitz	Principal Investigator	" " " " "
David Drake	" "	" " " " "
Larry Toimil	Co-Investigator	" " " " "
Doug Maurer	Assistant	" " " " "
David McDowell	"	" " " " "
Gene Gattung	"	" " " " "

III. Results

Considerable, in fact most of the time expended this quarter was devoted to preparations and carrying out the above described field season. Although ice conditions were ideal, numerous problems with shipping, and equipment breakdown limited the success of the summers program. The lack of ice also created unfavorable sea conditions for small boat work which also hampered the gathering of data.

IV. Preliminary interpretation of results.

A. Work on the delta front platform of the Colville River suggests that there has been very little change in the surface morphology in the last 25 years on the eastern and central portions of the delta. The reasons for this are not known as we are unable to find the depositional sites for the sediments derived from the Colville River. In addition there was no channel existing across the delta from platform in 1977. Apparently a channel has existed in other years.

B. Resurvey of the Prudhoe Bay entrance channel and the area around the west caseway shows little change from last year and in the channel, depths were shallower than expected at the end of the ice season.

C. The near surface geology of the sea floor was expected to change in the vacinity of Cape Halkett, due to decreasing coarse sand and gravel units and increasing amounts of fines westward of the Colville River in coastal outcrops. Preliminary examination of the reflection profiles between Cape Halkett and Smith Bay shows the same lack of well defined reflectors that we have observed to the east. Perhaps the change occurs further west.

D. The re-running of testlines of 1973, 1975, and 1976 shows additional gouges from the mild 1976-1977 winter ice season, in addition the test line was extended further seaward and a new test line off Cape Halkett established.

E. Precision distance measurements and aerial photography obtained this past summer has confirmed the onshore movement of several of the barrier islands and considerable change in morphologic shape since earlier aerial photography in 1970, 1955, and 1949.

F. Time lapse camera observations of the beach and nearshore ice environment north of Narwhal Island shows a complex shifting ice motion which commonly is in opposite directions inshore and seaward of a grounded ridge of ice.

G. Bathymetry and side-scanning sonar data from the inner shelf off Barrow shows a distinct zonation of ice gouging. The typical profile - onshore to offshore. Seaward of the bar, gouging becomes intense between the 6 and 10 meter isobath and remains intense downslope to the 25m isobath where densities of gouging is markedly reduced. Ice gouge terminations indicate that many of the gouges were formed during southwest to northeast ice movements.

See also attachment A - Preliminary observations on morphologic changes at Thetis Island.

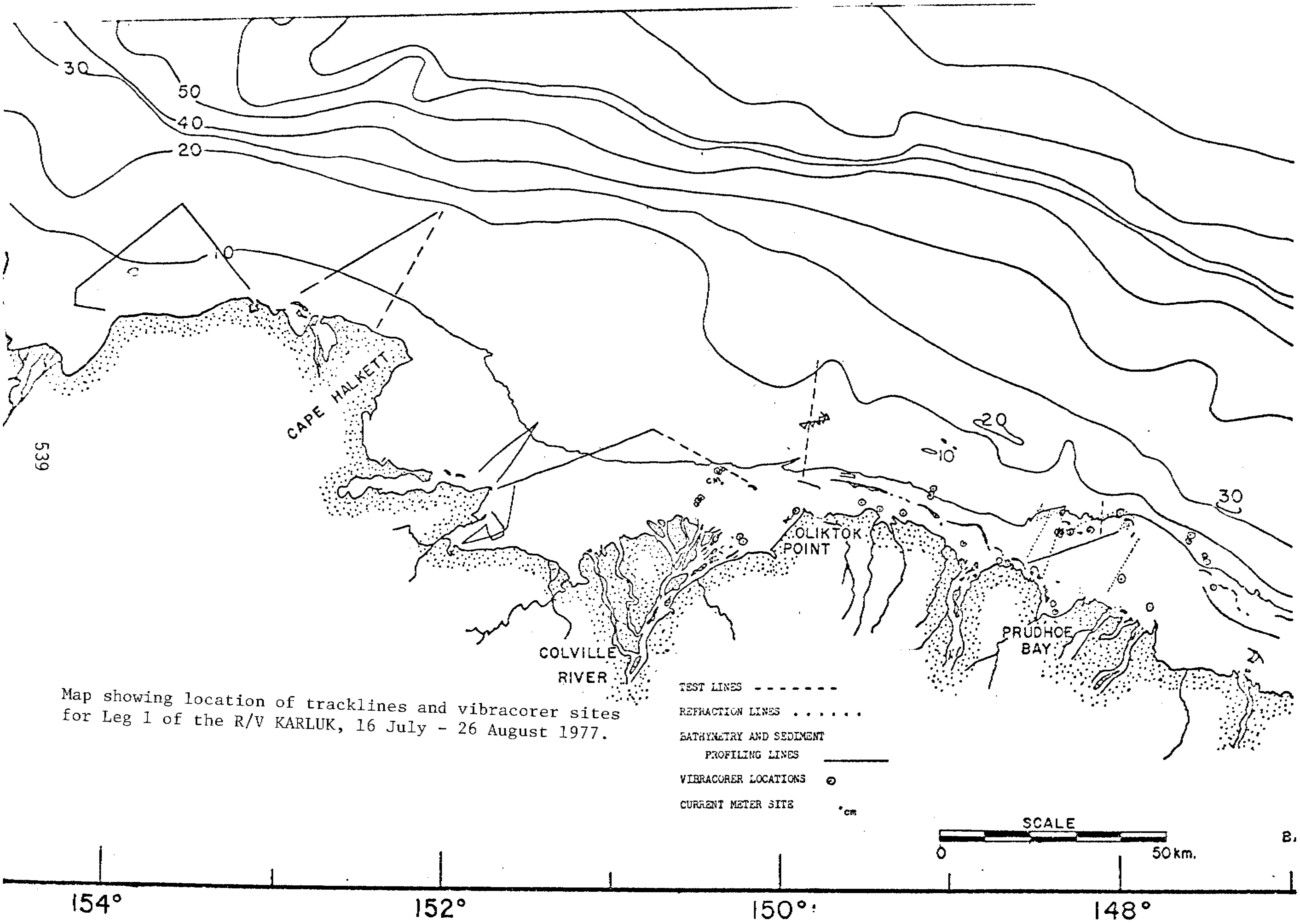
V. Problems encountered.

Logistics and operational support at Prudhoe Bay was somewhere between poor and nonexistant. Helicopters were not available when needed and when available were unable to fly overwater. Due to space limitations at V&E we were required to sleep aboard the KARLUK in V&E's yard; then we (OCS) were charged $30 for each meal. Wien's air freight operation was its notorious self aiding little in getting equipment and supplies from south the north. We would suggest a part time expiditer at Prudhoe to keep an eye on the contractor and coordinate operations. Also it might expiditious to check into trucking (LTI) some equipment and supplies from Fairbanks to Prudhoe, when time allows or when Wien falls down due to weather or other excuses.

VI. Estimate of Funds Expended.

All FY77 Funds have been expended.

NOAA/OCEAP (including KARLUK)	86,900
U.S.G.S. " "	38,600



Map showing location of tracklines and vibracorer sites for Leg 1 of the R/V KARLUK, 16 July - 26 August 1977.

ATTACHMENT A

PRELIMINARY OBSERVATIONS ON THE MORPHOLOGIC CHANGES OF THETIS ISLAND, ALASKA

by

David McDowell and Peter Barnes

It has been determined that morphologic changes in barrier islands of the Beaufort Sea do occur (Reimnitz et al, 1977, Wiseman et al, 1973, Burrell et al, 1974, Dygas et al, 1972). Westward and onshore migration under the influence of the dominant north easterly winds and periodic westerly storms are considered to be primary factors controlling this process. Ice and bathymetry also possibly influence changes of the barrier islands. The changes that have occurred on Thetis Island, generally follow the patterns found on the other islands along Simpson Lagoon and the offshore sand and gravel barrier islands such as Cross Island (Reimnitz et al 1977). The rates, sediment source, stability and regeneration mechanisms are poorly understood.

Sequential aerial photography flow in 1949, 1955, 1971, and aerial photos taken by the authors in 1977 are the basis for morphologic comparison. Lakes and beach ridges which have essentially remained intact are used as stable bases for the alignment of the photos. The consistent pattern of the net morphologic changes from 1949 to 1977 can be seen in Fig. 1 . These changes are threefold; 1) accreation of the northwest and southern ends, 2) erosion of the central portion of the island near the area of curvature, and 3) the seaward mirgration of the southern extension. These changes effect the overall shape of the island from a wide hook shape toward a thiner linear shape. In Figure 2, overlays show that the long term changes between 1949 and 1977, and short term changes between 1971 and 1977 are consitant with the same trend.

The rates of change appear to be consistent throughout the years. Measurements of the many time periods represented in the 4 photo sets for maximum erosion near the central part of the island show about 7 m/yr. in all comparisons. Surprisingly the eastward migration for the southern extension of the island occurs at a similar rate.

Discussion

The processes responsible for the morphological changes of Thetis Island are possibly unique to some of the sand and gravel barrier islands of the Beaufort Sea. During the winter months, the force of sea ice is greatest along the northern side of the island. Ice plowed sediment piles commonly 1-1.5 meters high are found 10-20m shoreward of the strandline in the spring as the ice recedes. This ice disrupted zone is easily eroded and trasported by wind generated waves and currents to the ends of the island. Because of the dominant northeasterly winds the greatest accumulations and accreation of the island is to the northwest.

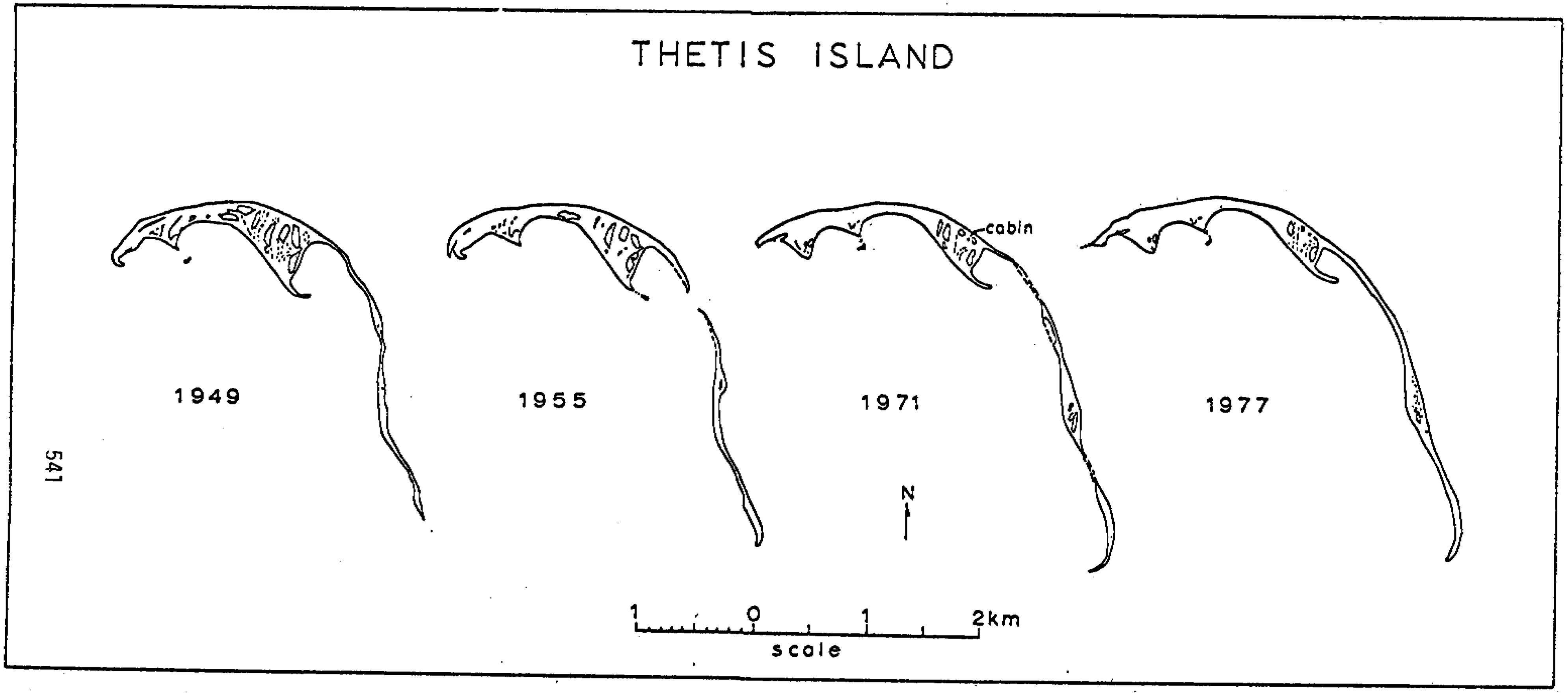


Figure 1. Thetis Island showing morphological changes from 1949 to 1977.
Note the changes to a longer, thinner, and linear form.

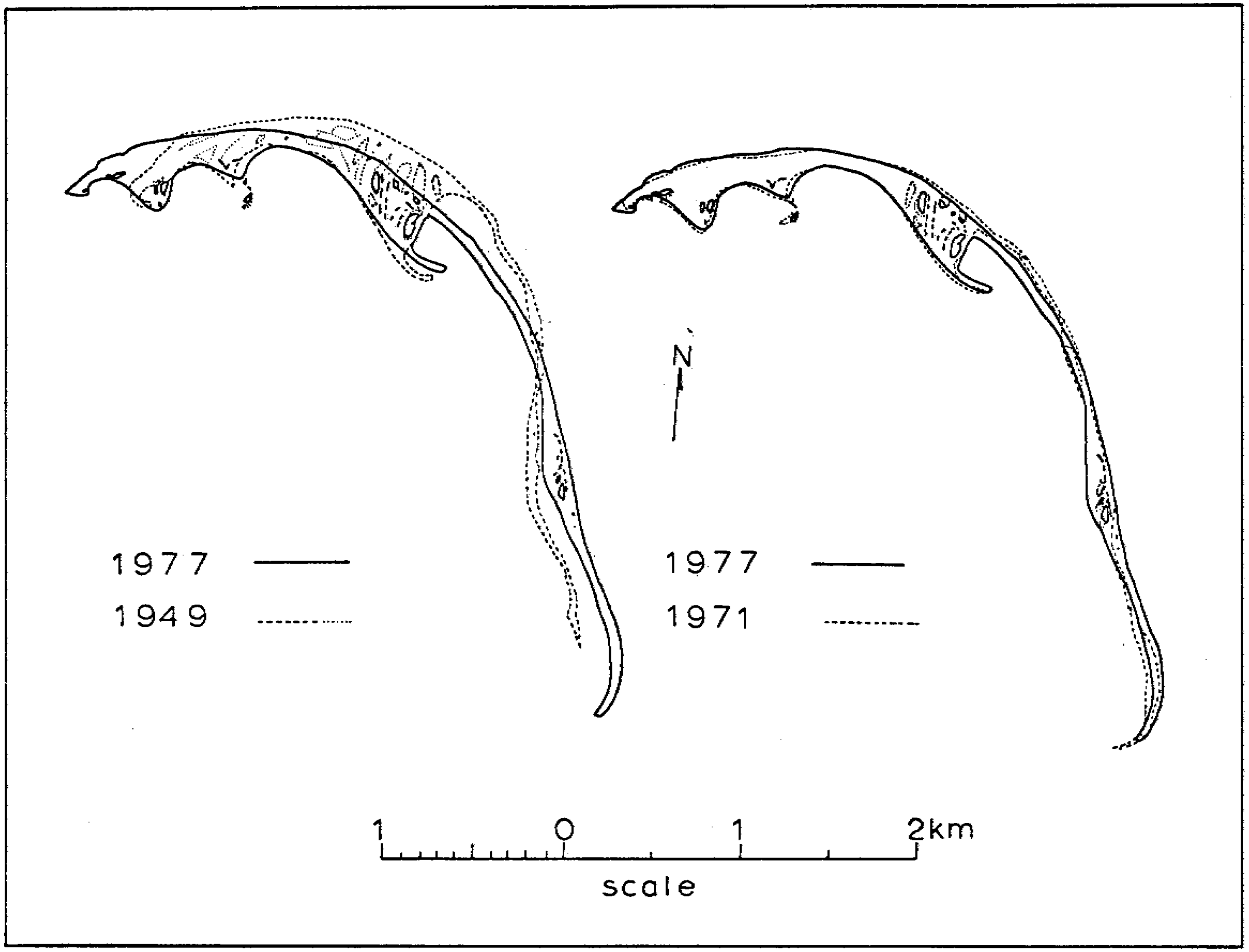


Figure 2. Overlays of Thetis Island comparing 1977 shorelines with 1949 (left) and 1971 (right). Note the zone of erosion on the northeast side of the island and the eastward migration of the southern extension.

Ice plow disruption of the foreshore sediments is not as great on the southern extension of the Island because of the protection from islands to the east and the low offshore graident. The eastward migration of this extension is apparently due to the effects of the westerly winds which effectively decrease the curvature of the island. A trend of increasing linearity of the barrier islands is evident along the Beaufort Sea to the east of Thetis.

REFERENCES

Burrell, D. C., Dygas, J. A., and Tucker, R. W., 1974, Beach morphology and sedimentology of Simpson Lagoon, in: V. Alexander, ed., Environmental Studies of an Arctic Estuarine System, University of Alaska Institute of Marine Studies, IMS Report R74, p. 45-144.

Dygas, J. A., Tucker, R, and Burrell, D. C., 1972, Geological report on the heavy minerals, sediment transport, and shoreline changes of the barrier islands and coast between Oliktok Point and Beechy Point, in: (P. J. Kenney et al., eds.) Baseline data study of the Alaskan Arctic aquatic environment, Univ. of Alaska, Inst. of Marine Sci., Rept. R-72-3, p. 61-121.

Reimnitz, Erk, Barnes, P. W., Melchior, J., 1977, Changes in Barrier Island morphology - 1949-1975, Cross Island, Beaufort Sea, Alaska part F in: Annual Report to Natl. Ocanic and Atmospheric Adm., Environmental Assessment of the Alaskan Continental Shelf; Principal Investigator's Reports, April 1977, 16 p.

Wiseman, W. J., Coleman, J. M., Gregory, A., Hsu, S. A., Short, A. D., Suhayda, J. N., Walters, C. D., Jr. and Wright, L. D., 1973, Alaskan Arctic Coastal Processes and morphology Technical Report No. 149, Coastal Studies Institute, Louisiana State University, Baton Rouge, Louisiana 70803, 171 p.

QUARTERLY REPORT

Contract #RK 6-6074
Research Unit: 206
Reporting period: 10th Quarter
Number of pages: 4

Faulting and slope instability in the
St. George Basin area, Southern Bering Sea.

T. L. Vallier and J. V. Gardner
Pacific-Arctic Branch of Marine Geology
U.S. Geological Survey
Menlo Park, California 94025

October, 1977

I. Abstract of highlights of Quarter's accomplishments.

The 10th Quarter of RU #206 was a field program aboard the USGS research vessel RV SEA SOUNDER. The cruise, designated S6-77, departed Dutch Harbor, Alaska on August 5 and arrived in Kodiak, Alaska on September 10. The objectives of this cruise were to delineate the character of the outermost continental shelf and upper continental slope and to investigate the effects of the Pribilof and Bering submarine canyons on the sediment dynamics in the area.

II. Task Objectives

The objectives of this project are to map the distribution and types of faults and to outline the areas of potentially unstable sediment masses in the St. George Basin region of the Southern Bering Sea continental margin.

III. Field or Laboratory Activities

A. Ship schedule: August 5 thru September 10 aboard USGS RV SEA SOUNDER

B. Scientific Party

James V. Gardner, USGS, Co-Chief Scientist

Tracy L. Vallier, USGS, Co-Chief Scientist

Walter E. Dean, USGS, geochemist

Kieth Kvenvolden, USGS, geochemist

George Redden, USGS, geochemist

Edith Stanley, Univ. Calif. Davis, paleontologist

Donald Reed, USGS, sedimentologist

John Cudnohufsky, Univ. Calif. Berkley, biologist

Helen Gibbons, Univ. Calif. Santa Cruz, navigator

Thomas Frost, USGS, petrologist

Steve Lewis, USGS, geophysist

Alexis Bukai, Scripps Inst. of Oceanography, sedimentologist

David Klise, USGS, sedimentologist

Roland Brady, USGS, marine technician

Herman Karl, USGS, sedimentologist

Gordon Hess, USGS, geophysist

Mike Underwood, USGS, sedimentologist

Margret Goud, USGS, navigator

Neil Barnes, USGS, sedimentologist

C. Methods

Methods utilized in cruise S6-77 include:

160 kjoule sparker

3.5 KHZ profiler

12 KHZ profiler

two-axis gravity meter

proton-precession magnetometer

chain dredge

gravity corer

Van Veen sampler

profiling current meter

CTD (conductivity - temperature vs. depth)

van Dorn water sampler

gas chromatography

bottom photography

underwater T.V.

thermosalinograph

D. Sample localities/ship tracklines

The data are in transit from Alaska to Menlo Park at the time of this report. Track charts and station locations will be presented in the next quarterly report.

E. Data Collected

See item III. D.

IV. Results

We were able to collect high quality single-channel and 3.5 KHZ profiles over Pribilof and Bering Canyons and the intervening continental slope. In addition approximately 40 stations of current meter data, CTD, and water samples were taken in the head of Pribilof Canyon. Unfortunately, heavy weather precluded the collection of many sediment samples.

V. Preliminary Interpretation of Results

As outlined in item III. D., it is much too early to speculate on the implications of the data collected.

VI. Problems encountered/recommended changes

The major problems encountered were weather related. Heavy seas and swell and high winds terminated what was to be an ambitious coring program.

VII. Estimate of funds expended.

All funds expended.

VIII. Bibliography

Gardner, J. V. and Vallier, T. L., 1977, Faulting, unstable sediments and surface sediments in the Southern Bering Sea outer Continental Shelf and Slope. Amer. Geophys. Union Ann. Mtg., EOS, v. 58, p. 404.

Gardner, J. V., Vallier, T. L., Lewis, S. P., Klise, D. H., and Underwood, M. B., 1977, Distribution and carbon content of surface sediments in the outer continental shelf of the Southern Bering Sea: Geol. Soc. Amer. Ann. Mtg.

Vallier, T. L., Gardner, J. V., Underwood, M. B., Klise, D. H., and Lewis, S. P., 1977, Heavy Minerals and clay mineralogy of surface sediments, Southern Bering Sea continental margin: Geol. Soc. Amer. Ann. Mtg.

Gardner, J. V. and Vallier, T. L., 1977, Underway geophysical data collected on USGS cruise S4-76: U.S. Geol. Survey Open-file Rept. 77-524, 5p.

Vallier, T. L. and Gardner, J. V., 1977, Maps showing types and distribution of faults interpreted from seismic profiles in the St. George Basin region, Southern Bering Sea: U.S. Geol. Survey Open-file Rept. 77-591, 13p.

Other papers resulting from cruise S4-76 in August-September 1976 are:

Dean, W. E., 1977, Major, minor, and trace-element variations in surface sediments, outer continental shelf, Southern Bering Sea, Alaska. Geol. Soc. Amer. Ann. Mtg.

Kvenvolden, K. A. and Redden, G. D., 1977, Hydrocarbon gases in Southern Bering Shelf sediments: Geol. Soc. Amer. Ann. Mtg.

9th Quarterly Report

1 July - 30 September 1977

TITLE: Earthquake Activity and Ground Shaking in and along the Eastern Gulf of Alaska

PREPARED BY: Christopher Stephens
John C. Lahr

RESEARCH UNIT: 210

PRINCIPAL INVESTIGATORS: John C. Lahr
Robert A. Page

I. Objectives

The objective of this research is to evaluate the hazards associated with earthquake activity in the Gulf of Alaska and adjacent onshore areas that pose a threat to the safety of petroleum exploration and development.

II. Field and Laboratory Activities

A. Seismic Network Changes

Figure 1 shows the USGS network in the Gulf of Alaska vicinity after the 1977 field season. Changes to the stations, apart from routine maintenance, are tabulated below:

STATION	ACTION
TSINA (TSI)	Connected to telephone drop which became available this summer.
KIMBAL PASS (KMP)	Moved station 1/4 mile from RCA tower to reduce effects of generator noise. Connected to telephone drop, which became available this summer.
HINCHINBROOK (HIN)	Installed plywood shelter over transmit antenna to prevent snow damage.
BOSWELL BAY RCA SITE	Removed all USGS radio receivers.
CORDOVA	Set up receive sites for stations which previously were transmitted to Boswell Bay. MTG and HIN are received at the RCA satellite ground station. SGA and KYK are received at the FAA facility at the airport.

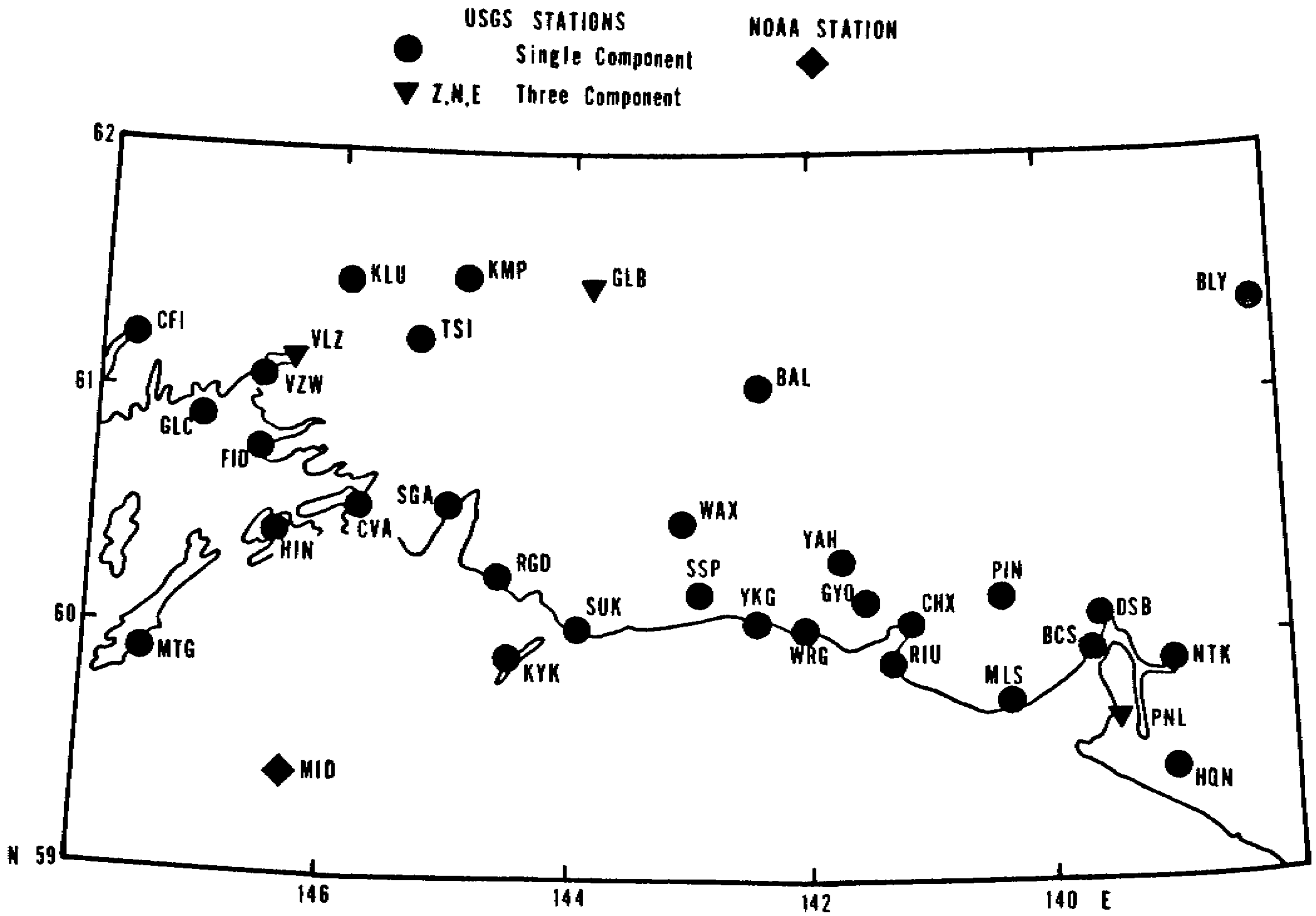


Figure 1. Seismic stations located in the eastern Gulf of Alaska region. The stations Kimball Pass (KMP) and Tsina (TSI) began operating in August, 1977.

RAGGED MTN (RGD)	Moved station to the NE so that it could transmit to Cape Yakataga RCA site and also relay WAX.
SUCKLING HILLS (SUK)	Station was disturbed. Both the electronic package and aluminum station housing were missing. Reinstalled station.
CHAIX HILLS (CHX)	Both 2 inch ID water pipes were bent over, probably due to high winds and icing conditions. Reinstalled lower antennas.
BANCAS POINT (BCS)	Bear damage had occurred. Reinstalled culvert and replaced electronics package and air cells.
PINNACLE (PIN)	Deep snow caused collapse of antenna mast. Reduced height of mast.

B. Field Party

John Roger, Electronics Engineer, 1 August - 31 August

Eric Fuglestad, Geologic Field Assistant, 1 August - 31 A August.

Marion Salsman, Physical Science Technician, 1 August - 31 August.

John Lahr, Geophysicist, 7 August - 21 August.

C. Notes on station maintenance.

The antenna systems were less of a problem this past year than in previous years along the Gulf of Alaska. The antennas which were installed in trees were all in good shape after the winter. We did find, however, that even 2" water pipe cannot withstand the winds on Chaix Hills. We experimented this summer with positioning the antenna near the ground and building a shelter over it. This method has worked so far. However, our shelters, made of 3/4" plywood, may not physically withstand the winter. We are planning to design a stronger and lighter fiberglass structure to install at certain stations next summer.

D. Laboratory Activities

1.) Routine Processing of Seismic Data

Two new personnel will begin working on the routine processing of seismic data in October. One of these people will be replacing Suzanne Conens, who left the Geological Survey in August. We also have a student working part-time scanning data films.

2.) Data Analysis

The results of our investigation of the seismicity around Icy Bay have been submitted for presentation at the 1977 Fall Annual Meeting of the American Geophysical Union in San Francisco. The abstract for this talk is presented in the appendix.

Our study of the seismic activity beneath Prince William Sound has revealed two groups of earthquake hypocenters that are clustered in space, one of which is also clustered in time. A more detailed study of these earthquakes, which we are pursuing, may provide evidence about the fault structures in this area.

Strong refracted P-arrivals from earthquakes which occur near

Icy Bay are recorded at stations in the central part of our network. These refracted arrivals can be observed at epicentral distances of at least 300 km. Further study of these arrivals will provide useful constraints for modeling the seismic velocity structure of the crust and uppermost mantle beneath the south central part of our network. We have begun to collect records of these observations to be used in analyzing and compiling travel time curves for the refracted waves.

APPENDIX

SEISMICITY OF ICY BAY, ALASKA

Christopher Stephens
John C. Lahr (both at: U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025)

A concentration of shallow microearthquake activity near Icy Bay, Alaska, relative to adjacent areas along the southeastern Gulf of Alaska, is apparent in the distribution of earthquakes located by the USGS seismic network in southern Alaska between 1974 and 1976. Icy Bay is located midway between Yakutat Bay and Cape Yakataga, two sites where uplift from the 1899-1900 series of great earthquakes was reported. Very little is known about which faults in this area were active during that series of earthquakes or which are presently active. Selected earthquakes which occurred beneath and near Icy Bay were relocated using a master event technique. The epicenters of the relocated earthquakes which occurred beneath Icy Bay define a linear trend about 30 km long striking NE, in contrast to the more diffuse distribution of epicenters of earthquakes lying within about 50 km north and northeast of Icy Bay. The focal depths of the earthquakes beneath Icy Bay are generally less than about 30 km. The data suggest that the present seismic activity beneath Icy Bay may be occurring along a single fault structure. A NE-trending thrust fault extending along the southern margin of Chaix Hills immediately northeast of Icy Bay has been inferred from geological evidence. Marine profiling provides evidence of a NE-trending thrust fault located about 25 km southwest of Icy Bay. Either or both of these structures may be related to the trend in the Icy Bay earthquakes. Earthquakes north and northeast of Icy Bay probably occur on several east trending, en-echelon thrust faults which have been mapped in this area.

RU #212

NO REPORT WAS RECEIVED

Quarterly Report

Contract # 03-5-022-55
Research Unit # 251
Task Order # C-1
Reporting Period: 7/1/77-9/30/77
Number of Pages: 53

SEISMIC AND VOLCANIC RISK STUDIES - WESTERN GULF OF ALASKA

J. Kienle
H. Pulpan
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

October 1, 1977

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending September 30, 1977

Project Title: Seismic and Volcanic Risk Studies - Western Gulf of Alaska.

Contract No.: 03-5-022-55

Task Order No.: C-1

Principal Investigators: J. Kienle, H. Pulpan

I. Abstract:

Last summer we continued field work on Augustine Volcano and at the Ukinrek Maars and began volcanologic-glaciologic studies on Redoubt Volcano.

A new topographic map of the summit of the volcano has been produced to show the dramatic changes that have occurred at the summit of Augustine during the 1976 eruptions. A thermal model of the hot pyroclastic flows, deposited on the NE-side of the volcano, showed that over the past 1 1/2 years cooling was mainly through evaporation of local precipitation. Local micro-earthquake activity has remained very low following the 1976 eruptions (lower than in any of the six years preceeding the eruptions) as could be expected from a model of cooling of the newly emplaced lava dome: If shallow micro-earthquakes at Augustine in the past resulted from thermal-mechanical stresses due to the cooling of the 1964 lava dome, the present absence of such micro-earthquakes may simply indicate that the rind of the 1976 dome is still too thin to accumulate enough elastic strain to produce earthquakes.

New topographic maps (in preparation) of the snow surface of the ice cap occupying the summit crater of Redoubt Volcano for 1977, 1957, 1954 will allow us to estimate the volume changes of the ice during the past 23 years. This kind of calorimetry is a valuable tool to monitor changing heat fluxes at Redoubt, especially if photogrammetric surveys are repeated in the future.

Preliminary seismic data from the Ukinrek Maars indicate that their position is tectonically controlled by the Bruin Bay fault.

During the report period the seismic system was slightly modified and completely recalibrated. The system is now performing better and more reliably then ever before.

II. Task Objectives:

It is the purpose of this research to determine the seismicity of the lower Cook Inlet, Kodiak, and the Alaska Peninsula and to evaluate the seismic risk to onshore and offshore development, and also to evaluate eruption potential and volcanic risk of Redoubt and Augustine volcanoes in Cook Inlet.

III. Field Activities:

A. Field Trip Schedules

1. Volcanology

June 16-19, 1977: Annual servicing of seismic station on Redoubt Volcano with Army helicopter support, while conducting a reconnaissance mission on Iliamna Volcano related to a search for a lost airplane on that volcano.

July 10-20, 1977: Volcanological-glaciological studies on Redoubt Volcano (July 14-17, 1977); volcanological studies on Augustine Volcano (July 18 and 19, 1977); transport of new helihut shelter from Fairbanks to Chinitna Bay (unforeseen circumstances did not allow us to take the building all the way to Augustine); this was accomplished with Army helicopter support in exchange for cooperation in an Army coordinated search for a lost aircraft on Iliamna Volcano.

August 23 - September 1, 1977: Volcanological studies at Ukinrek Maars (State of Alaska funds).

August 30 - September 3, 1977: Annual servicing, repair and calibration of lower Cook Inlet seismic stations SHU, CDA, OPT, AUP (new station that replaces BRB), RED and SPL (Kodiak). Augustine heat flow study on pyroclastic flows on NE-flank.

2. Seismic Networks

Table 1 gives the pertinent information about the annual service of the seismic network which took place during the report period.

From July 4 through July 14, 1977, Hans Rex, a graduate student, operated a three component short period seismic system near Narrow Cape. This station, together with the permanent stations of the Kodiak seismic network, provided land based data for the ocean bottom seismometer experiment conducted jointly by the United States Geological Survey and Lomont-Doherty Geological Observatory of Columbia University.

A complete recalibration of the seismic system was performed during this year's trip. A few changes have been made in the layout of the network. Figures 1 and 2 show the layout before and after the servicing period, respectively. Tables 2 and 3 list station names, station codes, station longitudes, latitudes and elevations before and after the changes. The following changes were made: the station located at Ugak Bay (UGB) was relocated to Sitkalidak Island. Originally planned to be moved only temporarily for purposes of the ocean bottom seismometer experiment, it was left at this location after realizing that better signals were received from the new installation. The station at Zachar Bay (ZRB) was abandoned. Telemetry links from this station to Kodiak via SPL, RAI and a repeater on Spruce Island proved marginal over the past years. By eliminating the station we expect to gain a greater reliability of the remainder of the stations within this link. On the Alaska Peninsula the station at Gas Rocks on the southern shore of Becharof Lake (MAA), installed last spring in connection with the formation of the Ukinrek Maars, was retained as seismic activity associated with the Maars is continuing. With this additional station, the coverage in that area of the Alaska Peninsula has become relatively dense, focused on the Bruin Bay fault in the vicinity of the Maars. The seismic station at King Salmon (KSL) was abandoned. The high background noise by man's activity there did not allow high quality signals to be recorded there. Eliminating one signal will provide a higher signal to noise margin for the remaining signals of the Alaska Peninsula circuit. The telemetry link from King Salmon to Big Mountain (BIG) via Naknek was abandoned when a commercial telephone line became available for lease between these two locations. This should further improve signal reliability on the Peninsula circuit.

The Bruin Bay (BRB) station was moved to Augustine to complete the new island based array which now consists of four stations. A three station array at the base of the volcano serves to locate local epicenters. The fourth station was needed to (1) distinguish positive from negative "depth" relative to the plane defined by the three lower stations and (2) to monitor very small micro-earthquakes originating from the new lava dome. AUW was moved from the small island west of Augustine to the flank of the volcano (AUF) in order to eliminate ground noise caused by ocean surf.

Time Period	Operation Base	Support	Station Visited	Personnel
June 16 - June 19	Anchorage	U. S. Army Helicopter	Redoubt Volcano	Kienle
June 20 - June 23	NOAA Ship Surveyor	NOAA Ship Based Helicopter	Chirikof Island	Stechman
			Choviet Island	
June 26 - July 26	Kodiak	NOAA UH-1H Helicopter	Sitkinak Island	Siwik, Huang
			Deadman Bay	Estes, Stechman
			Sitkalidak Island	
			Ugak Bay	
			Ugak Island	
			Middle Cape	
			Spiridon Lake	
			Zacher Bay	
			Rasperry Island	
			Spruce Island	
			Shuyak	
			Cape Chiniak	

TABLE 1

Seismic Station Service Schedule

Summer 1977

Time Period	Operation Base	Support	Station Visited	Personnel
July 17 - July 31	King Salmon	NOAA UH-1H Helicopter	Pinnacle Mountain	Siwik, Estes
			Yellow Creek Bluff	Huang
			Ugashik Lake	
			Featherly Pass	
			Blue Mountain	
			Gas Rocks	
			Cape Douglas	
			Augustine Mound	
			Augustine Kameshak	
			Augustine West	
			Bruin Bay	
			McNeil River	
			Augustine West	

TABLE 1

(CONT.)

Time Period	Operation Base	Support	Station Visited	Personnel
Aug. 30 - Sept. 3	Kodiak and Kenai	NOAA UH-1H Helicopter	Spiridon Lake	Kienle, Siwik
			Shuyak	Pearson
			Cape Douglas	
			Bruin Bay	
			Augustine Pinnacle	
			Oil Point	
			Redoubt Volcano	

TABLE 1

(CONT.)

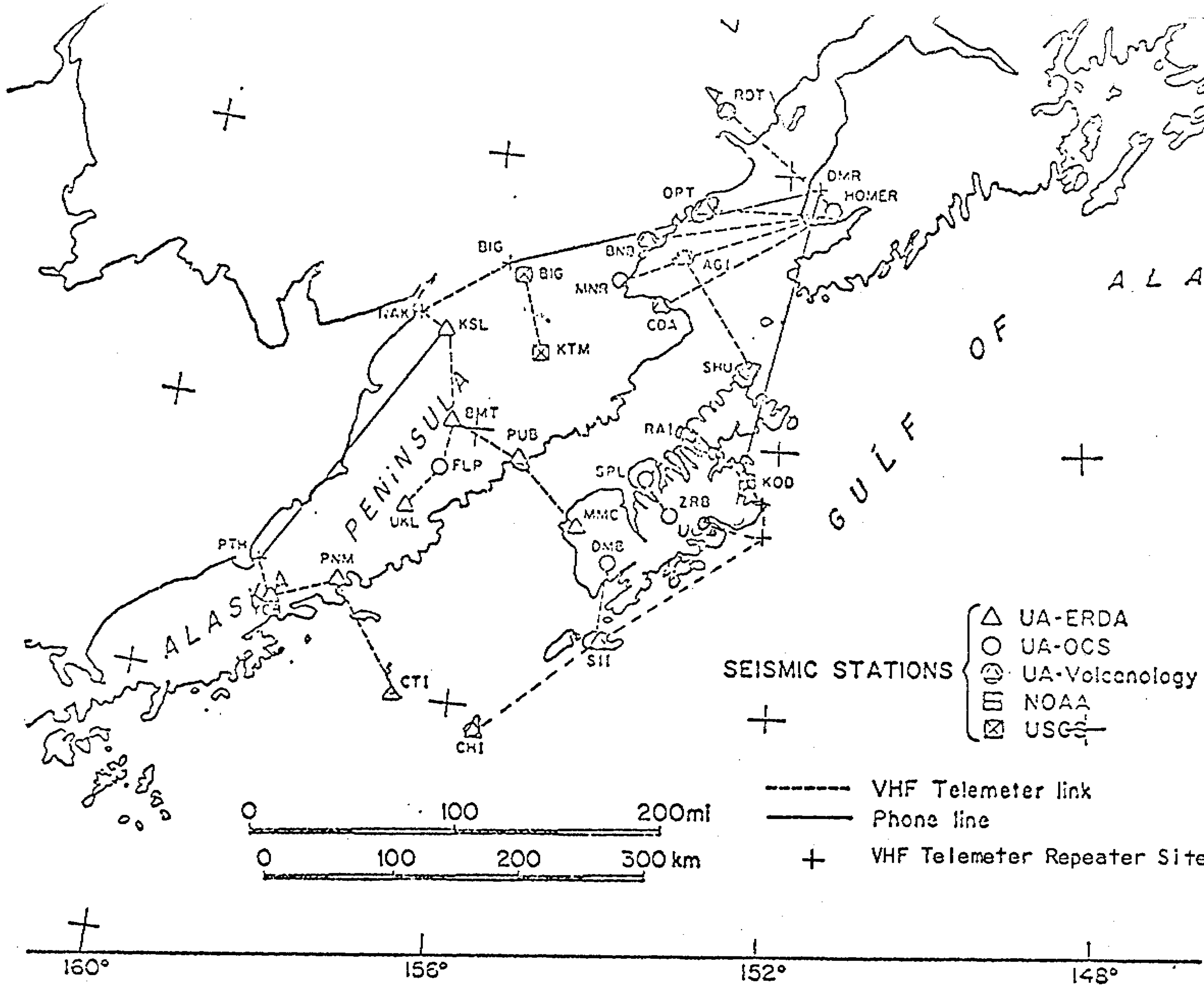


Figure 1. Seismic network before 1977 changes.

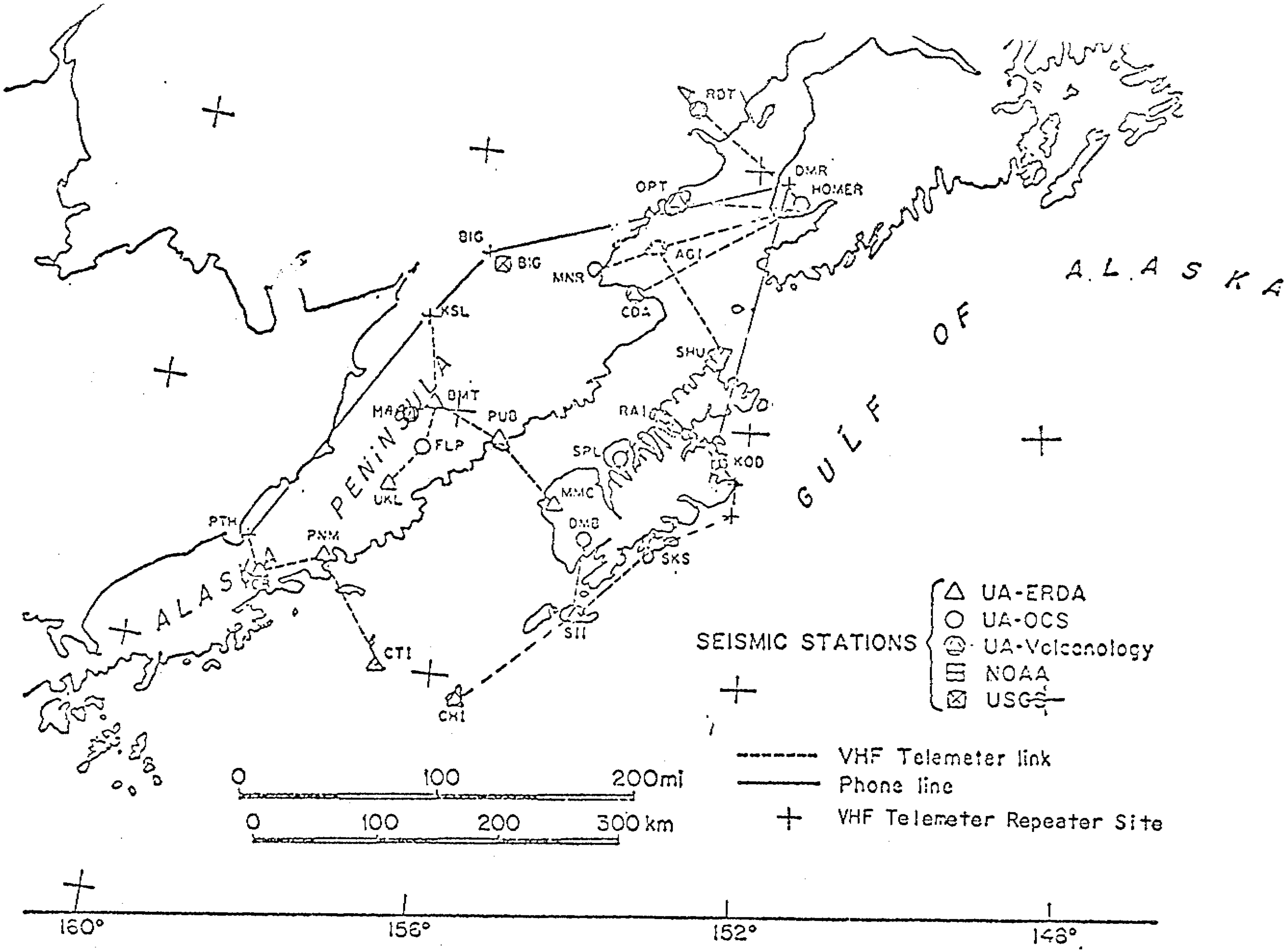


Figure 2. Seismic network after 1977 changes.

UNIVERSITY OF ALASKA

LOWER COOK INLET, KODIAK ISLAND,

AND ALASKA PENINSULA SEISMIC NETWORK

STATION NAME	CODE	LATITUDE (NORTH)	LONGITUDE (WEST)	ELEVATION (METERS)	COMPONETS
AUGUSTINE IS. KAMISHAK	AUK	59 20.05	153 25.62	259	SPZ
AUGUSTINE IS. MOUND	AUM	59 22.26	153 21.17	106	SPZ
AUGUSTINE IS. WEST	AUW	59 23.16	153 33.02	80	SPZ
BLUE MOUNTIAN	BMT	58 02.8	156 20.2	548	SPZ
BRUIN BAY	BRB	59 25.20	153 56.78	500	SPZ
CAPE DOUGLAS	CDA	58 57.32	153 31.77	386	SPZ
CHIRIKOF ISLAND	CHI	55 48.5	155 38.6	250	SPZ,SPI
CHOWIET ISLAND	CHO	56 02.0	156 42.7	160	SPZ
DEADMAN BAY	DMB	57 05.23	153 57.63	300	SPZ
FEATHERLY PASS	FLP	57 42.7	156 15.7	485	SPZ
HOMER	HOM	59 39.50	151 38.60	198	SPZ
KING SALMON	KSL	58 42.2	156 39.7	25	SPZ
SITKINAK ISLAND	SII	56 33.60	154 10.92	500	SPZ
MCNEIL RIVER	MCN	59 06.06	154 11.99	273	SPZ
MIDDLE CAPE	MMC	57 20.00	154 38.1	340	SPZ
OIL POINT	OPT	59 39.16	153 13.78	625	SPZ
PINNACLE MOUNTIAN	PNM	56 48.3	157 35.0	442	SPZ
PUALE BAY	PUB	57 46.4	155 31.0	280	SPZ
RASPBERRY ISLAND	RAI	58 03.63	153 09.55	520	SPZ
REDOUBT VOLCANO	RED	60 25.14	152 46.32	1067	SPZ
SHUYAK ISLAND	SHU	58 37.68	152 20.93	34	SPZ
SPIRIDON LAKE	SPL	57 45.55	153 46.28	600	SPZ
UGAK BAY	UGB	57 29.00	152 55.00	100	SPZ
UGASHIK LAKE	UKL	57 24.1	156 51.3	410	SPZ
YELLOW CREEK BULFF	YCB	56 38.9	158 40.9	320	SPZ
ZACHER BAY	ZRB	57 32.58	153 34.68	770	SPZ

TABLE 2: Station Locations before 1977 Changes

UNIVERSITY OF ALASKA

LOWER COOK INLET, KODIAK ISLAND,

AND ALASKA PENINSULA SEISMIC NETWORK

STATION NAME	CODE	LATITUDE (NORTH)	LONGITUDE (WEST)	ELEVATION (METERS)	COMPONETS
AUGUSTINE IS. FLOW	AUF	59 23.27	153 27.45	166	SPZ
AUGUSTINE IS. KAMISHAK	AUK	59 20.05	153 25.62	259	SPZ
AUGUSTINE IS. MOUND	AUM	59 22.26	153 21.17	106	SPZ
AUGUSTINE IS. PINNACLE	AUP	59 21.73	153 25.23	1033	SPZ
BLUE MOUNTIAN	BMT	58 02.8	156 20.2	548	SPZ
CAPE DOUGLAS	CDA	58 57.32	153 31.77	386	SPZ
CHIRIKOF ISLAND	CHI	55 48.5	155 38.6	250	SPZ
CHOWIET ISLAND	CHO	56 02.0	156 42.7	160	SPZ
DEADMAN BAY	DMB	57 05.23	153 57.63	300	SPZ
FEATHERLY PASS	FLP	57 42.7	156 15.9	485	SPZ
HOMER	HOM	59 39.50	151 38.60	198	SPZ
MAARS	MAA	57 51.40	153 04.82	131	SPZ
MCNEIL RIVER	MCN	59 06.06	154 11.99	273	SPZ
MIDDLE CAPE	MMC	57 20.00	154 38.1	340	SPZ
OIL POINT	OPT	59 39.16	153 13.78	625	SPZ
PINNACLE MOUNTIAN	PNM	56 48.3	157 35.0	442	SPZ
PUALE BAY	PUB	57 46.4	155 31.0	280	SPZ
RASPBERRY ISLAND	RAI	58 03.63	153 09.55	520	SPZ
REDOUBT VOLCANO	RED	60 25.14	152 46.32	1067	SPZ
SHUYAK ISLAND	SHU	58 37.68	152 20.93	34	SPZ
SITKINAK ISLAND	SII	56 33.60	154 10.92	500	SPZ,SPE-W
SITKALIDAK ISLAND	SKS	57 09.85	153 04.82	135	SPZ
SPIRIDON LAKE	SPL	57 45.55	153 46.28	600	SPZ
UGASHIK LAKE	UKL	57 24.1	156 51.3	410	SPZ
YELLOW CREEK BLUFF	YCB	56 38.9	158 40.9	320	SPZ

TABLE 3: Station Locations after 1977 Changes

The present technical layout of the seismic system and the manufacturer's technical specifications of the equipment used are given in Appendix 1.

The performance of the system since the service trips has greatly improved. Table A1-2 of Appendix 1 shows the percentage of down-time of each station since the 1977 service

B. Scientific Party

Redoubt Volcano: J. Kienle, Co-Principal Investigator
C. Benson, Glaciologist, U. of Alaska (State of Alaska funds)
J. Johnston, Consultant, U. of Washington, Seattle (State of Alaska funds)

Augustine Volcano: J. Kienle
D. Johnston
D. Lalla, Ph.D. candidate, U. of Alaska
J.-P. Huot, graduate student, U. of Alaska
C. Pearson, graduate student, U. of Alaska

Ukinrek Maars: J. Kienle
J.-P. Huot

Seismic Networks: J. Kienle, Co-Principal Investigator, U. of Alaska
H. Pulpan, Co-Principal Investigator, U. of Alaska
J. Siwik, Technician, U. of Alaska
J. Stechman, Technician, U. of Alaska
S. Estes, graduate student, U. of Alaska
P. Huang, graduate student, U. of Alaska
C. Pearson, graduate student, U. of Alaska
H. Rex, graduate student, U. of Alaska

C. Methods

The Redoubt, Augustine and Ukinrek studies involved mapping, surveying, temperature logging, snow pit studies, and sampling of hand specimen and volcanic gases.

D. Sample Locations

Redoubt and Augustine Volcanoes and Ukinrek Maars at the southern shore of Becharof Lake, Alaska Peninsula.

IV. and V. Results and Preliminary Interpretation:

A. Volcanology

Redoubt Volcano: Snow and ice fills the summit crater (1 by 1.6 km in size and at an elevation of about 8-8500 ft). The snow surface responds with time to the long-term changes of heat flux of the volcano beneath. For example, extensive melting in the summit crater caused a break-up and flash-flooding of the Drift River during eruptive activity in January 1966 (Post and Mayo, 1971).

During 3 days of field work at Redoubt's summit in July 1977, we have surveyed prominent landmarks surrounding the crater and ran several level lines across the crater floor, which will allow us to prepare a high resolution topographic map of the snow surface from aerial photography. This map of Redoubt summit is now being prepared by North Pacific Aerial Surveys in Anchorage. Similar maps will be produced from available photography taken by the U. S. Geological Survey in 1954 and 1957 (i.e., prior to the 1966-68 eruptive cycle). By comparing these maps we will be able to determine the long-term volume changes of the ice in the crater for the past 23 years, and through resurveys in the future. As demonstrated at Wrangell Volcano by the Geophysical Institute's glaciology group and on Mt. Baker (Malone and Frank, 1975), this kind of "calorimetry" yields valuable information about the changing heat flux beneath a glaciated volcano.

Preliminary snow accumulation studies indicate large snow accumulation rates at more than 10 m per year at the summit of Redoubt.

Hand specimen and gases were collected from all outcrops that could be climbed to at the summit of the volcano and are now being petrologically analyzed.

From the literature and through an advertising campaign in the news media we are in the process of reconstructing the events of the 1966-68 eruptions and we are also compiling the previous eruptive history.

Augustine Volcano: We are presently developing a thermal-mechanical model of the volcano, which relates shallow micro-earthquake activity to thermal stresses resulting from the cooling of newly extruded lava domes. Every major eruption in the past ended with the extrusion of such a dome. At the present, our island-based seismic network shows a surprisingly low level of micro-earthquake activity following the 1976 eruption--far lower than in any of the 6 years preceding the recent eruptions. This absence of micro-earthquake activity may be explained by the youthfulness of the 1976 summit dome which was extruded as a viscous mass that has not yet developed a thick enough cooling rind to allow accumulation of elastic strain (the release of which results in micro-earthquakes). The new station at the summit will be very valuable to observe the cooling processes occurring within the new dome.

Hand specimen and gas samples collected from the new lava dome are now being analyzed by David Johnston (University of Washington).

Figure 3 shows the latest temperature data obtained in a shallow hole located near sea level on the 1976 pyroclastic flow deposit on the NE-flank of the volcano. Shortly after the emplacement of the flows in early 1976 cooling was predominantly by conductive heat transfer. By September 1976 cooling was predominantly convective. In August 1977 the convection cells had broken down and cooling is again predominantly conductive. The temperature data and penetration tests indicate that several pyroclastic flow units are superimposed at the test site (Lalla and Kienle, 1977).

Two new topographic maps based on aerial photography are now available which show the summit at a scale of 1 mile to 400 ft just prior to the 1976 eruptions and another showing the present configuation. The contour interval is 10 feet. The 1976 eruption greatly altered and lowered the summit of Augustine.

Ukinrek Maars: A ballistic study of the ejecta was begun with State of Alaska funds in August 1977 to study the eruption mechanism and energetics of maar formation. Of relevance to OCSEAP is the fact that the maars have formed on the trace of the Bruin Bay fault (see also our quarterly report for April-June 1977). With emergency funds from the U. S. Geological Survey, a new seismic station (MAA, Figure 2) has been established last May on Gas Rocks, 3 km N of the maars. The station has been integrated into the existing Alaska Peninsula telemetered seismic network. Since the end of July 1977, when that network was serviced and a new telephone line was leased between King Salmon and Big Mountain, we have located a cluster of epicenters 7 to 10 km NW of the maars in Becharof Lake. These events occur at depths of 5 to 10 km and have body wave magnitudes between 1.5 and 2.5. It appears that the rising magma which produced the maars during phreatic-magmatic explosions in April 1977, followed the Bruin Bay fault plane. As more data becomes available, we will be able to study this process in greater detail. Unfortunately, the seismic epicenter plots from April through June 1977, given in Appendix 3, show no seismic activity at the maars, even though they were formed in the first month of the reporting period. However, portable seismograph systems operated at the maars in April, just after the eruptions had ceased, showed earthquake activity amounting to hundreds of small magnitude events per day. The reasons for not locating these events are:

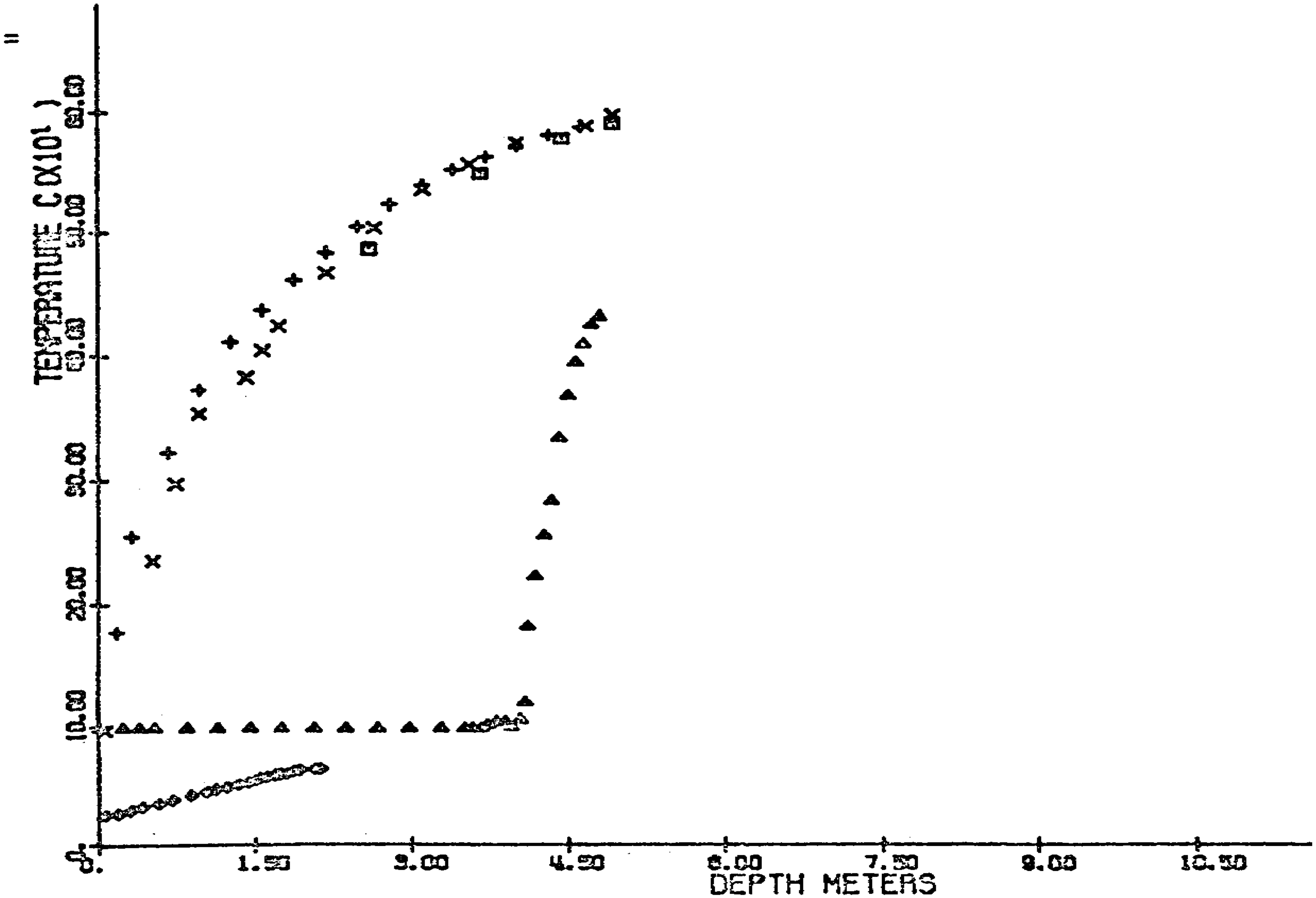


Figure 3. Temperature measurements in an Augustine pyroclastic flow erupted on February 10, 1976; temperature log on February 26, 1976, shown as squares; on February 28, 1976, as pulses; on February 29, 1976, as crosses; on September 26, 1976, as triangles and on September 2, 1977, as diamonds.

(1) We suffered from an extremely noisy telemetry link between Naknek and Big Mountain which relays all the Peninsula data. Many of these noisy films have not yet been carefully scaled.

(2) In order to locate magnitude 1.5-2.5 events near the maars, we need at least three nearby stations. Unfortunately, a key station (FLP) was not operational until late July.

B. Seismicity

Appendix 2 and Appendix 3 give listings of earthquake hypocenters and epicenter maps for the time period April through June, 1977. Listings and plots are given in two groups: one includes all events for which a location was obtained and the other includes only what we term Class 1 events--our most accurate locations. The criteria for class 1 events are given in Appendices 2 and 3. The small number of high-quality events is largely due to the larger number of station outages during this time period, before the annual servicing. However, the poorer solutions are now reanalyzed and the final number of high-quality locations will no doubt be much larger.

The overall smaller number of events located in the Kodiak-Alaska Peninsula areas, as compared to Cook Inlet, reflects problems with the array during the report period and also the larger aperture of the Kodiak-Peninsula system, which limits our earthquake detection capability to somewhat larger events than in Cook Inlet.

The Cook Inlet data (Figures A3-1 and A3-2) clearly show a heavy clustering of shallow events near Iliamna Volcano, a cluster that we consistently locate ever since we began operating in Cook Inlet. In previous report periods we observed similar but less pronounced clusters of shallow events at Augustine and Douglas Volcanoes. The class 1 events mainly show the well-defined Benioff zone seismicity associated with the subducting Pacific Plate in Cook Inlet. Note the excellent alignment of the volcano line with Benioff zone events at depths of 126 to 150 km (E, Figure A3-2).

VI. References and Papers in Print:

Lalla, D. J., and J. Kienle, Cooling history of 1976 pyroclastic flows at Augustine Volcano, Alaska, Geophys. Res. Letters, in preparation, 1977.

Malone, S. D., and D. Frank, Increased heat emission from Mount Baker, Washington, EOS, 56(10), 679-685, 1975.

Post, A., and R. Mayo, Glacier dammed lakes and outburst floods in Alaska, U. S. Geol. Survey, Hydrologic Investigations Atlas HA-455, 1971.

VIII. Estimate of Funds Expended:

	July	August	September	Total Expended	Outstand Obligations
Labor			257.89	257.89	
Staff Benefits			30.95	30.95	
Overhead			128.95	128.95	
Travel		⟨108.53⟩	275.03	166.50	66.00
Materials	3.00	461.34	9.07	473.41	
Services		131.99	1,094.75	1,266.74	122.00
	3.00	484.80	1,796.64	2,324.44	188.00

Appendix 1

Lower Cook Inlet, Kodiak Island, and Alaska Peninsula Seismic Network:

Station locations, station coordinates, station downtime, technical layout, and technical specifications of equipment used.

UNIVERSITY OF ALASKA

LOWER COOK INLET, KODIAK ISLAND,

AND ALASKA PENINSULA SEISMIC NETWORK

STATION NAME	CODE	LATITUDE (NORTH)	LONGITUDE (WEST)	ELEVATION (METERS)	COMPONETS
AUGUSTINE IS. FLOW	AUF	59 23.27	153 27.45	166	SPZ
AUGUSTINE IS. KAMISHAK	AUK	59 20.05	153 25.62	259	SPZ
AUGUSTINE IS. MOUND	AUM	59 22.26	153 21.17	106	SPZ
AUGUSTINE IS. PINNACLE	AUP	59 21.73	153 25.23	1033	SPZ
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DEADMAN BAY	DMB	57 05.23	153 57.63	300	SPZ
FEATHERLY PASS	FLP	57 42.7	156 15.9	485	SPZ
HOMER	HOM	59 39.50	151 38.60	198	SPZ
MAARS	MAA	57 51.40	153 04.82	131	SPZ
MCNEIL RIVER	MCN	59 06.06	154 11.99	273	SPZ
MIDDLE CAPE	MMC	57 20.00	154 38.1	340	SPZ
OIL POINT	OPT	59 39.16	153 13.78	625	SPZ
PINNACLE MOUNTIAN	PNM	56 48.3	157 35.0	442	SPZ
PUALE BAY	PUB	57 46.4	155 31.0	280	SPZ
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REDOUBT VOLCANO	RED	60 25.14	152 46.32	1067	SPZ
SHUYAK ISLAND	SHU	58 37.68	152 20.93	34	SPZ
SITKINAK ISLAND	SII	56 33.60	154 10.92	500	SPZ,SPE-W
SITKALIDAK ISLAND	SKS	57 09.85	153 04.82	135	SPZ
SPIRIDON LAKE	SPL	57 45.55	153 46.28	600	SPZ
UGASHIK LAKE	UKL	57 24.1	156 51.3	410	SPZ
YELLOW CREEK BLUFF	YCB	56 38.9	158 40.9	320	SPZ

July, 1977

Table A1-1

Percent Downtime of Seismic Stations

Station	July 1 - October 1, 1977[1]
AUF	0
AUK	0
AUM	0
AUP	100[5]
BMT	0
CDA	0
CHI	0
CHO	0
DMB	40[2]
FLP	0
HOM	100[3]
MAA	0
MCN	0
OPT	0
PNM	0
PUB	0
RAI	0
RED	C
SHU	0
SII	0
SKS	0
SPL	20[4]
UKL	0
YCB	0

---

1. Actual starting time is date station was serviced.

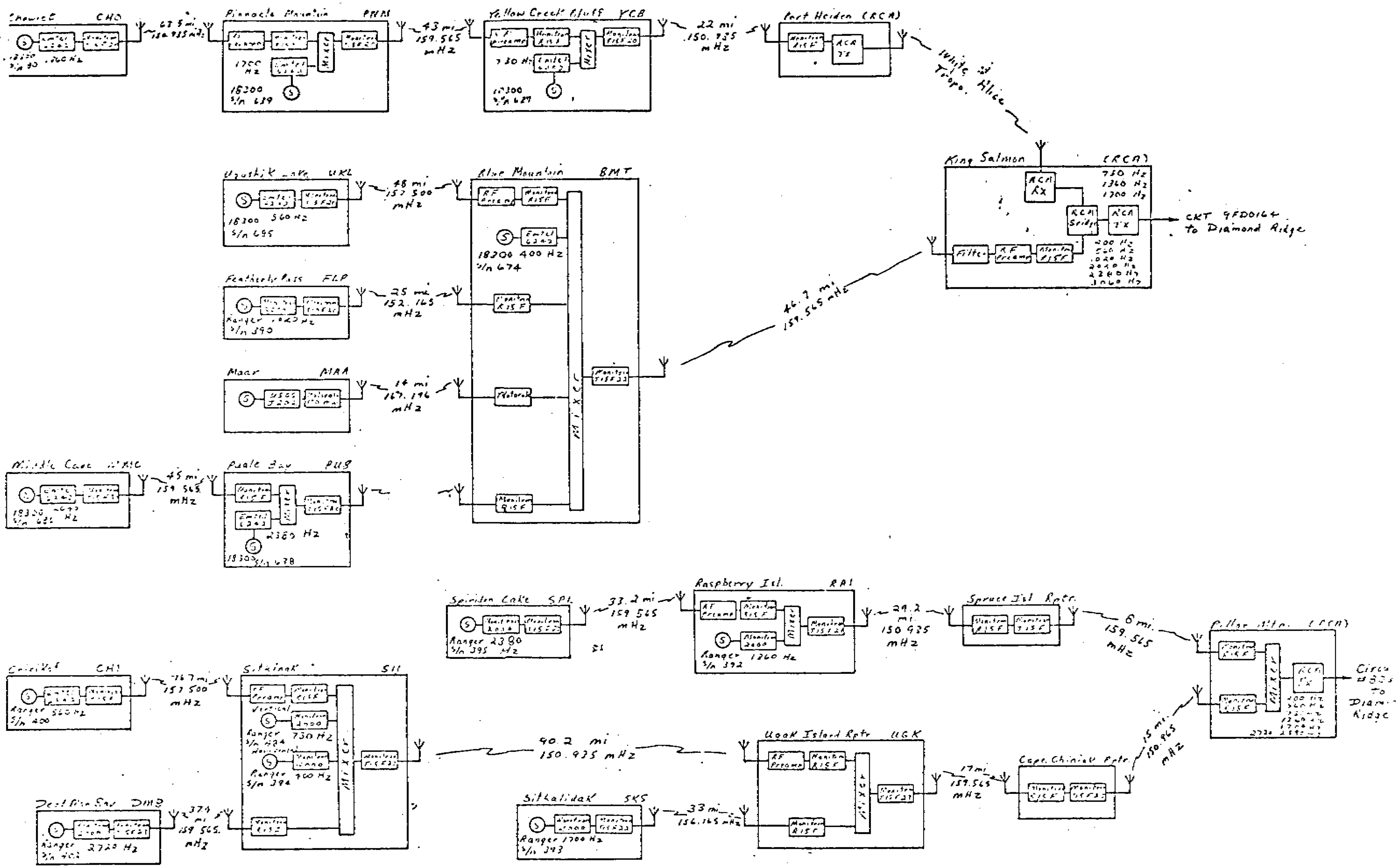
2. Signal lost late August, 1977.

3. Sensor removed for use as spare during service period. Will be reinstalled during October.

4. Sensor unplugged, apparently by a bear. Station was revisited in September and put back in operation.

5. Telemetry problem. Attempt will be made in October to fix problem

Table A1-2



Technical Layout of Seismic System
(Part I)
(Part II not legible - deleted.)

Monitron Corporation
7743 EAST 21st STREET TULSA, OKLAHOMA 74129 (918) 663-6631

VHF TRANSMITTER SPECIFICATIONS

GENERAL:

Transmitter type:	Frequency modulation.
Frequency Range:	150-175 MHz. Factory preset to any frequency within this band.
Model Number:	TXXFYY. XX = 15 for 150-160MHz band. 16 for 160-170MHz band. 17 for 170-175MHz band. YY = Minimum output power desired, expressed in dbm (24 dbm maximum).

ELECTRICAL:

Input Power:	10 to 15 VDC @ 50ma typical for 100mw output. 60ma max.
Power Protection:	Protected against reversed supply polarity; internally regulated.
Output Power:	Factory preset. 24dbm (250mw) maximum.
Frequency Stability:	±0.0005% of assigned frequency.
Spurious Signals:	More than 43db + 10_{log}Output Power below carrier.
Output Impedance:	50 ohms.
Load Protection:	Will withstand infinite VSWR without damage.
Modulation Type:	20F3. ±5KHz for 100% @ 1KHz modulation.
Modulation Bandwidth:	300Hz to 3KHz, minimum.
Modulation Response:	± 1db referred to 1KHz, maximum. 0.5db typical.
Modulation Limiting:	Factory preset for 5KHz deviation.
Deviation Sensitivity:	Factory preset for 5KHz deviation with 1.0VRMS modulation.
Modulation Distortion:	5% maximum. 1% typical @ 1KHz with 5KHz deviation.
Audio Input Impedance:	10k ohms, minimum.

ENVIRONMEMTAL:

Shock:	10g's, any direction.
Vibration:	10g's any of three major axes.
Temperature:	Operating: $-30^{\circ}C$ to $+60^{\circ}C$. Storage: $-50^{\circ}C$ to $+85^{\circ}C$.
Humidity:	90% relative. Sealed against moisture and dust.
Altitude:	Sea level to 20,000 feet.

MECHANICAL:

Housing:	Single-piece 2024-T3 Aluminum alloy. 4.00"X2.75"X1.25".
Mounting:	Flanges at each end of housing.
Connectors:	RF: Specify type desired. DC: Bendix PT02P-8-4P. Options available.

PRICE:

Monitron Corp

MODEL 2000 DCA/VCO

FINAL TEST DATA

JOB# 77-24

DATE 7-20-77; BY MDN.

UNIT# 2; FREQ. 2720 Hz; % DEV 125Hz(CBW) S/N 078.

TEMPERATURE	-40°C	+25°C	+60°C
DC-DC CONVERTER:			
+ REG (VDC)	+5.870	+5.993	6.047
- REG (VDC)	-5.897	-6.023	-6.076
E_{in} = 12VDC; I_{in}(ma)	21ma	19ma	18
VCO:			
FREQ. (Hz)	2721	2720	2720
OUTPUT (dbm, 600Ω)	-0.2	0	+0.1
DEV. SENS. (Hz/v)	44	45	44
DISTORTION(%)	0.2	0.2	0.2
DC AMPLIFIER:			
*OUTPUT LEVEL (dbm)	+0.5dbm	0	0
*OFF-SET (VDC)	-1.2VDC -0.3VDC at 78db gain	0	+0.8VDC 0.3VDC at 78db gain

*GAIN SET @ 90db (12db ATTN.), 20Hz, FOR ALL TESTS.

NOTES:

VCO DC Z_{in} = 1K. Allow 30 sec for freq to stabilize.

Output Filtering	250 Hz bandwidth at 1 dB down, outputs of harmonic frequencies less than 3% of fundamental signal.
Output Level	0 to 1.75 V rms into 600 ohms. The outputs of several units can be paralleled provided that the peak signal level does not exceed 3.3 volts.
Output Impedence	Floating transformer output with X_L = 12K ohm at 600 Hz.
Common Mode Rejection	Greater than 100,000.

Emtel Div., Develco Corp.
530 Logue Ave.
Mountain View, CA 94040

ELECTRICAL CHARACTERISTICS MODEL 6242

Maximum Voltage Gain	90 dB
Input Voltage Range (for full scale output)	170 μV to 20 mV peak
Gain Adjustment Range	42 dB (6 dB panel switch increments plus 6 dB internal vernier adjustment).
Gain Stability	Within ±1% at any gain setting
Frequency Response	0.1 to 30 Hz 12 dB/octave rolloff above 30 Hz 18 dB/octave rolloff below 0.1 Hz
Sensitivity	Noise level less than 0.25 μV peak referred to input for a source impedance of 4000 ohms.
Input Impedance	4k ohm fixed
Power Requirements Voltage Power	 +5 to +14 V dc 200 mW maximum
Linearity	0.25% of full bandwidth, output frequency with respect to input voltage.
VCO Output Frequency Range	±125 Hz full scale, sharply limited to 135 Hz by a symmetrical limiting amplifier preceding the VCO.
VCO Frequency Drift	Less than .05% drift over 200 hours at constant temperature, less than 0.005% per degree C.

VCO Output Frequencies

Option	-01	680 Hz	
	-02	1020 Hz	
	-03	1360 Hz	= 680 Hz
	-04	1700 Hz	
	-05	2040 Hz	= 1020 Hz
	-06	2380 Hz	
	-07	2720 Hz	= 1360 Hz
	-08	3060 Hz	

MECHANICAL & ENVIRONMENTAL CHARACTERISTICS

Temperature Range	-20°C to +60°C operating -40°C to +80°C non-operating
Front Panel Controls	Input attenuator; VCO output level
Connectors	Input signal connector, VCO output and power connector (mating connectors provided), BNC monitor of signal input to VCO, and VCO output monitor.
Size	3 1/8"H x 5 1/8"D; (8 cm H x 13 cm W x 20.4 cm D)

Kinemetrics, Inc.
222 Vista
Pasadena, CA 91107

1.0 GENERAL DESCRIPTION Model SS-1 Seismometer

The SS-1 Ranger Seismometer is a versatile, high-sensitivity, portable seismometer specifically designed for a variety of seismic field applications under adverse environmental conditions. The Ranger combines high sensitivity, field selectable mode (horizontal or vertical) and rugged water-tight construction, in a package measuring only 5 inches in diameter by 11 inches long and weighing only 9 pounds. A separate calibration coil in the base provides a simple means of field calibrating the Ranger using only a known-voltage battery and a fixed precision resistor. Under normal usage, the Ranger should provide years of data acquisition with little, if any, maintenance.

The Ranger is a spring-mass instrument with electromagnetic transduction. Its permanent magnet assembly is the seismic mass while the coil is attached to the frame. The Ranger can be used either horizontally or vertically and is well suited to field or laboratory use. The relationship between major parts is shown schematically in Figure 1. The mass is supported by two angular flexures which constrain it to a single degree of freedom. A helical spring is used to suspend the mass. When the seismometer is used vertically, the suspension spring is fully extended; when used horizontally, the spring is unstressed. The force of the suspension spring is controlled by positioning a hanger rod attached to the spring. The basic natural period of the mass, flexures, and suspension spring is extended by the addition of small rod-magnets installed around the mass. These period-extending magnets interact with the magnetic field of the mass, effectively producing a negative restoring force. In order to achieve the desired period, the field strength and position of the period-extending magnets are carefully adjusted at the factory.

1.1 TYPICAL SPECIFICATIONS

Natural Period	1 second
Coil Resistance	5500 ohms
Critical Damping Resistance	6400 ohms
Generator Constant	340 volts/meter/sec
Total Mass Travel	2mm
Mass Weight	1.45 kg
Motor Constant of the Calibration Coil	.4 newtons/amp

Teledyne/Geotech

3401 Shiloh

Garland, Texas

1.3 SPECIFICATIONS

Model 18300 Seismometer

1.3.1 Operating Characteristics

Mode of operation	Convertible, vertical to horizontal
Natural period	Adjustable 1.33 to 0.91 sec/cycle
Natural frequency	Adjustable 0.75 to 1.1 cps
Tilt (vertical mode)	Operates within 4° of vertical, at 0.8 cps natural frequency
Weight of inertial mass	5 kg (11 lb) ± 1%
Spring rate	(Approx 10 to 1 lever) 3.82 newton/mm (21.8 lb/in.) ± 5%
Temperature range	-51 to +60° C (-60 to 140°F)
Transducer	
Type	Moving coil (velocity)
Damping	Electromagnetic
Air gap flux density	4850 ± 50 gauss, average over 22.224 mm coil length (0.875 in.); 4450 ± 50 gauss, average over 25.4 mm coil length (1 in., standard coil); varies less than 2% over temperature range
Air gap length	3.81 mm (0.150 in.)
Area of smallest pole piece	0.00393 sq m (6.1 sq in.)
Coil volume	25.4 mm coil length - 15.1 x 10^{-6} cu m; 22.2 mm coil length - 13.2 x 10^{-6} cu m
Coil to pole clearance	0.762 mm (min)

Generator constant	130.5 v-sec/m ±2% when using the standard coil
Coil specifications	See table 1 (page 4)
Calibration coil	
Motor constant	0.1975 ±0.002 newton/amp
Number of turns	50
Wire size	No. 42
Resistance	23 ±3 ohms at 25°C (77°F)

1.3.2 Physical Characteristics

Basic dimensions	
Height	0.378 m (15 in.)
Diameter	0.167 m (6.625 in.)
Net weight	10.9 kg (24 lb)
Shipping weight	15.4 kg (34 lb)
Shipping volume	0.042 cu m (1.5 cu ft)
Seismometer bulk specific gravity	1.82

1.3.3 Connectors

Output	Receptacle MS3102C-14S-6P

1.4 EQUIPMENT SUPPLIED

1 Portable Short-Period Seismometer, Model 18300
1 Mating connector, MS3108B-14S-6S, and cable clamp MS3057-6
1 Operation and maintenance manual
1 Calibration Kit, No. 21323

Appendix 2

Hypocenter Listings for Cook Inlet,
Kodiak, and Alaska Peninsula

April through June, 1977

Table A2-1	Class 1 events
Table A2-2	All events

This appendix lists origin times, focal coordinates, magnitudes, and related parameters for earthquakes which occurred in the lower Cook Inlet, Kodiak, and Alaska Peninsula areas. The following data are given for each event:

(1) Origin time in Greenwich Civil Time (GCT): date, hour (HR), minute (MN), and second (SEC). To convert to Alaska Standard Time (AST), subtract ten hours.

(2) Epicenter in degrees and minutes of north latitude (LAT N) and west longitude (LONG W).

(3) DEPTH, depth of focus in kilometers.

(4) MAG, magnitude of the earthquake. A zero means not determined.

(5) NP, number of P arrivals used in locating earthquake.

(6) NS, number of S arrivals used in locating earthquake.

(7) GAP, largest azimuthal separation in degrees between stations.

(8) DM, epicentral distance in kilometers to the closest station to the epicenter.

(9) RMS, root-mean-square error in seconds of the travel time residuals:

$$RMS = \sum_i (R^2_{Pi} + R^2_{Si}) \;/\; (NP + NS)$$

where R_{Pi} and R_{Si} are the observed minus the computed arrival times of P and S waves, respectively, at the i-th station.

(10) ERH, largest horizontal deviation in kilometers from the hypocenter within the one-standard-deviation confidence ellipsoid. This quantity is a measure of the epicentral precision for an event.

(11) ERZ, largest vertical deviation in kilometers from the hypocenter within the one-standard-deviation confidence ellipsoid. This quantity is a measure of the depth precision for an event.

(12) Q, quality of the hypocenter. This index is a measure of the precision of the hypocenter and is the average of two quantities, QS and QD, defined below:

QS	RMS (sec)	ERH (km)	ERZ (km)
A	< 0.15	≤ 1.0	≤ 2.0
B	< 0.30	≤ 2.5	≤ 5.0
C	< 0.50	≤ 5.0	
D	Others		

QD is rated according to the station distribution as follows:

QD	NO	GAP	DMIN
A	≥ 6	≤ 90°	≤ DEPTH or 5 km
B	≥ 6	≤ 135°	≤ 2x DEPTH or 10 km
C	≥ 6	≤ 180°	≤ 50 km
D	Others		

The following tables are included:

Table A2-1	Cook Inlet, western Gulf of Alaska Class 1 events
Table A2-2	Cook Inlet, western Gulf of Alaska All events

Class 1 events have the following quality parameters:

RMS	$\leq$	1 sec
ERZ	$\leq$	10 km
ERH	$\leq$	10 km
NP	>	5

Table A2-1

COOK INLET–WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN TIME DAY	HR	MN	SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
APR	2	3	20	54.0	60	15.2	152	33.8	[illegible]	2.0	6	174	21	0.08	2.4	4.1	C
	5	3	51	44.0	58	31.8	151	32.0	[illegible]	1.7	5	214	103	0.25	5.8	4.5	D
	5	4	39	[illegible]	59	[illegible]	151	42.9	[illegible]	1.5	6	242	31	0.14	4.2	1.9	D
	6	12	45	[illegible]	59	21.5	153	30.1	[illegible]	2.1	5	197	44	0.14	5.2	8.3	D
	7	[illegible]	5	[illegible]	59	[illegible]	[illegible]	3.9	[illegible]	1.9	6	98	17	0.16	2.1	3.2	B
	[illegible]	14	[illegible]	[illegible]	59	[illegible]	151	[illegible]	[illegible]	1.4	6	198	29	0.11	4.0	6.7	D
	[illegible]	[illegible]	[illegible]	[illegible]	59	[illegible]	151	[illegible]	[illegible]	1.2	5	229	37	0.13	6.2	9.4	D
	[illegible]	5	31	[illegible]	59	[illegible]	[illegible]	[illegible]	[illegible]	1.8	6	271	75	0.12	7.9	5.1	D
	[illegible]	11	1	[illegible]	59	[illegible]	[illegible]	[illegible]	[illegible]	2.2	9	69	10	0.27	4.6	8.0	B
	[illegible]	[illegible]	55	[illegible]	62	[illegible]	[illegible]	45.1	[illegible]	3.1	14	140	138	0.75	5.7	7.1	D
	17	[illegible]	[illegible]	[illegible]	59	52.5	[illegible]	[illegible]	[illegible]	1.8	5	217	31	0.42	2.7	8.4	D
	17	[illegible]	53	[illegible]	59	22.7	[illegible]	1.7	[illegible]	1.3	5	128	22	0.14	4.8	9.7	D
	[illegible]	16	52	12.2	59	[illegible]	[illegible]	52.6	[illegible]	1.5	5	152	30	0.06	3.1	8.3	D
	[illegible]	[illegible]	3	[illegible]	59	[illegible]	[illegible]	[illegible]	[illegible]	1.9	7	64	7	0.28	5.4	9.0	C
	23	23	3	52.7	59	25.2	153	11.8	[illegible]	1.4	5	134	20	0.08	2.9	1.6	D
	26	[illegible]	49	12.0	59	21.4	152	48.8	[illegible]	2.9	14	85	35	0.36	2.4	3.5	B
	[illegible]	10	50	[illegible]	59	35.2	153	2.3	95.5	1.2	6	153	29	0.21	4.3	8.0	C
	[illegible]	[illegible]	[illegible]	14.1	59	[illegible]	[illegible]	[illegible]	[illegible]	1.7	6	127	53	0.23	4.6	9.9	C
	[illegible]	[illegible]	22	[illegible]	59	1.7	[illegible]	43.2	[illegible]	2.6	12	122	75	0.20	1.8	5.0	B
	[illegible]	[illegible]	[illegible]	[illegible]	59	23.4	[illegible]	38.8	[illegible]	0.	20	88	44	0.32	1.6	2.7	B
	7	[illegible]	17	23.2	59	[illegible]	152	39.8	[illegible]	2.8	19	125	50	0.26	1.4	2.5	B
	7	[illegible]	39	[illegible]	59	23.9	152	54.1	[illegible]	2.3	6	102	33	0.17	2.8	6.2	C
	7	23	12	44.1	60	11.2	152	28.0	[illegible]	2.7	5	181	31	0.11	5.7	9.2	D
	8	12	5	27.8	59	52.9	[illegible]	19.9	[illegible]	2.3	7	178	26	0.19	5.0	9.5	C
	[illegible]	[illegible]	22	[illegible]	58	[illegible]	[illegible]	51.3	[illegible]	1.9	9	137	38	0.18	1.8	3.2	C
	[illegible]	14	25	[illegible]	59	[illegible]	151	59.7	[illegible]	1.6	5	216	67	0.20	4.8	5.0	D
	13	[illegible]	25	[illegible]	59	15.4	151	27.4	[illegible]	2.1	7	230	66	0.23	5.0	2.3	D
	13	17	55	[illegible]	59	47.1	[illegible]	50.3	[illegible]	2.3	10	111	54	0.26	3.1	6.8	C
	14	[illegible]	27	[illegible]	59	[illegible]	[illegible]	40.6	[illegible]	2.2	6	274	55	0.12	8.1	4.8	D
	14	[illegible]	40	[illegible]	59	[illegible]	[illegible]	46.9	[illegible]	2.7	10	266	57	0.24	7.3	4.9	D
	15	14	30	26.7	59	[illegible]	[illegible]	59.1	[illegible]	2.2	11	118	48	0.27	3.1	5.9	C
	15	[illegible]	40	16.4	60	[illegible]	151	46.7	[illegible]	2.7	13	223	43	0.32	6.4	7.6	D
	15	[illegible]	44	[illegible]	59	31.5	152	22.5	70.9	1.6	5	97	44	0.17	4.0	9.9	D
	15	[illegible]	45	[illegible]	59	[illegible]	153	43.1	[illegible]	2.1	7	136	21	0.13	3.1	4.6	C
	15	[illegible]	7	[illegible]	59	[illegible]	153	34.2	136.5	2.4	16	142	41	0.36	3.7	5.7	C
	16	4	16	[illegible]	59	34.2	153	0.4	107.3	2.5	15	75	29	0.33	2.5	3.9	B
	16	11	20	14.5	60	8.1	150	24.0	82.1	2.8	5	290	87	0.07	9.4	4.9	D
	19	1	43	[illegible]	58	59.6	[illegible]	21.0	144.4	2.6	19	71	14	0.56	3.3	6.1	C
	20	11	51	[illegible]	59	13.2	153	44.0	123.6	2.0	7	99	21	0.20	3.5	7.1	C
	21	15	47	17.2	59	32.6	153	1.8	90.5	2.0	6	135	32	0.20	3.7	7.5	C
	22	18	27	[illegible]	59	37.5	152	49.0	109.5	2.0	6	128	47	0.19	3.9	9.1	C
	23	3	51	[illegible]	59	1.3	152	59.1	106.6	2.0	5	144	15	0.08	2.3	3.5	C
	23	4	23	31.8	59	7.8	153	30.2	92.2	2.5	16	84	23	0.33	2.1	4.0	B
	23	11	23	42.6	58	50.8	154	27.2	119.2	2.0	5	223	31	0.	0.	0.	C
	26	4	13	17.2	61	23.5	147	18.3	31.3	3.3	17	129	99	0.34	2.0	2.0	D

Table A2-1 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN TIME HR	MN	SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
MAY 23	[illegible]	23	[illegible]	59	21.6	151	55.3	67.2	[illegible]	7	133	26	0.25	5.3	9.5	C
24	21	[illegible]	[illegible]	59	27.3	152	0.7	105.4	1.9	7	110	39	0.19	2.9	6.8	C
JUN 2	[illegible]	10	57.1	59	35.5	152	40.6	137.4	1.9	5	190	36	0.01	0.3	0.8	C
3	[illegible]	41	[illegible]	57	[illegible]	[illegible]	14.5	[illegible]	2.5	11	117	34	[illegible]	2.9	1.8	C
4	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.0	8	168	24	[illegible]	4.0	6.0	C
[illegible]	[illegible]	10	[illegible]	59	[illegible]	[illegible]	[illegible]	[illegible]	1.7	7	127	45	0.10	2.0	5.1	C
[illegible]	[illegible]	22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52	0.25	5.1	9.2	D
[illegible]	[illegible]	3	[illegible]	59	[illegible]	[illegible]	[illegible]	[illegible]	2.1	[illegible]	[illegible]	15	0.30	6.2	8.9	D
[illegible]	[illegible]	41	[illegible]	[illegible]	[illegible]	[illegible]	4.1	[illegible]	[illegible]	10	[illegible]	41	[illegible]	5.5	9.1	D
13	[illegible]	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.1	9	[illegible]	33	[illegible]	4.6	9.0	C
[illegible]	[illegible]	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.7	3.2	D
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.3	11	138	41	[illegible]	2.1	3.7	C
[illegible]	[illegible]	12	[illegible]	57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21	58	70	[illegible]	3.4	3.4	C
[illegible]	[illegible]	41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	159	50	[illegible]	5.7	4.4	D
14	2	5	57.3	59	[illegible]	151	[illegible]	[illegible]	1.8	5	304	23	0.01	1.8	0.3	C
15	[illegible]	32	[illegible]	57	[illegible]	[illegible]	9.1	[illegible]	2.2	9	169	81	0.40	4.2	4.5	D
17	[illegible]	[illegible]	[illegible]	61	[illegible]	[illegible]	18.0	[illegible]	3.9	17	60	29	0.48	3.0	4.3	B
17	[illegible]	[illegible]	[illegible]	57	[illegible]	[illegible]	58.2	[illegible]	2.4	5	275	71	0.03	4.2	0.7	D
[illegible]	[illegible]	[illegible]	[illegible]	59	[illegible]	[illegible]	[illegible]	[illegible]	2.0	5	177	17	0.04	3.6	4.7	D
[illegible]	[illegible]	[illegible]	[illegible]	59	[illegible]	[illegible]	43.8	[illegible]	2.3	5	211	[illegible]	0.03	3.1	2.6	D
22	[illegible]	50	14.6	60	[illegible]	[illegible]	21.3	[illegible]	2.0	6	204	44	0.04	2.4	6.1	D
23	2	36	[illegible]	60	5.4	[illegible]	40.1	[illegible]	2.0	6	147	37	0.13	4.3	8.8	C
23	[illegible]	22	[illegible]	59	11.8	[illegible]	41.6	[illegible]	2.0	6	131	21	0.17	5.5	9.8	C
23	[illegible]	59	51.2	58	4.3	[illegible]	36.2	32.7	2.3	9	133	63	0.51	5.6	6.1	C

Table A2-2

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN TIME HR	MN	SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
SEP 1	4	13	34.4	59	1.2	151	56.5	107.4	1.4	5	304	84	0.93	142.2	103.7	D
1	9	11	24.2	59	4.5	151	4.3	34.6	1.5	5	303	52	0.08	25.1	1.6	D
1	12	15	52.7	59	35.6	152	25.8	5.0	0.9	3	243	45	0.12	0.	0.	C
1	17	57	33.6	62	20.4	150	19.2	12.0	3.1	17	37	149	1.67	9.7	18.0	D
1	19	36	20.9	59	24.3	155	2.9	305.4	2.3	4	321	93	0.24	0.	0.	C
1	19	51	15.6	57	37.1	154	36.0	72.9	2.1	9	217	60	1.41	43.3	72.6	D
2	9	33	54.3	60	15.2	152	33.8	132.	2.0	6	174	21	0.08	2.4	4.1	C
2	4	36	53.5	59	54.2	152	28.1	1.6	0.9	5	123	47	1.63	11.0	85.8	D
2	14	15	[illegible]	51	[illegible]	152	12.2	30.	1.1	4	250	31	0.56	0.	0.	D
2	14	45	[illegible]	59	[illegible]	152	0.5	[illegible]	1.3	4	112	20	3.08	0.	0.	D
2	21	24	3.7	59	53.5	152	15.5	84.1	0.9	4	167	61	0.	0.	0.	C
3	4	23	57.7	60	15.9	151	55.6	2.9	0.9	4	238	49	0.64	0.	0.	D
3	5	34	21.3	59	52.7	152	21.9	2.6	1.4	7	142	47	0.81	15.5	47.0	D
3	6	25	25.9	59	52.0	151	57.6	67.9	1.6	7	179	29	0.92	26.3	59.0	D
3	7	13	14.1	59	54.5	152	16.6	84.4	1.4	6	167	60	0.98	25.1	72.8	D
3	9	59	23.3	59	24.7	152	26.8	.1	1.0	5	147	50	0.25	4.7	566.3	D
3	10	13	44.7	60	4.3	151	48.7	30.3	1.6	6	222	47	1.23	24.3	19.8	D
3	12	28	59.3	59	45.2	152	0.1	110.4	1.6	6	130	14	0.49	11.9	33.7	C
3	13	31	27.6	60	4.1	152	54.0	5.0	0.7	3	238	39	0.31	0.	0.	D
3	19	43	50.7	59	43.0	153	24.7	26.7	0.8	6	200	12	1.44	26.7	26.8	D
4	5	59	7.0	59	26.4	152	21.8	34.7	2.0	8	102	45	7.38	59.1	55.8	C
4	6	6	40.6	60	10.5	152	3.2	2.9	1.2	4	214	48	0.64	0.	0.	D
4	14	54	54.9	59	52.8	152	31.7	5.0	0.6	3	143	46	0.	0.	0.	C
4	21	43	39.5	58	54.1	152	24.7	70.6	2.0	7	145	64	0.86	11.6	32.0	D
4	9	23	27.6	59	35.2	153	3.0	105.1	1.6	5	102	12	0.24	8.8	20.0	D
5	2	51	44.0	58	31.9	151	32.0	25.0	1.7	5	214	103	0.25	5.8	4.5	D
5	4	4	33.2	59	51.2	153	1.0	110.8	1.6	5	164	25	0.65	25.4	61.6	D
5	6	36	24.6	59	41.4	151	2.9	34.1	1.5	6	242	31	0.14	4.2	1.9	D
5	9	13	30.3	59	53.4	152	45.1	5.0	1.4	5	148	59	1.21	17.5	0.	D
5	9	7	4.7	59	23.4	151	52.9	54.0	1.6	7	116	17	0.56	15.1	23.6	C
5	19	6	23.8	58	6.1	151	9.5	34.7	2.2	6	259	84	2.30	492.7	345.6	D
5	21	6	2.3	59	47.3	151	57.4	33.0	1.1	4	162	22	0.47	0.	0.	D
6	4	15	34.2	59	19.9	152	28.5	102.4	1.2	6	165	50	0.46	13.1	31.9	D
6	11	46	53.9	59	21.5	153	20.1	115.9	2.1	5	197	44	0.14	5.2	8.3	D
6	15	42	35.2	60	2.6	153	40.8	13.2	1.8	6	142	65	2.46	26.9	0.	D
7	14	42	13.3	60	24.5	152	35.1	53.9	1.6	6	231	10	1.28	116.4	142.3	D
7	14	43	54.1	60	25.2	152	5.2	26.0	1.2	4	254	37	0.37	0.	0.	D
7	15	5	30.3	59	52.8	151	55.2	5.0	0.8	4	186	29	1.43	0.	0.	D
7	22	14	49.2	59	39.6	150	38.9	444.4	2.9	4	311	56	0.73	0.	0.	D
7	23	5	23.1	59	31.5	153	3.9	104.5	1.9	8	98	17	0.16	2.1	3.2	B
8	1	37	57.5	59	52.0	151	46.8	103.2	1.1	4	204	24	0.08	0.	0.	C
8	7	4	15.0	59	52.9	153	13.6	5.0	1.0	4	193	64	0.38	0.	0.	D
8	8	39	49.3	57	46.6	153	40.8	0.9	1.6	6	271	44	1.07	19.2	31.2	D
8	13	30	26.6	59	56.1	152	42.8	10.5	1.4	5	134	42	1.78	25.0	0.	D
8	16	19	39.1	59	17.8	151	58.6	62.5	1.4	6	193	29	0.11	4.0	6.7	D

Table A2-2 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977		ORIGIN TIME HR	MN	SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
APR	8	23	30	38.1	60	22.1	152	19.8	9.1	1.9	6	220	25	0.31	11.1	10.8	D
	9	3	52	52.7	60	3.9	153	34.2	190.6	2.7	7	137	59	0.28	7.6	16.3	D
	9	11	19	27.6	59	50.1	152	51.0	5.0	1.4	3	244	65	0.18	0.	0.	C
	9	17	36	17.4	60	3.7	152	33.0	131.9	1.6	4	161	31	0.19	0.	0.	C
	9	2[illegible]	4	18.3	60	37.1	154	24.1	[illegible]	1.3	4	292	77	3.73	0.	0.	D
	10	2	19	20.5	59	25.0	153	30.4	1.2	0.8	5	227	10	6.87	3.1	7.9	D
	10	6	21	2[illegible].6	60	5.6	152	50.5	9[illegible].1	1.4	5	162	36	0.36	9.0	28.1	D
	10	7	35	2[illegible].2	59	16.3	151	52.7	47.6	1.2	6	229	37	0.13	6.2	9.4	D
	10	[illegible]	37	1[illegible].9	60	24.7	152	32.6	67.9	1.3	4	235	12	3.26	0.	0.	D
	10	11	15	2[illegible].0	60	[illegible]1.3	152	1.7	[illegible]	1.7	6	273	42	1.45	544.2	195.5	D
	10	13	11	2[illegible].3	59	3[illegible].2	154	12.0	120.6	1.3	4	249	54	0.01	0.	0.	C
	10	14	3	[illegible].4	59	[illegible].8	15[illegible]	24.4	33.1	1.3	5	321	76	0.17	78.0	13.4	D
	10	1[illegible]	53	59.2	59	47.1	15[illegible]	23.0	12[illegible]	2.0	7	201	17	0.34	9.1	14.6	D
	10	1[illegible]	15	10.2	59	2[illegible].4	15[illegible]	4.6	10.[illegible]	2.3	6	175	30	0.78	10.6	0.	D
	10	1[illegible]	31	4[illegible].2	59	55.[illegible]	152	25.2	2[illegible]	2.2	8	176	20	1.28	21.6	19.0	D
	10	21	35	56.8	59	5[illegible].0	153	6.6	[illegible]	1.0	6	194	24	0.33	21.9	48.3	D
	11	2	19	44.3	57	36.7	156	19.9	54.0	2.7	9	147	178	1.74	30.4	580.4	D
	11	3	53	35.5	59	43.3	151	59.1	[illegible].4	1.4	7	140	20	1.04	11.0	15.3	D
	11	[illegible]	3	1[illegible].7	59	55.1	153	22.2	126.5	1.5	6	206	30	0.56	20.8	48.7	D
	11	1[illegible]	23	1[illegible].4	59	20.5	151	50.6	6[illegible].3	1.6	7	162	20	0.78	14.7	22.2	D
	11	1[illegible]	55	53.6	59	57.6	153	21.4	11[illegible].4	1.9	7	131	34	0.64	10.8	22.1	C
	11	17	29	[illegible].2	56	41.3	158	19.4	5.0	3.0	3	305	192	3.70	0.	0.	D
	11	20	46	45.5	59	42.5	152	28.5	51.6	1.2	6	108	42	2.60	36.0	97.0	C
	11	22	26	37.0	60	7.1	152	0.5	10.8	1.1	5	210	53	0.71	15.0	0.	D
	12	1	37	54.7	61	35.3	151	34.0	34.4	2.1	7	284	145	1.49	82.2	0.	D
	12	3	22	21.7	59	45.4	153	22.0	129.2	1.6	5	198	14	0.36	18.2	40.0	D
	12	[illegible]	47	33.3	60	14.0	153	43.6	233.2	3.0	12	115	56	3.22	59.0	106.9	C
	12	[illegible]	56	4[illegible].0	60	17.0	151	38.3	5.0	1.5	5	254	63	1.55	57.4	0.	D
	12	1[illegible]	31	13.0	56	10.5	160	7.5	5.0	3.6	3	324	310	5.52	0.	0.	D
	12	10	35	22.2	59	43.0	152	20.3	69.[illegible]	0.8	4	124	39	0.48	0.	0.	D
	12	13	6	[illegible].8	60	52.9	142	34.3	36.0	3.0	15	262	178	2.44	58.4	0.	D
	12	15	3	53.3	59	35.3	153	5.2	93.5	1.1	5	100	10	0.28	9.6	19.5	D
	12	1[illegible]	46	27.1	59	2[illegible]	152	15.1	5.0	1.4	5	199	40	3.16	25.9	45.4	D
	12	21	58	1[illegible].0	56	5.7	160	8.4	5.0	3.5	3	325	316	6.96	0.	0.	D
	13	[illegible]	56	53.4	56	31.0	152	38.2	[illegible].1	2.5	12	262	35	13.63	287.0	603.0	D
	13	1	43	57.0	60	12.3	152	17.7	5.0	1.3	4	202	35	1.86	0.	0.	D
	13	1	57	1.5	59	34.7	152	41.0	0.6	1.2	9	76	31	11.65	63.0	295.4	D
	13	3	33	28.7	59	34.0	152	11.5	82.1	1.2	6	118	32	0.48	11.6	28.3	C
	13	12	31	[illegible].7	60	24.5	152	23.2	127.3	1.9	6	223	21	1.10	37.8	48.5	D
	13	1[illegible]	53	3[illegible].3	59	26.2	152	59.9	131.8	1.3	6	122	26	0.14	4.3	12.9	C
	13	1[illegible]	16	3[illegible]	60	21.9	152	37.7	49.8	2.1	9	198	9	2.16	30.0	33.4	D
	13	20	0	5[illegible].6	60	15.0	150	54.9	97.8	1.5	6	283	77	1.01	127.1	130.9	D
	14	2	23	4[illegible].6	60	28.9	152	16.3	90.7	2.2	9	228	29	1.19	23.3	25.4	D
	14	2	38	25.7	60	12.1	149	50.1	52.2	2.3	8	291	118	2.10	153.0	209.4	D
	14	3	11	2[illegible].6	59	45.6	153	29.5	140.7	1.5	6	207	19	0.29	11.7	28.7	D

Table A2-2 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN HR	TIME MN	SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
APR 14	4	5	15.3	60	2.3	152	53.7	15.0	1.2	5	168	39	1.89	11.5	130.3	D
14	7	19	10.7	58	17.9	156	42.2	262.6	3.3	14	158	35	5.11	64.7	120.8	D
14	7	34	25.3	58	15.7	151	27.9	23.1	1.4	6	260	102	0.95	31.4	12.1	D
14	12	0	32.7	58	[illegible]	152	27.7	5.0	1.5	6	172	72	5.85	82.9	0.	D
14	17	21	55.8	60	7.5	151	35.1	52.7	1.3	5	243	52	1.18	69.1	113.9	D
14	[illegible]	25	[illegible]	59	[illegible]	151	28.4	[illegible]	1.6	5	286	6	8.96	745.3	424.3	D
14	22	17	[illegible]	59	[illegible]	[illegible]	0.0	[illegible]	1.6	5	82	13	0.37	5.6	10.3	C
14	22	18	[illegible]	[illegible]	[illegible]	[illegible]	52.8	5.0	0.9	3	240	50	0.27	0.	0.	C
14	[illegible]	41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.0	11	111	9	1.09	11.8	15.2	C
15	[illegible]	[illegible]	[illegible]	60	[illegible]	[illegible]	[illegible]	31.4	1.4	5	141	36	1.11	7.7	24.5	D
15	[illegible]	29	[illegible]	59	[illegible]	[illegible]	6.9	5.0	0.9	3	254	30	0.01	0.	0.	C
15	[illegible]	55	[illegible]	[illegible]	[illegible]	[illegible]	45.7	[illegible]	2.5	14	138	29	3.97	55.7	74.3	D
15	[illegible]	4	[illegible]	59	[illegible]	[illegible]	35.0	341.[illegible]	2.8	5	139	37	0.22	31.9	302.8	D
15	[illegible]	44	[illegible]	60	[illegible]	[illegible]	43.8	[illegible]	1.5	5	[illegible]	59	2.91	63.3	0.	D
15	[illegible]	30	[illegible]	[illegible]	[illegible]	[illegible]	5.0	[illegible]	0.4	3	172	77	0.	0.	0.	C
15	[illegible]	28	[illegible]	57	[illegible]	[illegible]	13.9	[illegible]	2.6	16	113	48	7.32	32.4	127.1	D
15	23	20	[illegible]	59	[illegible]	152	57.5	95.4	1.6	6	146	22	0.65	14.5	38.5	D
16	[illegible]	28	[illegible]	54	[illegible]	160	33.6	5.0	3.4	5	326	336	4.56	0.	0.	D
16	[illegible]	29	[illegible]	61	[illegible]	151	53.4	[illegible]	2.6	9	265	153	1.23	66.2	56.0	D
16	[illegible]	31	[illegible]	55	[illegible]	155	16.2	[illegible]	1.8	6	271	75	0.12	7.9	5.1	D
16	7	17	[illegible]	59	51.3	151	15.8	53.3	1.1	4	250	45	0.97	0.	0.	D
16	[illegible]	5	[illegible]	59	17.7	153	36.9	92.1	1.3	6	144	11	0.47	16.0	14.2	D
16	[illegible]	36	34.1	59	21.5	152	30.3	5.0	0.	3	284	52	0.	0.	0.	C
16	[illegible]	21	[illegible]	59	50.9	153	19.9	141.9	1.5	5	200	22	0.44	24.5	59.3	D
16	[illegible]	13	[illegible]	58	55.3	152	24.3	[illegible]	1.7	7	167	64	0.60	8.9	23.6	D
16	11	1	[illegible]	59	[illegible]	[illegible]	2.8	123.4	2.2	9	89	10	0.27	4.6	8.0	B
16	[illegible]	56	[illegible]	62	[illegible]	[illegible]	45.1	[illegible]	3.1	14	140	138	0.75	5.7	7.1	D
16	[illegible]	1	[illegible]	57	[illegible]	[illegible]	[illegible]	[illegible]	1.1	4	205	15	0.	0.	0.	C
16	[illegible]	31	1.6	59	[illegible]	[illegible]	9.6	[illegible]	2.2	12	220	115	9.07	110.2	0.	D
16	[illegible]	4	[illegible]	60	[illegible]	[illegible]	19.5	7.1	1.4	6	223	26	1.63	325.6	439.0	D
16	21	4	33.7	59	41.6	[illegible]	48.9	44.4	1.6	6	145	10	0.86	28.5	39.8	D
16	21	6	13.7	61	47.2	151	34.3	[illegible]	2.3	7	241	165	1.49	45.4	0.	D
17	7	15	43.2	62	[illegible]	[illegible]	36.3	[illegible]	2.3	13	70	91	4.36	29.7	219.8	D
17	7	57	[illegible]	59	[illegible]	152	28.8	5.0	0.9	5	123	42	2.11	28.9	39.2	D
17	[illegible]	4	[illegible]	59	54.5	152	[illegible]	[illegible]	1.8	5	217	31	0.42	2.7	8.4	D
17	[illegible]	53	35.8	59	22.7	153	1.7	90.6	1.3	5	128	23	0.14	4.8	9.7	D
17	[illegible]	25	[illegible]	58	53.8	151	56.3	32.2	2.6	20	153	67	4.05	21.1	18.1	D
17	17	44	41.7	60	24.2	[illegible]	53.8	[illegible]	2.0	4	231	62	0.49	0.	0.	D
17	17	49	[illegible]	59	54.4	152	50.0	10.7	0.6	5	149	38	1.84	26.7	0.	D
17	[illegible]	53	[illegible]	59	54.0	151	59.0	5.0	1.3	6	182	33	5.14	193.2	356.2	D
17	22	2	43.2	61	15.9	[illegible]	51.6	[illegible]	2.1	6	299	134	2.00	200.4	0.	D
17	22	46	[illegible]	59	44.2	153	9.7	[illegible]	1.5	5	173	10	0.41	17.4	41.2	D
17	23	38	[illegible]	58	43.8	153	55.2	104.9	1.3	6	190	33	1.26	58.2	55.0	D
18	[illegible]	9	48.0	60	2.4	153	1.9	113.7	1.8	8	167	44	0.74	16.8	29.9	D
18	2	14	4.9	59	26.1	155	59.6	33.5	1.6	5	256	146	0.91	49.2	0.	D

Table A2-2 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	DAY	HR	MN	TIME SEC	LAT DEG	LAT MIN	LONG DEG	LONG MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
[illegible]	18	[illegible]	24	23.6	59	1.4	153	51.2	127.3	1.6	6	159	44	0.76	26.5	77.8	D
	18	4	32	3.9	59	31.2	150	20.3	5.0	1.2	4	305	164	0.74	0.	0.	D
	18	7	0	47.3	59	32.6	152	28.3	81.3	1.6	6	125	37	0.30	5.6	15.2	C
	18	[illegible]	[illegible]	21.1	60	5.4	151	51.6	87.0	1.7	6	220	49	1.25	58.6	108.3	D
	18	10	12	27.0	58	[illegible]	151	40.1	74.4	1.5	6	214	16	0.81	34.7	51.7	D
	18	[illegible]	24	42.5	59	[illegible]	153	42.3	250.2	1.7	4	261	27	0.06	0.	0.	C
	18	13	51	21.0	59	[illegible]	154	37.6	5.0	1.2	3	303	100	1.62	0.	0.	D
	18	14	5	31.3	59	47.9	151	28.2	22.5	2.0	9	227	36	1.08	15.1	10.6	D
	18	15	20	31.3	[illegible]	37.2	[illegible]	[illegible]	100.5	1.5	6	257	22	1.24	117.9	173.7	D
	18	17	53	10.9	60	1.0	[illegible]	18.4	[illegible]	1.6	6	256	45	0.64	60.3	109.1	D
	18	[illegible]	34	43.4	59	[illegible]	151	[illegible]	80.9	1.2	4	272	84	0.16	0.	0.	C
	18	[illegible]	52	12.2	59	[illegible]	155	53.6	141.[illegible]	1.5	5	152	30	0.06	3.1	8.3	D
	18	[illegible]	7	34.3	59	47.5	[illegible]	45.7	[illegible]	1.6	4	275	87	0.08	0.	0.	C
	19	[illegible]	18	[illegible]	59	[illegible]	[illegible]	45.3	[illegible]	2.3	7	241	56	0.49	23.9	39.8	D
	19	[illegible]	31	[illegible]	59	11.9	[illegible]	[illegible]	[illegible]	1.2	4	196	37	1.83	0.	0.	D
	18	[illegible]	59	4.1	59	56.0	151	40.0	[illegible]	1.5	5	226	55	1.32	32.9	0.	D
	18	22	8	53.5	59	[illegible]	154	18.3	122.[illegible]	1.2	4	280	60	0.	0.	0.	C
	18	22	43	39.7	64	27.7	154	20.9	5.0	3.5	7	319	178	11.58	0.	0.	D
	[illegible]	[illegible]	12	[illegible]	59	[illegible]	[illegible]	7.6	[illegible]	1.3	5	180	21	0.61	25.1	56.3	D
	19	[illegible]	27	[illegible]	60	[illegible]	[illegible]	46.3	[illegible]	1.6	6	149	42	0.89	25.9	43.3	D
	19	14	12	[illegible]	60	[illegible]	152	39.5	[illegible]	2.3	12	168	14	0.98	13.4	16.7	D
	19	14	39	9.2	57	1.7	155	20.3	66.9	2.9	19	164	54	1.11	7.1	12.5	D
	19	15	53	20.3	60	56.9	146	47.7	34.8	3.5	17	157	133	0.81	4.9	924.1	D
	19	17	28	56.1	60	16.3	152	7.6	96.7	1.8	5	224	39	4.28	301.9	669.2	D
	20	[illegible]	14	[illegible]	59	[illegible]	159	17.6	[illegible]	1.1	5	196	52	1.05	1.4	2.3	D
	20	[illegible]	17	[illegible]	60	25.7	153	45.9	352.2	2.9	4	280	54	0.42	0.	0.	D
	20	12	11	45.7	59	23.4	[illegible]	32.9	4.5	2.4	14	173	59	0.50	5.9	20.7	D
	20	[illegible]	4	[illegible]	59	27.4	[illegible]	6.4	[illegible]	1.9	7	64	7	0.28	5.4	9.0	C
	21	2	20	[illegible]	59	12.5	151	38.7	213.1	2.1	4	277	49	0.	0.	0.	C
	21	3	51	[illegible]	58	21.5	[illegible]	17.0	[illegible]	2.2	3	172	254	0.28	0.	0.	C
	21	11	52	[illegible]	59	[illegible]	156	26.5	65.1	2.0	5	308	65	0.60	121.4	56.0	D
	21	11	57	54.0	59	27.6	152	15.5	140.4	1.6	4	166	15	0.04	0.	0.	C
	21	[illegible]	29	10.0	59	20.0	[illegible]	7.9	63.8	1.6	4	233	45	0.09	0.	0.	C
	21	21	1	[illegible]	59	34.1	153	19.1	93.8	1.6	5	185	10	3.03	26.8	46.1	D
	22	[illegible]	34	[illegible]	59	32.3	153	5.1	260.3	2.4	7	126	28	6.06	110.2	163.5	C
	22	3	34	3.1	59	27.2	153	46.1	0.5	1.0	7	221	23	18.91	258.2	668.6	D
	22	10	16	53.4	58	57.8	155	56.4	42.1	2.0	6	286	138	1.30	92.3	0.	D
	22	22	[illegible]	[illegible]	59	[illegible]	[illegible]	30.6	[illegible]	1.7	6	197	4	0.37	13.9	16.6	D
	23	14	39	41.2	60	26.8	152	17.6	91.3	2.1	7	254	26	1.19	71.7	90.3	D
	23	15	32	42.7	59	39.2	154	11.4	211.9	1.9	4	273	54	0.02	0.	0.	C
	23	15	43	34.5	59	56.8	151	26.5	83.0	2.0	5	240	33	0.85	63.0	105.9	D
	23	17	50	24.3	59	36.3	150	17.1	279.2	2.6	4	317	76	0.33	0.	0.	D
	23	18	31	39.5	59	21.0	153	16.9	103.4	1.5	5	164	8	0.44	101.9	46.9	D
	23	19	35	36.9	56	40.9	146	13.0	37.8	3.0	5	333	444	7.14	0.	0.	D
	23	20	51	49.1	58	51.9	152	12.6	49.8	1.5	5	222	76	1.13	281.4	0.	D

Table A2-2 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN TIME HR	MN	SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
22	21	57	23.3	60	14.6	15[illegible]	23.9	6[illegible].5	2.8	3	226	70	1.12	24.0	27.1	D
23	22	3	52.7	59	20.2	153	11.8	40.0	1.4	5	134	20	0.08	2.9	1.6	D
24	7	44	5.4	58	57.9	152	28.1	44.3	1.4	5	208	61	1.20	109.1	438.3	D
25	4	24	33.[illegible]	60	11.4	152	25.4	154.4	2.4	4	220	45	2.62	0.	0.	D
25	13	12	34.4	59	37.1	15[illegible]	31.7	3.[illegible]	2.1	5	301	61	0.22	43.6	5.6	D
25	19	33	27.[illegible]	60	7.6	150	30.1	5.0	0.9	3	162	35	0.	0.	0.	C
25	21	6	31.[illegible]	5[illegible]	24.9	15[illegible]	42.5	34.4	0.	4	191	46	0.04	0.	0.	C
25	21	26	51.3	5[illegible]	11.1	151	18.3	[illegible]	1.6	3	251	110	0.08	0.	0.	C
25	2[illegible]	55	31.[illegible]	59	2[illegible]	151	[illegible].3	3[illegible]	1.7	4	249	[illegible]	0.	0.	0.	C
26	[illegible]	4[illegible]	17.0	59	21.[illegible]	15[illegible]	4[illegible].9	[illegible]	2.9	14	55	25	0.36	2.4	3.5	B
27	[illegible]	36	56.8	59	51.5	152	27.6	44.2	1.3	4	147	64	0.	0.	0.	C
27	[illegible]	55	28.5	59	5[illegible]	154	34.7	5.[illegible]	1.4	4	227	111	0.13	0.	0.	C
27	[illegible]	53	[illegible]	59	13.7	14[illegible]	[illegible]	2.5	2.1	5	306	159	0.76	58.1	53.5	D
27	11	13	1[illegible].3	60	[illegible].4	151	55.2	6[illegible]	1.4	4	204	42	0.24	0.	0.	C
27	1[illegible]	2[illegible]	1[illegible].0	61	[illegible]	151	19.6	[illegible]	2.2	10	84	78	10.30	87.5	354.9	D
27	1[illegible]	37	4[illegible].3	63	1.5	151	8.8	29.7	3.3	17	73	166	1.06	5.5	0.	D
27	1[illegible]	16	33.2	53	54.2	154	24.1	130.7	2.2	7	246	50	0.25	10.5	9.6	D
27	1[illegible]	45	45.8	59	55.[illegible]	151	50.7	34.[illegible]	1.1	4	191	23	0.45	0.	0.	D
27	1[illegible]	10	[illegible].8	60	14.7	153	29.8	102.8	1.6	4	181	44	0.08	0.	0.	C
27	1[illegible]	20	4[illegible].2	61	43.[illegible]	14[illegible]	57.4	34.[illegible]	2.6	3	266	210	1.09	40.4	0.	D
27	19	46	4[illegible].4	60	5.3	153	1.2	119.3	2.0	5	187	39	0.29	18.5	41.5	D
27	20	27	39.1	60	1.5	152	18.8	72.6	1.6	4	167	50	0.24	0.	0.	C
27	21	59	47.2	59	37.3	153	10.2	113.8	1.6	7	169	29	0.29	6.3	10.9	D
28	4	12	25.8	58	45.1	153	11.5	0.[illegible]	1.0	4	171	29	0.38	0.	0.	D
28	[illegible]	1	[illegible].3	60	7.7	151	36.9	104.7	1.8	5	242	52	0.09	12.0	19.0	D
28	1[illegible]	34	1[illegible].1	59	53.2	15[illegible]	9.4	75.6	1.1	4	188	56	0.35	0.	0.	D
28	1[illegible]	50	[illegible].7	59	38.[illegible]	15[illegible]	2.3	95.5	1.2	6	153	29	0.21	4.3	8.0	C
28	1[illegible]	49	3[illegible].4	58	42.7	15[illegible]	48.6	61.1	1.2	5	212	72	5.37	20.0	48.9	D
28	1[illegible]	5[illegible]	52.4	61	22.6	150	57.0	8[illegible].2	3.2	15	88	64	0.92	6.7	13.3	C
28	1[illegible]	9	53.[illegible]	59	47.9	152	57.5	5.0	1.4	4	169	69	0.41	0.	0.	D
28	2[illegible]	1	19.9	57	39.5	156	41.9	155.2	2.6	4	318	214	0.41	0.	0.	D
28	23	5	14.1	59	41.8	152	38.9	94.2	1.7	6	127	53	0.23	4.6	9.9	C
29	[illegible]	19	55.3	57	5[illegible]	151	12.5	34.4	1.9	5	269	77	0.16	13.1	3.7	D
29	1	23	2.1	61	59.3	149	2.0	[illegible].6	3.2	16	102	44	0.25	44.9	124.4	D
29	4	17	47.7	59	36.8	152	36.3	[illegible]	1.3	3	249	54	0.08	0.	0.	C
29	7	2	12.8	59	36.7	152	35.9	5.0	1.4	3	249	54	0.08	0.	0.	C
29	13	41	47.4	63	1.6	151	21.8	35.8	2.6	13	70	171	0.75	4.5	904.3	D
MAY 2	[illegible]	41	[illegible].4	57	50.8	154	23.9	[illegible]	2.3	3	171	148	0.15	0.	0.	C
6	6	4	41.3	60	45.0	151	13.6	[illegible].5	2.6	5	269	94	0.48	50.6	225.3	D
6	[illegible]	22	3[illegible].6	59	1.7	152	43.2	73.6	2.6	12	122	75	0.20	1.8	5.0	B
6	7	14	32.4	60	24.5	153	1.5	131.7	2.8	6	209	22	0.42	25.3	26.6	D
6	14	46	43.4	59	27.9	152	51.6	40.1	2.1	5	176	72	0.40	6.2	215.3	D
6	16	43	24.0	59	23.4	152	38.8	79.9	0.	20	88	44	0.32	1.6	2.7	B
7	0	54	24.3	53	3.2	152	0.1	65.0	3.0	13	212	44	22.21	337.9	437.8	D
7	4	38	37.0	59	56.1	152	58.7	5.0	1.5	3	249	55	0.48	0.	0.	D

Table A2-2 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977 DAY	ORIGIN HR	MIN	TIME SEC	LAT DEG	LAT MIN	LONG DEG	LONG MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
7	[illegible]	17	2[illegible]	[illegible]	1.3	15[illegible]	39.6	79.7	2.8	19	125	53	0.26	1.4	2.5	B
7	[illegible]	39	5[illegible].5	59	23.2	15[illegible]	54.1	83.[illegible]	2.3	5	102	33	0.17	2.8	6.2	C
7	13	6	1[illegible].1	58	15.4	155	29.5	[illegible].1	1.3	4	153	55	1.21	0.	0.	D
7	2[illegible]	12	4[illegible].1	59	11.2	15[illegible]	25.[illegible]	[illegible]	2.7	5	181	31	0.11	5.7	9.2	D
8	[illegible]	13	21.1	5[illegible]	4[illegible].4	153	46.8	37.9	1.5	5	249	46	1.14	58.8	33.8	D
8	[illegible]	7	53.[illegible]	59	5[illegible].7	15[illegible]	43.4	112.4	1.7	4	136	43	0.	0.	0.	C
8	1[illegible]	5	27.[illegible]	59	[illegible]	15[illegible]	[illegible]	12[illegible]	2.3	7	178	26	0.19	5.0	9.5	C
8	14	10	2[illegible].5	5[illegible]	[illegible]	15[illegible]	[illegible]	3[illegible]	1.6	4	216	69	0.07	0.	0.	C
8	1[illegible]	22	[illegible].1	59	[illegible]	15[illegible]	51.3	[illegible].4	1.[illegible]	9	137	38	0.18	1.8	3.2	C
8	14	25	2[illegible]	58	[illegible]	15[illegible]	[illegible]	[illegible]	1.6	5	215	67	0.20	4.8	5.0	D
9	19	0	1[illegible].3	59	52.7	154	13.9	102.3	2.2	4	258	33	0.	0.	0.	C
9	2[illegible]	57	4[illegible]	51	[illegible]	15[illegible]	4[illegible]	[illegible]	[illegible]	4	319	135	0.40	0.	0.	D
9	1[illegible]	5	4[illegible]	5[illegible]	[illegible]	15[illegible]	2.7	[illegible]	1.2	3	292	127	0.12	0.	0.	C
9	18	21	3[illegible].7	60	[illegible]	15[illegible]	21.5	5.[illegible]	2.0	5	261	7[illegible]	0.73	31.8	0.	D
10	[illegible]	9	5[illegible]	59	[illegible]	154	14.9	4[illegible]	1.7	5	159	84	1.08	23.3	0.	D
10	14	40	34.3	57	24.7	153	16.1	5.0	1.3	5	160	23	4.73	89.7	116.2	D
11	[illegible]	38	23.8	57	11.0	155	33.2	5.0	2.2	3	193	75	0.13	0.	0.	C
11	11	9	13.2	57	52.3	152	33.0	5.0	2.2	3	183	58	0.01	0.	0.	C
11	1[illegible]	24	[illegible]	5[illegible]	51.5	153	9.0	5.[illegible]	1.3	4	163	65	0.16	0.	0.	C
11	2[illegible]	5	5[illegible].1	57	4[illegible].4	15[illegible]	25.0	[illegible]	[illegible]	7	250	129	1[illegible].39	376.8	0.	D
11	21	11	[illegible].6	59	54.3	152	5.0	5.[illegible]	1.9	6	220	68	0.99	21.3	0.	D
12	13	45	42.0	59	5.0	152	39.4	90.0	1.6	4	212	52	0.	0.	0.	C
12	14	10	37.3	59	[illegible].7	152	52.0	5.0	1.7	3	170	42	0.	0.	0.	C
13	[illegible]	59	22.9	58	1[illegible].6	155	23.3	5.0	2.1	5	163	62	1.17	18.7	0.	D
13	3	25	4[illegible].1	58	15.4	151	27.4	38.[illegible]	2.1	7	230	66	0.23	5.0	2.3	D
13	1[illegible]	23	31.5	59	[illegible].1	15[illegible]	20.0	154.[illegible]	2.9	17	61	10	2.58	22.7	34.4	C
13	1[illegible]	53	11.1	57	[illegible].4	153	5[illegible].4	[illegible].2	2.1	12	105	37	3.96	37.7	72.5	D
13	1[illegible]	2	1[illegible].4	59	2[illegible]	152	[illegible]	11[illegible]	1.6	6	153	41	0.14	3.4	10.4	C
13	17	55	[illegible].9	59	47.1	152	5[illegible].3	97.6	2.3	10	111	54	0.26	3.1	6.8	C
13	1[illegible]	45	41.3	59	47.4	151	28.8	5.0	1.2	3	277	100	0.17	0.	0.	C
13	2[illegible]	58	4[illegible].9	59	17.0	153	11.1	8[illegible]	1.6	4	136	14	0.01	0.	0.	C
13	22	37	42.6	59	4[illegible]	15[illegible]	48.4	62.7	2.7	15	106	49	7.73	56.2	98.0	C
14	1	13	13.2	58	1[illegible].3	15[illegible]	10.7	23.2	2.1	13	130	31	5.02	46.0	45.2	C
14	[illegible]	55	57.6	59	5[illegible]	152	46.4	5.0	1.8	7	138	58	1.08	9.5	0.	D
14	[illegible]	26	4[illegible]	5[illegible]	5.[illegible]	153	50.5	17.[illegible]	1.6	4	315	93	20.10	0.	0.	D
14	[illegible]	27	21.2	59	56.4	150	49.6	7[illegible].2	2.2	6	274	55	0.12	8.1	4.8	D
14	11	35	29.5	59	51.2	152	48.7	5.0	1.6	5	151	63	1.40	22.9	0.	D
14	1[illegible]	15	4[illegible].7	60	1[illegible]	152	3.4	134.[illegible]	2.1	5	214	47	0.18	24.0	55.0	D
14	12	40	[illegible].4	59	5[illegible].1	15[illegible]	46.9	7[illegible]	2.7	10	266	57	0.24	7.3	4.9	D
14	13	23	2[illegible].7	59	[illegible]2.3	153	3.0	5.0	1.0	4	179	62	0.44	0.	0.	D
14	14	46	[illegible]	60	41.5	153	36.2	23[illegible]	2.9	9	293	54	0.23	17.5	24.8	D
15	[illegible]	56	27.2	59	4[illegible]	15[illegible]	12.1	5.0	1.6	4	219	82	0.37	0.	0.	D
15	1	31	12.3	59	51.5	153	15.2	5.0	1.5	3	224	67	0.	0.	0.	C
15	2	22	31.0	59	16.6	152	35.6	40.9	1.6	4	109	48	0.	0.	0.	C
15	14	36	24.7	59	46.1	152	59.1	104.8	2.2	11	118	48	0.27	3.1	5.9	C

Table A2-2 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	DAY	ORIGIN TIME HR	MN	SEC	LAT DEG	MIN	LONG DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
MAY	15	1[illegible]	43	16.4	60	2.2	151	46.7	84.6	2.7	13	223	43	0.32	6.4	7.6	D
	15	1[illegible]	46	22.0	59	20.4	152	37.5	91.1	1.5	5	93	45	0.17	4.4	13.1	D
	15	2[illegible]	54	33.1	59	25.9	152	17.0	5.0	1.4	3	196	65	0.	0.	0.	C
	15	[illegible]	44	7.7	59	31.3	152	22.5	79.0	1.6	5	97	44	0.17	4.0	9.9	D
	16	1	46	53.3	60	[illegible]	15[illegible]	45.9	24.3	1.4	5	225	44	0.64	20.1	12.8	D
	16	[illegible]	46	54.[illegible]	59	13.[illegible]	15[illegible]	43.1	120.[illegible]	2.1	7	136	21	0.13	3.1	4.6	C
	16	[illegible]	7	1.[illegible]	59	[illegible]	15[illegible]	24.2	13[illegible].5	2.4	16	142	41	0.36	3.7	5.7	C
	16	6	16	31.[illegible]	59	24.[illegible]	15[illegible]	6.4	137.[illegible]	2.5	15	175	29	0.33	2.5	3.9	B
	16	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15[illegible]	5.[illegible]	[illegible].1	2.1	4	22[illegible]	43	0.52	0.	0.	D
	16	11	2[illegible]	1.[illegible]	[illegible]	[illegible].1	15[illegible]	24.[illegible]	[illegible].1	2.[illegible]	5	290	[illegible]7	0.07	9.4	4.9	D
	16	1[illegible]	1	1[illegible].2	57	3[illegible].2	15[illegible]	28.6	28[illegible].6	3.2	10	223	12	3.48	136.4	236.6	D
	16	1[illegible]	27	[illegible].3	62	[illegible].1	15[illegible]	45.7	[illegible].5	2.2	9	195	61	0.59	7.0	11.8	D
	17	[illegible]	44	2[illegible]	5[illegible]	1[illegible].1	15[illegible]	25.9	5.0	1.4	5	120	59	1.59	24.2	0.	D
	17	[illegible]	17	[illegible].1	53	4[illegible].1	15[illegible]	11.5	5.[illegible]	1.8	5	132	71	0.37	5.3	828.5	D
	17	[illegible]	22	1[illegible].1	59	[illegible]	153	[illegible].3	[illegible]	1.9	4	216	74	0.32	0.	0.	D
	17	13	26	[illegible].0	57	53.0	15[illegible]	51.7	12.[illegible]	2.5	4	269	80	0.	0.	0.	C
	17	1[illegible]	51	2[illegible].6	63	15.5	150	29.9	30.[illegible]	3.2	14	83	191	2.28	12.8	0.	D
	1[illegible]	[illegible]	43	[illegible].3	59	50.6	154	21.0	14[illegible].4	2.6	19	71	14	0.56	3.3	6.1	C
	[illegible]	[illegible]	53	51.5	59	4[illegible].7	15[illegible]	34.3	[illegible].0	0.8	3	225	55	0.12	0.	0.	C
	1[illegible]	1[illegible]	23	4[illegible].4	59	4[illegible]	154	[illegible]	[illegible]	1.2	3	256	68	0.56	0.	0.	D
	19	1[illegible]	37	24.2	59	5[illegible].0	152	51.8	5.0	2.1	3	238	50	0.23	0.	0.	C
	19	14	45	56.1	59	15.9	152	30.9	5.0	1.2	3	287	57	0.45	0.	0.	D
	19	17	7	13.7	56	44.9	155	34.3	16.5	3.0	17	204	105	7.09	57.4	45.1	D
	20	4	29	4[illegible].9	59	23.1	151	57.3	13.9	1.3	4	201	23	0.69	0.	0.	D
	20	4	16	34.9	59	17.2	152	47.7	44[illegible]	2.3	4	281	39	1.68	0.	0.	D
	20	11	51	3[illegible].3	59	13.2	153	44.0	123.[illegible]	2.0	7	99	21	0.20	3.5	7.1	C
	20	1[illegible]	11	[illegible]	59	[illegible].6	152	5[illegible].9	5.0	0.5	3	232	34	0.20	0.	0.	C
	20	1[illegible]	25	4[illegible].6	56	4[illegible]	14[illegible]	52.1	4.[illegible]	2.8	9	297	194	0.45	26.9	33.9	D
	21	[illegible]	12	27.[illegible]	59	3.7	154	19.7	1.6	1.3	8	164	8	9.09	62.3	65.1	D
	21	[illegible]	53	2[illegible].7	57	[illegible].1	15[illegible]	1.1	5.0	2.2	7	278	6	11.49	493.2	30.6	D
	21	[illegible]	59	44.2	59	27.0	153	27.0	1.3	2.2	4	297	197	0.62	0.	0.	D
	21	15	47	17.2	59	22.6	153	1.8	90.6	2.0	6	135	32	0.20	3.7	7.5	C
	22	11	46	22.[illegible]	59	34.3	152	27.7	1[illegible]	0.9	4	142	47	0.52	0.	0.	D
	22	1[illegible]	33	5[illegible]	59	46.4	153	21.7	18[illegible].4	2.0	4	201	50	0.12	0.	0.	C
	22	1[illegible]	27	59.2	59	37.5	152	49.0	10[illegible].5	2.0	6	128	47	0.19	3.9	9.1	C
	23	[illegible]	23	[illegible].5	61	29.5	151	37.2	99.8	2.9	4	319	134	0.08	0.	0.	C
	23	3	51	1[illegible].0	59	1.3	153	59.1	106.6	2.0	5	144	15	0.08	2.3	3.5	C
	23	6	28	31.8	59	7.9	153	30.2	92.2	2.5	16	84	23	0.33	2.1	4.0	B
	23	1[illegible]	55	46.7	60	[illegible].2	152	25.2	5.0	1.4	5	175	35	0.92	24.4	59.0	D
	23	1[illegible]	15	23.9	59	35.5	152	46.0	5.0	1.2	3	131	47	0.	0.	0.	C
	23	11	23	43.6	58	5[illegible].8	154	27.2	11[illegible].2	2.0	5	223	31	0.	0.	0.	C
	23	12	20	2[illegible].4	59	4[illegible].4	152	59.4	74.9	1.6	4	165	59	0.37	0.	0.	D
	23	1[illegible]	59	22.5	60	11.7	152	42.3	129.3	2.6	6	144	25	0.21	9.9	22.7	D
	23	1[illegible]	43	21.3	59	32.9	152	17.2	5.0	1.4	3	148	40	0.	0.	0.	C
	23	19	18	14.9	58	5[illegible].3	153	6.5	66.[illegible]	1.7	4	275	42	0.03	0.	0.	C

Table A2-2 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977		ORIGIN TIME H	M	SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
MAY	23	20	49	[illegible]	59	[illegible]	152	37.1	[illegible]	2.2	5	144	51	0.20	6.7	21.2	D
	23	21	22	[illegible]	59	53.1	152	2.3	[illegible]	2.5	6	173	33	0.19	10.6	24.1	D
	24	[illegible]	27	[illegible]	59	[illegible]	152	38.9	5.0	0.8	3	244	56	0.01	0.	0.	C
	24	[illegible]	53	[illegible]	59	14.7	[illegible]	15.6	[illegible]	2.7	11	127	46	2.97	41.7	79.2	C
	24	11	53	[illegible]	[illegible]	[illegible]	[illegible]	33.4	[illegible]	2.6	8	246	11	0.32	15.1	21.3	D
	24	22	32	[illegible]	60	[illegible]	[illegible]	52.0	5.0	0.7	3	236	43	0.56	0.	0.	D
	25	[illegible]	47	[illegible]	58	[illegible]	[illegible]	57.3	[illegible]	3.0	3	290	[illegible]	0.53	32.5	37.0	D
	25	11	42	[illegible]	[illegible]	[illegible]	151	47.0	[illegible]	1.3	5	221	13	0.32	12.0	6.6	D
	25	12	55	[illegible]	[illegible]	13.6	[illegible]	6.6	[illegible]	[illegible]	3	297	41	[illegible]	0.	0.	C
	25	13	59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.7	3	247	53	[illegible]	0.	0.	C
	25	[illegible]	33	[illegible]	60	1.5	153	35.0	[illegible]	2.7	7	173	62	0.21	7.1	17.2	D
	26	[illegible]	[illegible]	[illegible]	61	[illegible]	[illegible]	18.3	[illegible]	3.3	17	129	99	0.34	2.0	2.0	D
	26	[illegible]	4	[illegible]	60	[illegible]	[illegible]	18.4	[illegible]	1.4	4	181	42	2.59	0.	0.	D
	26	[illegible]	47	[illegible]	59	[illegible]	152	56.7	[illegible]	0.9	3	256	71	0.48	0.	0.	D
	26	11	7	[illegible]	[illegible]	43.4	152	45.4	[illegible]	1.4	5	138	57	1.80	25.5	0.	D
	26	14	12	[illegible]	59	50.9	[illegible]	57.4	5.0	0.8	3	251	64	0.42	0.	0.	D
	27	[illegible]	52	[illegible]	58	[illegible]	154	41.3	[illegible]	2.1	7	133	81	1.30	10.7	0.	D
	27	[illegible]	50	[illegible]	60	[illegible]	152	36.6	[illegible]	2.1	5	162	23	0.20	18.4	48.3	D
	27	11	17	[illegible]	60	[illegible]	[illegible]	43.7	[illegible]	1.5	4	164	8	[illegible]	0.	0.	C
	[illegible]	[illegible]	23	[illegible]	59	21.5	151	[illegible]	[illegible]	[illegible]	7	133	26	[illegible]	5.3	9.5	C
	29	[illegible]	43	[illegible]	60	[illegible]	152	1.7	[illegible]	2.0	5	215	49	1.48	192.4	532.9	D
	29	13	41	[illegible]	60	6.1	[illegible]	20.0	[illegible]	1.3	4	176	42	[illegible]	0.	0.	C
	29	[illegible]	42	[illegible]	57	[illegible]	154	[illegible]	[illegible]	1.9	7	251	24	21.38	219.0	189.6	D
	29	[illegible]	50	17.3	59	[illegible]	[illegible]	47.7	5.0	1.3	6	138	61	1.85	19.2	0.	D
	[illegible]	21	0	[illegible]	[illegible]	37.3	[illegible]	[illegible]	[illegible]	1.9	7	110	39	0.19	2.9	6.8	C
	30	[illegible]	41	[illegible]	[illegible]	[illegible]	151	1.7	[illegible]	2.1	3	289	173	[illegible]	[illegible]	0.	D
	30	[illegible]	[illegible]	[illegible]	61	[illegible]	[illegible]	21.4	[illegible]	3.1	17	79	25	1.26	8.2	6.8	C
	30	[illegible]	57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	265	[illegible]	11.81	0.	0.	D
	30	[illegible]	2	[illegible]	[illegible]	[illegible]	151	25.6	[illegible]	2.3	7	287	107	10.56	281.7	325.2	D
	30	[illegible]	30	[illegible]	[illegible]	[illegible]	151	24.5	[illegible]	0.9	3	292	113	1.43	0.	0.	D
	31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	153	[illegible]	1.2	1.8	7	282	1	46.31	0.	136.2	D
	31	[illegible]	3	[illegible]	58	[illegible]	153	[illegible]	61.1	2.0	7	163	58	0.46	7.0	14.1	D
JUN	1	7	13	[illegible]	60	[illegible]	154	2.9	[illegible]	2.7	11	99	82	3.36	32.3	60.0	C
	1	14	19	[illegible]	59	59.5	152	12.8	[illegible]	2.0	4	246	56	0.	0.	0.	C
	2	[illegible]	10	[illegible]	[illegible]	35.5	[illegible]	[illegible]	137.4	1.9	5	[illegible]	36	0.01	0.8	0.8	C
	2	15	1	43.9	57	50.2	153	33.5	5.0	1.3	3	203	55	0.01	0.	0.	C
	2	19	59	6.3	59	54.3	152	47.1	5.0	1.5	6	139	57	1.13	12.7	0.	D
	3	6	41	[illegible]	57	44.4	153	14.5	[illegible]	2.5	11	117	34	0.33	2.9	1.8	C
	3	14	0	43.3	59	33.7	153	7.5	112.1	1.7	6	118	30	0.19	4.4	11.7	C
	4	17	50	21.7	59	55.3	152	52.5	5.0	0.8	3	241	55	0.26	0.	0.	C
	4	17	1	53.2	59	[illegible]	154	48.5	175.1	2.0	8	168	34	0.15	4.0	6.0	C
	4	19	15	53.8	60	23.9	150	27.1	[illegible]	2.7	8	300	105	0.28	48.7	38.3	D
	4	[illegible]	32	[illegible]	59	27.4	152	23.3	9.4	1.1	4	169	45	0.54	0.	0.	D
	5	6	13	17.4	59	23.2	153	15.2	140.7	1.6	4	185	11	0.	0.	0.	C
	6	0	57	21.9	59	59.3	151	55.2	83.2	1.8	4	202	39	0.19	0.	0.	C

Table A2-2 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977 DATE	ORIGIN TIME HR	MN	SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
JUN 6	[illegible]	[illegible]	[illegible].8	58	56.9	151	[illegible].0	173.3	1.8	4	266	47	0.90	0.	0.	D
6	6	10	15.7	59	22.0	152	24.7	89.1	1.7	7	127	45	0.10	2.0	5.1	C
6	12	[illegible]	[illegible].0	62	16.0	149	26.5	5.0	3.5	11	276	272	0.71	26.0	889.1	D
6	[illegible]	[illegible]	3[illegible].5	58	42.0	151	53.7	14.2	1.0	4	139	14	0.	0.	0.	C
6	1[illegible]	37	[illegible]	57	11.5	15[illegible]	38.0	35.4	2.1	4	325	260	0.62	0.	0.	D
6	1[illegible]	52	[illegible].1	59	[illegible].7	15[illegible]	34.8	34.7	1.3	4	319	65	0.40	0.	0.	D
6	1[illegible]	43	[illegible]	59	[illegible].1	15[illegible]	33.1	[illegible]	0.	3	224	7	21.50	0.	0.	D
6	1[illegible]	12	[illegible]	60	[illegible]	15[illegible]	44.4	[illegible]	1.4	6	162	29	3.38	278.0	687.9	D
6	21	21	[illegible].1	59	[illegible]	15[illegible]	55.3	[illegible]	1.7	4	216	53	3.16	13.2	10.4	D
7	[illegible]	19	4[illegible]	59	55.1	15[illegible]	24.7	103.1	[illegible]	9	148	59	0.25	5.1	9.2	D
7	[illegible]	3	[illegible].7	59	15.0	15[illegible]	38.5	110.3	2.1	3	138	15	0.30	6.2	8.9	D
7	[illegible]	42	2[illegible].4	57	11.[illegible]	15[illegible]	27.3	[illegible]	2.4	4	232	32	0.	0.	0.	C
7	[illegible]	[illegible]	[illegible]	58	47.7	15[illegible]	26.6	14[illegible]	1.8	4	178	49	0.01	0.	0.	C
7	11	1	[illegible]	59	5[illegible]	15[illegible]	45.4	4.5	1.1	4	150	56	0.53	0.	0.	D
7	14	[illegible]	22.1	59	[illegible].5	152	47.8	[illegible]	1.4	4	149	64	0.49	0.	0.	D
7	22	59	55.1	59	23.5	15[illegible]	21.8	5.0	1.9	5	202	98	0.41	8.5	909.6	D
9	7	13	1[illegible].2	60	25.5	152	10.0	39.2	1.2	4	253	33	0.39	0.	0.	D
9	15	49	3[illegible].3	59	5[illegible].3	152	47.0	[illegible].5	1.2	4	140	53	0.45	0.	0.	D
9	17	30	33.2	60	[illegible].2	152	41.[illegible]	20.4	1.9	6	138	35	0.46	32.1	32.9	D
9	19	21	37.4	59	14.3	15[illegible]	7.6	5.	0.9	3	294	40	0.	0.	0.	C
10	11	17	3[illegible].2	60	12.1	151	46.0	37.1	1.4	4	239	60	0.58	0.	0.	D
10	12	14	[illegible].3	56	57.6	153	38.8	22.0	1.3	5	178	23	0.29	11.0	20.9	D
10	14	36	[illegible].5	60	2.1	153	21.3	162.2	2.4	6	192	53	0.19	7.9	16.5	D
11	1	13	[illegible].7	58	48.3	15[illegible]	31.3	60.0	1.3	4	168	78	0.	0.	0.	C
12	[illegible]	2[illegible]	42.1	59	55.[illegible]	152	55.6	[illegible]	0.3	3	245	55	0.37	0.	0.	D
12	[illegible]	7	47.[illegible]	60	1[illegible].1	15[illegible]	10.0	169.2	2.9	6	240	24	0.30	17.4	24.3	D
12	2[illegible]	41	37.[illegible]	60	1.[illegible]	15[illegible]	4.1	143.2	2.9	10	140	41	0.29	5.5	9.1	D
13	[illegible]	2[illegible]	1[illegible]	60	[illegible]	152	33.3	111.[illegible]	2.1	[illegible]	158	33	0.20	4.6	8.0	C
13	7	2[illegible]	4[illegible]	57	4[illegible].5	15[illegible]	45.4	33.4	1.9	8	140	17	0.40	5.7	3.2	D
13	[illegible]	[illegible]	3[illegible].8	57	[illegible].1	154	54.2	31.1	2.3	11	138	41	0.17	2.1	3.7	C
13	11	41	4[illegible].3	58	5[illegible].3	15[illegible]	35.0	83.5	2.0	5	268	65	0.14	26.6	32.9	D
13	1[illegible]	5	[illegible].1	59	2.8	15[illegible]	15.6	174.2	1.9	4	298	67	0.06	0.	0.	C
13	14	44	1[illegible].7	59	41.4	15[illegible]	6.7	34.1	1.4	5	122	26	0.16	7.1	21.3	D
13	1[illegible]	12	57.6	57	10.3	155	6.9	36.[illegible]	0.	21	58	70	0.78	3.4	3.4	C
13	14	2	1[illegible].6	57	3[illegible].5	154	1[illegible].2	9[illegible].3	2.5	9	219	127	0.17	5.3	10.9	D
13	20	41	39.1	58	19.8	152	26.0	31.4	1.3	10	159	50	0.58	5.7	4.4	D
13	20	55	15.7	58	1.0	155	22.3	41.2	2.3	16	122	131	2.46	16.5	0.	D
14	[illegible]	27	1[illegible].5	60	15.8	152	12.2	5.[illegible]	1.3	5	216	35	1.24	798.2	0.	D
14	13	8	37.9	59	5.9	152	36.1	7.9	1.6	7	110	54	1.03	8.6	0.	D
14	20	6	57.3	59	27.5	151	9.8	10.1	1.8	5	304	23	0.01	1.8	0.3	C
15	[illegible]	3	4[illegible].4	60	17.4	152	29.5	44.9	1.3	4	193	21	0.46	0.	0.	D
15	7	31	4[illegible].8	60	12.3	152	12.8	159.3	2.1	6	201	34	0.21	10.6	25.4	D
15	8	7	2[illegible].8	60	4.5	153	28.8	183.4	2.6	7	174	49	0.19	6.3	17.4	D
15	9	11	44.1	59	16.9	153	10.5	181.2	1.8	4	279	41	0.	0.	0.	C
15	9	18	20.8	56	4.2	152	57.3	10.3	3.3	11	257	129	0.37	8.9	12.3	D

Table A2-2 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	ORIGIN TIME DAY	HR	MN	SEC	LAT N DEG	MIN	LONG W DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
JUN	15	10	10	[illegible]	[illegible]	[illegible]	[illegible]	24.5	[illegible]	2.8	13	83	169	2.30	15.4	68.4	D
	15	11	12	47.4	56	44.0	153	9.3	23.6	2.0	4	289	63	0.01	0.	0.	C
	15	[illegible]	23	37.8	60	3.2	153	22.3	244.9	1.9	4	229	45	0.18	0.	0.	C
	15	[illegible]	32	11.9	57	41.4	154	[illegible]	[illegible]	2.2	9	169	81	0.40	4.2	4.5	D
	15	[illegible]	17	[illegible]	[illegible]	[illegible]	152	42.7	[illegible]	1.3	5	135	44	1.28	18.1	0.	D
	15	[illegible]	25	27.5	59	[illegible]	[illegible]	19.7	72.2	1.6	4	322	71	0.	0.	0.	C
	16	[illegible]	[illegible]	[illegible]	59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	143	46	0.	0.	0.	C
	16	1	24	[illegible]	56	[illegible]	[illegible]	5.7	[illegible]	3.7	7	307	380	8.40	0.	0.	D
	17	[illegible]	[illegible]	[illegible]	57	[illegible]	152	[illegible]	[illegible]	3.4	13	130	20	4.12	56.6	80.1	C
	17	[illegible]	[illegible]	[illegible]	59	[illegible]	[illegible]	[illegible]	[illegible]	2.0	4	159	37	0.	0.	0.	C
	17	[illegible]	26	24.5	61	[illegible]	150	[illegible]	[illegible]	3.9	17	60	29	0.48	3.0	4.3	B
	17	[illegible]	13	[illegible]	57	[illegible]	155	[illegible]	[illegible]	2.4	5	275	71	0.03	4.2	0.7	D
	17	[illegible]	24	[illegible]	57	[illegible]	154	52.9	[illegible]	3.2	10	139	38	16.27	390.2	732.3	D
	18	[illegible]	52	24.4	[illegible]	[illegible]	149	34.7	[illegible]	2.7	4	311	176	4.96	0.	0.	D
	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	154	26.3	[illegible]	1.8	3	253	83	0.16	0.	0.	C
	19	4	10	[illegible]	57	[illegible]	155	3.7	5.0	0.	3	202	45	0.02	0.	0.	C
	20	[illegible]	31	34.9	60	[illegible]	152	5.7	[illegible]	1.6	5	284	41	0.51	0.	134.0	D
	21	[illegible]	32	[illegible]	57	[illegible]	153	55.1	[illegible]	0.	15	135	14	1.82	15.2	15.1	C
	21	[illegible]	30	[illegible]	60	14.5	152	12.0	[illegible]	1.8	6	216	37	1.19	136.3	952.1	D
	21	[illegible]	32	[illegible]	59	[illegible]	[illegible]	41.9	[illegible]	2.5	5	224	33	0.07	6.2	14.9	D
	21	6	0	14.2	61	[illegible]	154	25.6	37.2	2.9	6	289	215	2.26	159.2	0.	D
	21	17	45	7.5	59	46.1	153	26.2	145.6	2.0	5	177	17	0.04	3.6	4.7	D
	21	18	41	[illegible]	61	38.5	156	50.0	31.2	2.6	7	303	258	3.27	303.5	0.	D
	21	22	47	[illegible]	60	1.3	155	15.4	5.0	2.0	3	306	121	0.05	0.	0.	C
	21	[illegible]	2	[illegible]	56	31.1	152	25.3	[illegible]	0.	7	303	271	3.03	302.9	0.	D
	21	[illegible]	27	[illegible]	59	[illegible]	152	43.8	[illegible]	2.3	5	211	28	0.03	3.1	2.6	D
	22	[illegible]	22	[illegible]	59	[illegible]	[illegible]	53.1	[illegible]	2.9	4	280	63	0.	0.	0.	C
	22	[illegible]	9	[illegible]	[illegible]	51.9	151	[illegible]	[illegible]	2.3	6	233	44	0.13	218.7	88.9	D
	22	17	9	17.3	59	16.6	159	46.8	37.3	2.5	10	136	61	3.68	40.6	49.8	D
	22	[illegible]	50	[illegible]	60	[illegible]	153	21.3	[illegible]	2.0	6	204	44	0.04	2.4	6.1	D
	22	21	32	45.7	[illegible]	[illegible]	155	54.3	[illegible]	2.4	6	269	174	3.30	154.7	0.	D
	23	[illegible]	26	17.0	59	[illegible]	[illegible]	57.8	30.6	1.5	4	276	63	0.	0.	0.	C
	23	[illegible]	30	[illegible]	60	[illegible]	152	40.1	[illegible]	2.0	6	147	37	0.13	4.3	8.8	C
	23	5	22	[illegible]	59	[illegible]	[illegible]	41.6	[illegible]	2.0	6	131	21	0.17	5.5	9.8	C
	23	[illegible]	5	[illegible]	58	37.1	[illegible]	51.9	[illegible]	1.8	6	228	57	0.18	3.5	12.5	D
	23	6	59	24.7	60	15.2	152	40.1	124.9	1.7	4	162	19	0.	0.	0.	C
	23	9	59	51.2	58	4.3	154	36.2	32.7	2.3	9	133	63	0.51	5.6	6.1	C
	23	[illegible]	50	45.4	60	13.3	152	20.7	5.0	0.9	4	200	32	0.55	0.	0.	D
	23	[illegible]	50	44.4	55	[illegible]	147	26.5	37.4	3.4	5	343	460	2.36	0.	0.	D
	24	5	1	31.5	59	25.3	150	59.3	5.0	1.6	6	263	34	4.75	151.2	88.1	D
	24	11	14	5.7	60	36.9	153	56.0	5.0	2.0	3	289	64	0.50	0.	0.	D
	24	11	37	24.4	60	0.4	154	53.0	5.0	1.5	3	296	100	0.03	0.	0.	C
	24	15	20	37.5	57	32.6	156	25.9	5.0	2.1	3	321	35	0.08	0.	0.	C
	24	16	13	25.8	57	6.2	155	16.7	5.0	2.4	3	197	79	0.01	0.	0.	C
	24	20	55	24.0	60	4.0	155	21.2	5.0	1.7	3	308	128	0.13	0.	0.	C

Table A1-2 Contd.

COOK INLET-WESTERN GULF OF ALASKA EARTHQUAKES

1977	DAY	ORIGIN TIME HR	MN	SEC	LAT DEG	MIN	LONG DEG	MIN	DEPTH KM	MAG	NO	GAP DEG	DM KM	RMS SEC	ERH KM	ERZ KM	Q
JUN	24	21	23	32.4	60	22.4	15[illegible]	45.8	5.0	1.8	3	300	109	0.04	0.	0.	C
	24	23	53	2[illegible].5	60	18.4	152	44.2	5.0	-0.7	3	209	10	0.22	0.	0.	C
	24	[illegible]	14	[illegible]	58	[illegible].2	154	11.2	5.0	1.9	4	158	83	0.11	0.	0.	C
	25	[illegible]	[illegible]	[illegible]	5[illegible]	[illegible].2	15[illegible]	35.4	5.0	2.5	4	269	128	0.58	0.	0.	D
	25	[illegible]	58	1[illegible]	60	[illegible].4	15[illegible]	24.5	5.0	2.0	4	202	115	0.08	0.	0.	C
	25	[illegible]	33	[illegible]	[illegible]	26.[illegible]	15[illegible]	47.5	[illegible]	3.3	5	171	[illegible]	1.98	105.6	326.0	D
	25	17	23	[illegible]	57	[illegible]	1[illegible]	[illegible]	[illegible].7	3.4	6	150	[illegible]	0.40	7.7	12.3	D
	25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15[illegible]	10.8	[illegible]	3.6	16	103	64	4.49	39.8	61.1	C
	25	[illegible]	[illegible]	[illegible]	[illegible]	4[illegible].7	15[illegible]	33.4	[illegible]	4.0	6	232	391	3.80	0.	0.	D
	25	[illegible]	[illegible]	[illegible]	57	[illegible]	152	17.4	34.	1.4	4	119	9	0.	0.	0.	C
	26	1[illegible]	52	2[illegible].1	60	[illegible].2	153	[illegible].3	5.0	[illegible].4	3	271	38	0.93	0.	0.	D
	26	1[illegible]	52	4[illegible]	58	7.4	15[illegible]	47.4	5.[illegible]	1.[illegible]	5	237	142	0.19	7.0	433.2	D
	27	1[illegible]	15	4[illegible]	5[illegible]	[illegible]5.4	1[illegible]	29.4	127.[illegible]	[illegible].	4	192	33	0.03	0.	0.	C
	27	1[illegible]	[illegible]	[illegible]	5[illegible]	[illegible]	1[illegible]	27.0	[illegible]	1.5	3	344	9	5.05	0.	0.	D
	28	[illegible]	5	5[illegible]	5[illegible]	[illegible].2	15[illegible]	[illegible].8	5.0	[illegible].	3	210	48	0.	0.	0.	C
	29	[illegible]	31	56.2	60	11.4	154	10.7	5.0	1.4	3	251	81	0.10	0.	0.	C
	29	1[illegible]	7	54.5	60	12.2	152	49.0	5.0	1.1	3	194	24	0.03	0.	0.	C
	30	[illegible]	53	23.5	[illegible]	15.5	15[illegible]	18.0	191.1	2.5	6	169	63	1.67	48.2	94.5	D
	30	[illegible]	10	[illegible]	60	5[illegible]	1[illegible]	47.0	5.0	2.7	3	339	383	8.35	0.	0.	D
	30	1[illegible]	34	54.[illegible]	[illegible]	[illegible].3	15[illegible]	45.9	72.9	2.5	6	156	49	0.40	24.4	47.6	D

Appendix 3

Epicenter Location Maps for April through June, 1977

This appendix shows cumulative plots of epicenters for April through June, 1977. Triangles with three-letter codes show the locations of seismic stations. The one-letter code shows the epicenter location with the following depth code:

A	$0 \leq 25$
B	$26 \leq 50$
C	$51 \leq 100$
D	$101 \leq 125$
E	$126 \leq 150$
F	$151 \leq 175$
G	$176 \leq 200$
etc.	

The following is a list of figures:

Figure	Caption
A3-1	Cook Inlet, all events
A3-2	Cook Inlet, class 1 events
A3-3	Kodiak-Alaska Peninsula, all events
A3-4	Kodiak-Alaska Peninsula, class 1 events

Class 1 events have the following quality parameters (see Appendix 2 for definition):

RMS	≤ 1 sec
ERZ	≤ 10 km
ERH	≤ 10 km
NP	< 5

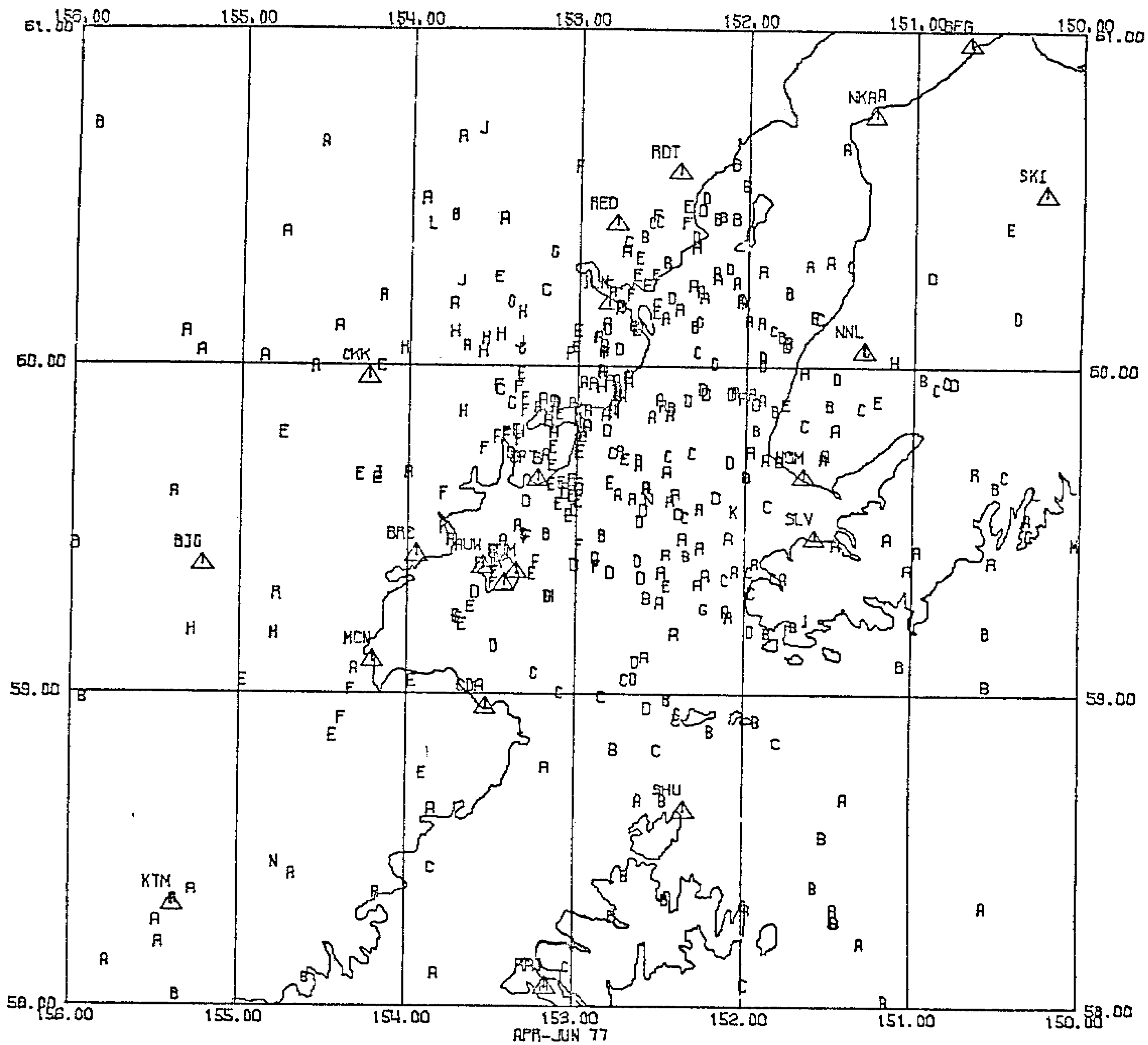


Figure A3-1: Cook Inlet, all events

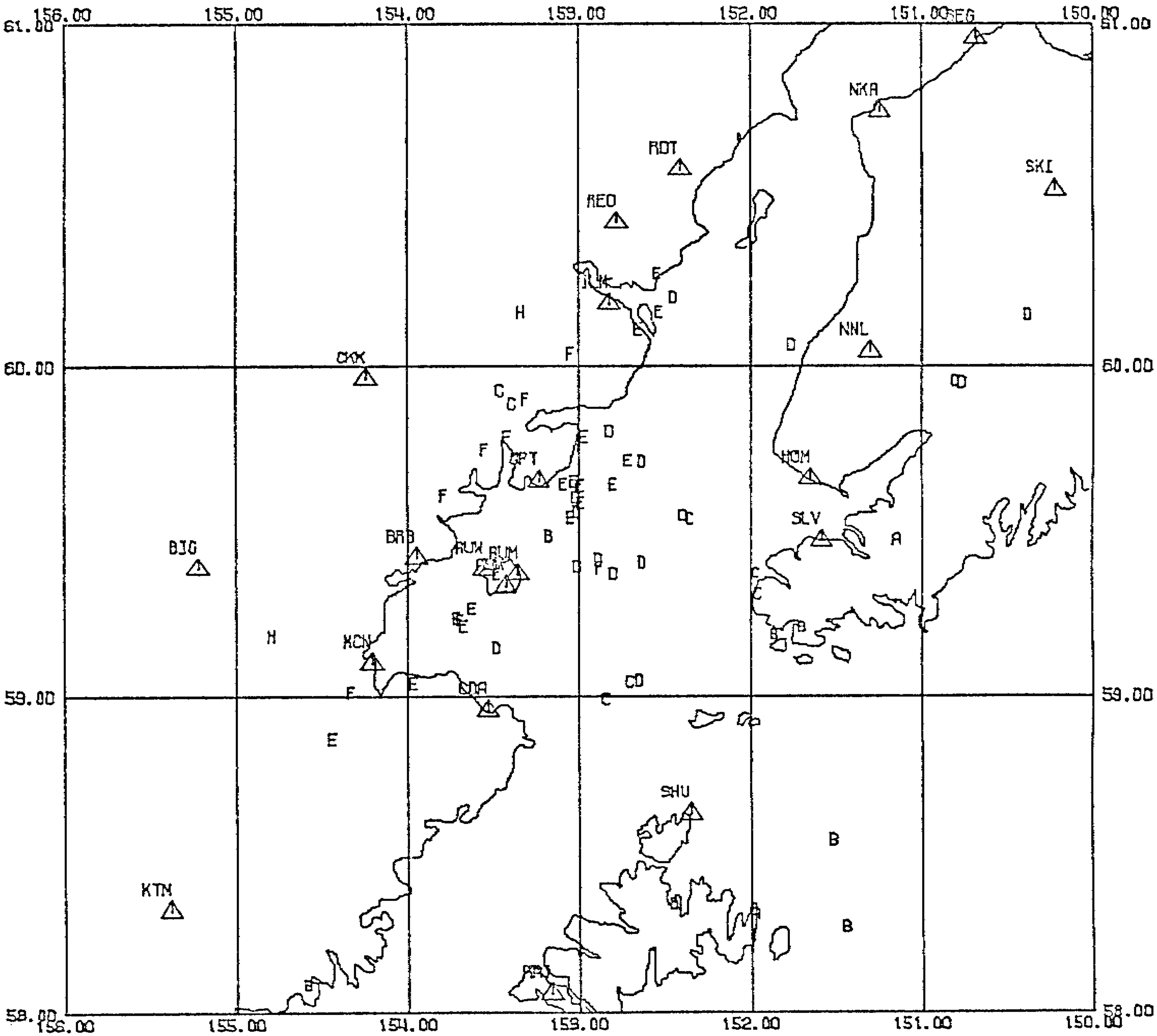


Figure A3-2: Cook Inlet, class 1 events

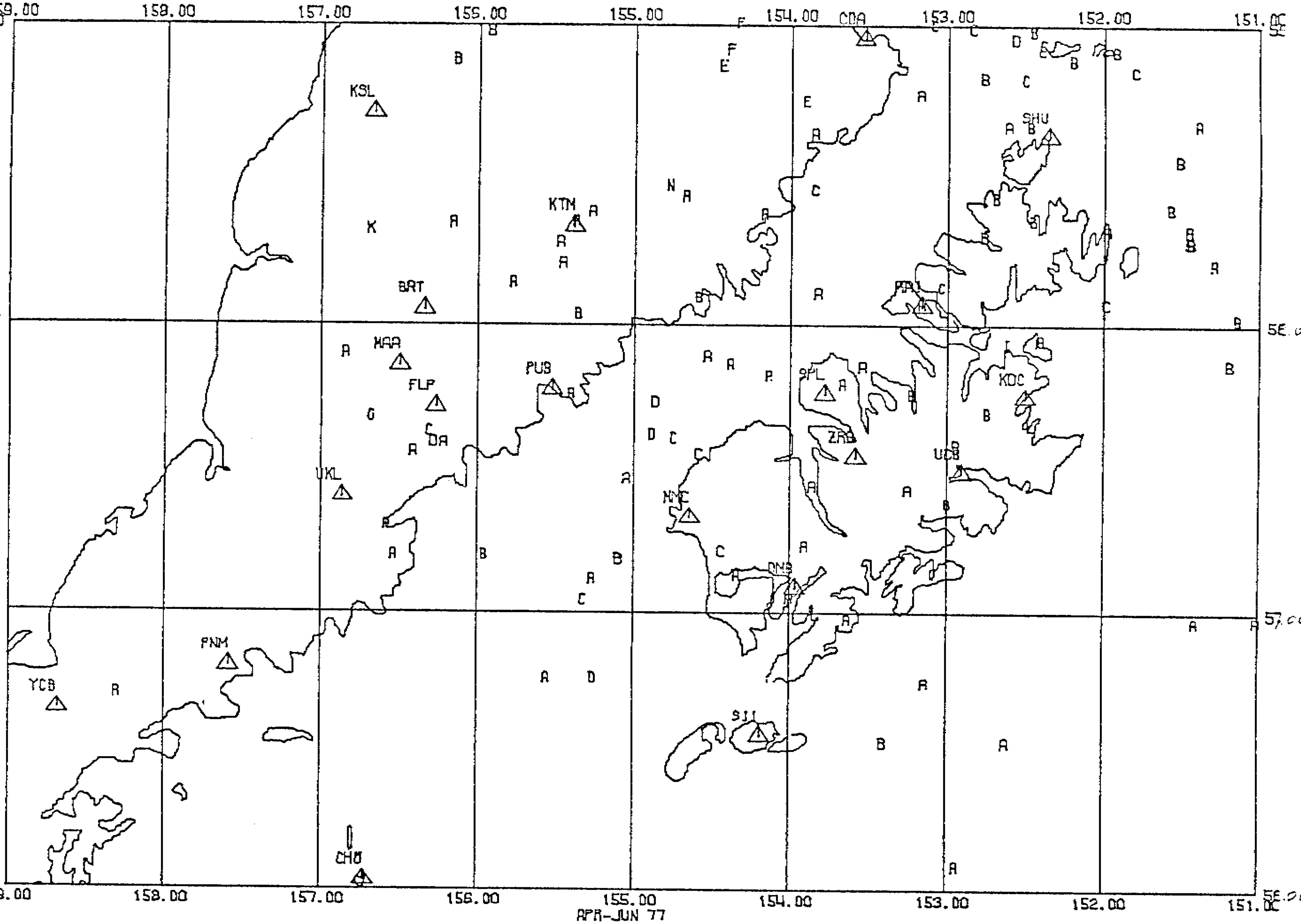


Figure A3-3: Kodiak Alaska Peninsula, all events

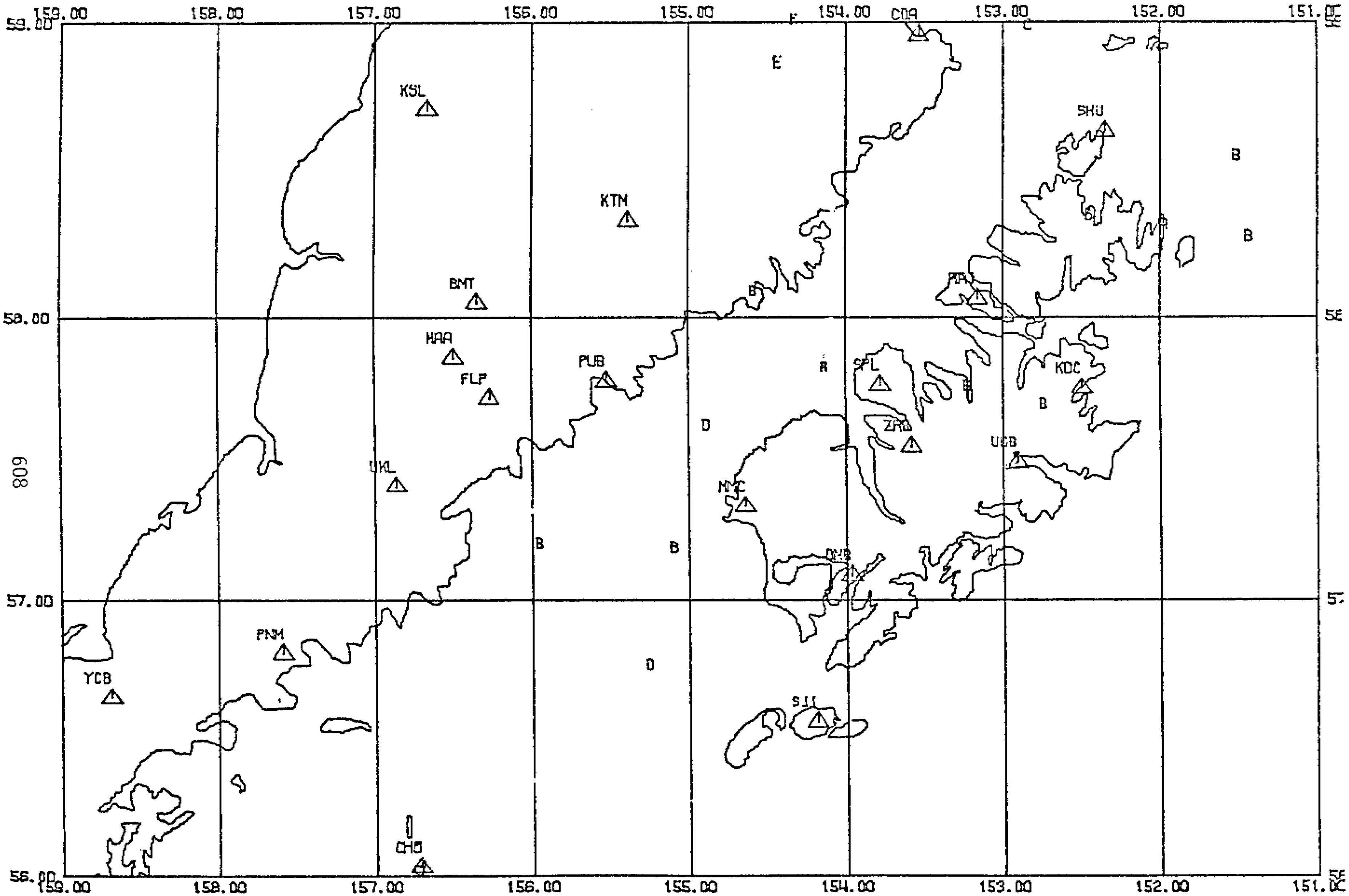


Figure A3-4: Kodiak Alaska Peninsula, class 1 events

Quarterly Report

Contract # 03-5-022-55
Research Unit # 253
Task Order # 1
Reporting Period: 7/1/77-9/30/77
Number of Pages: 9

SUBSEA PERMAFROST: PROBING, THERMAL REGIME AND DATA ANALYSIS

T. E. Osterkamp
W. D. Harrison
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

October 1, 1977

Project Title: Subsea Permafrost: Probing, Thermal Regime and Data Analysis

Contract Number: 03-5-022-55

Task Order Number: 1

Principal Investigators: T. E. Osterkamp and W. D. Harrison

I. Task Objectives:

To determine the subsea permafrost regime in selected near-shore areas in the Chukchi and Beaufort Seas using lightweight probing techniques and appropriate data analysis (D-9).

II. Field and laboratory work:

No field work was done during this quarter.

We have carried out an extensive recalibration of our thermistor probe used for determining temperatures during our Spring 1977 field program. The electrical conductivity of interstitial water samples from hole 798 at Tekegakrok Point (see our last quarterly report for hole locations) was measured in the laboratory. The results normalized to 25°C were as follows: 5.6 $(ohm\text{-}m)^{-1}$ at the sea bed, 5.5 $(ohm\text{-}m)^{-1}$ at the 2.2 m depth below the sea bed, 10.4 $(ohm\text{-}m)^{-1}$ at the 5.3 m depth and 9.2 $(ohm\text{-}m)^{-1}$ at the 8.3 m depth. Normal sea water is $\sim$ 5.3 $(ohm\text{-}m)^{-1}$ for comparison. The surprisingly large conductivity values at the 5.3 and 8.3 m depths requre further analysis for their interpretation. Major ion analysis of these water samples is now being done.

The sea bed profile at Tekegakrok Point is shown in Figure 1. This profile was obtained very close to that of Lewellen's (1973) profile. It is similar except that we found a more abrupt decrease in depth between 500 and 600 m offshore than given by Lewellen (1973).

Figures 2 through 6 are blow count profiles obtained during our Spring 1977 field program. There are some interesting maximums in these profiles suggestive of bonded permafrost, changes in sediment type or even rocks, however, their interpretation must await the reduction of the temperature data.

III. & IV. Results and interpretation:

The interpretation of our results must await a more complete reduction of our data.

V. Problems:

None.

VI. Funds expended:

$194,069.72 as of the end of August.

T0770512

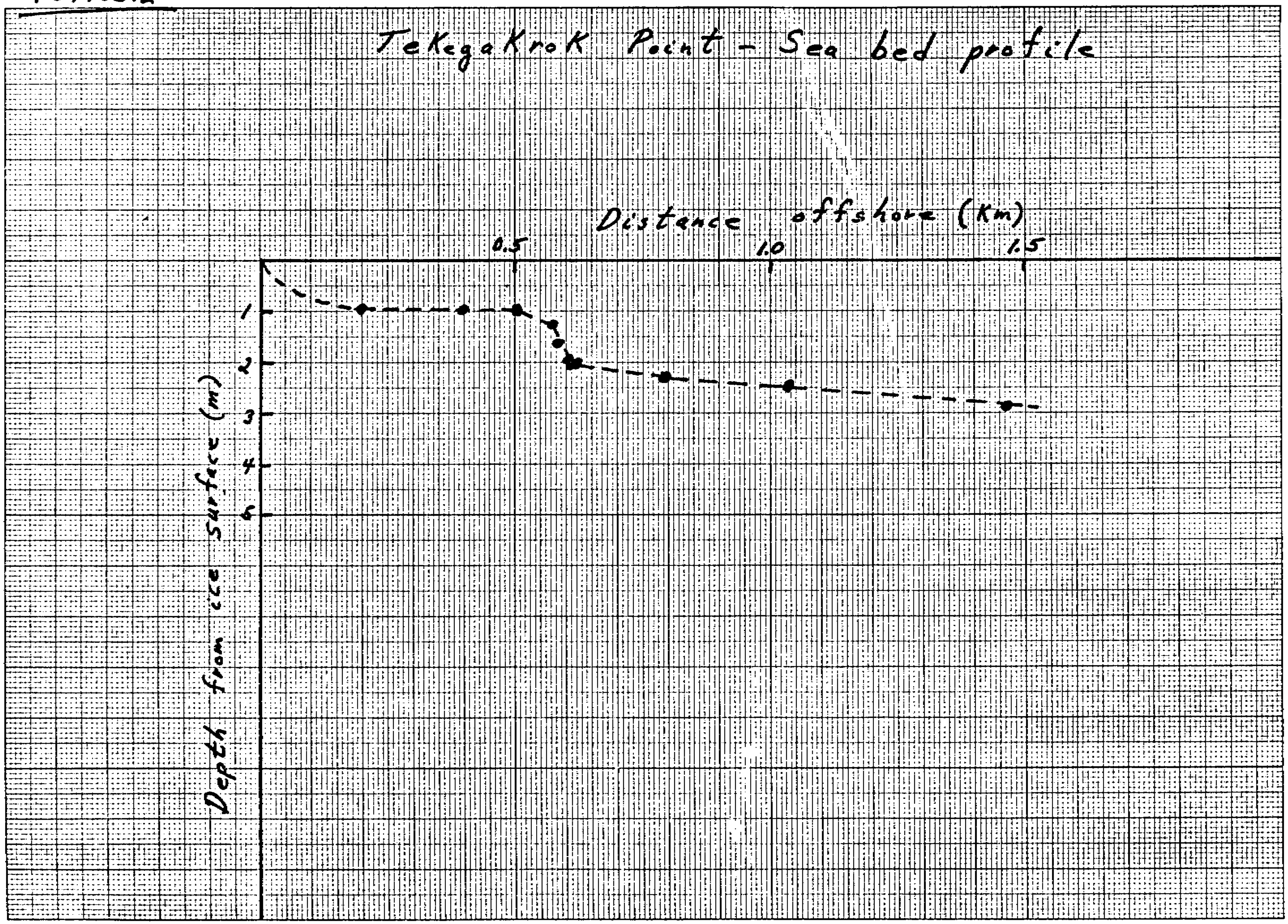
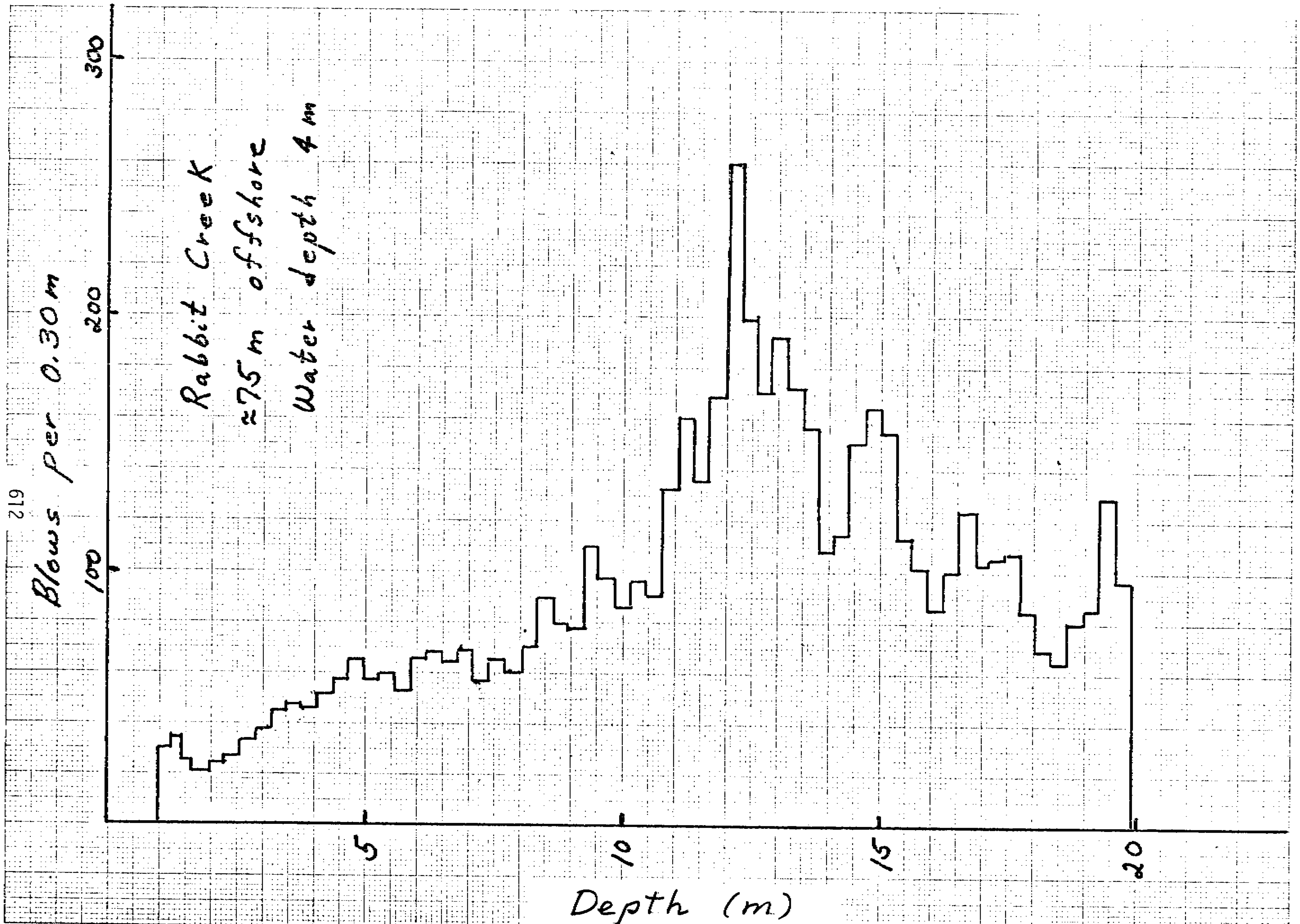
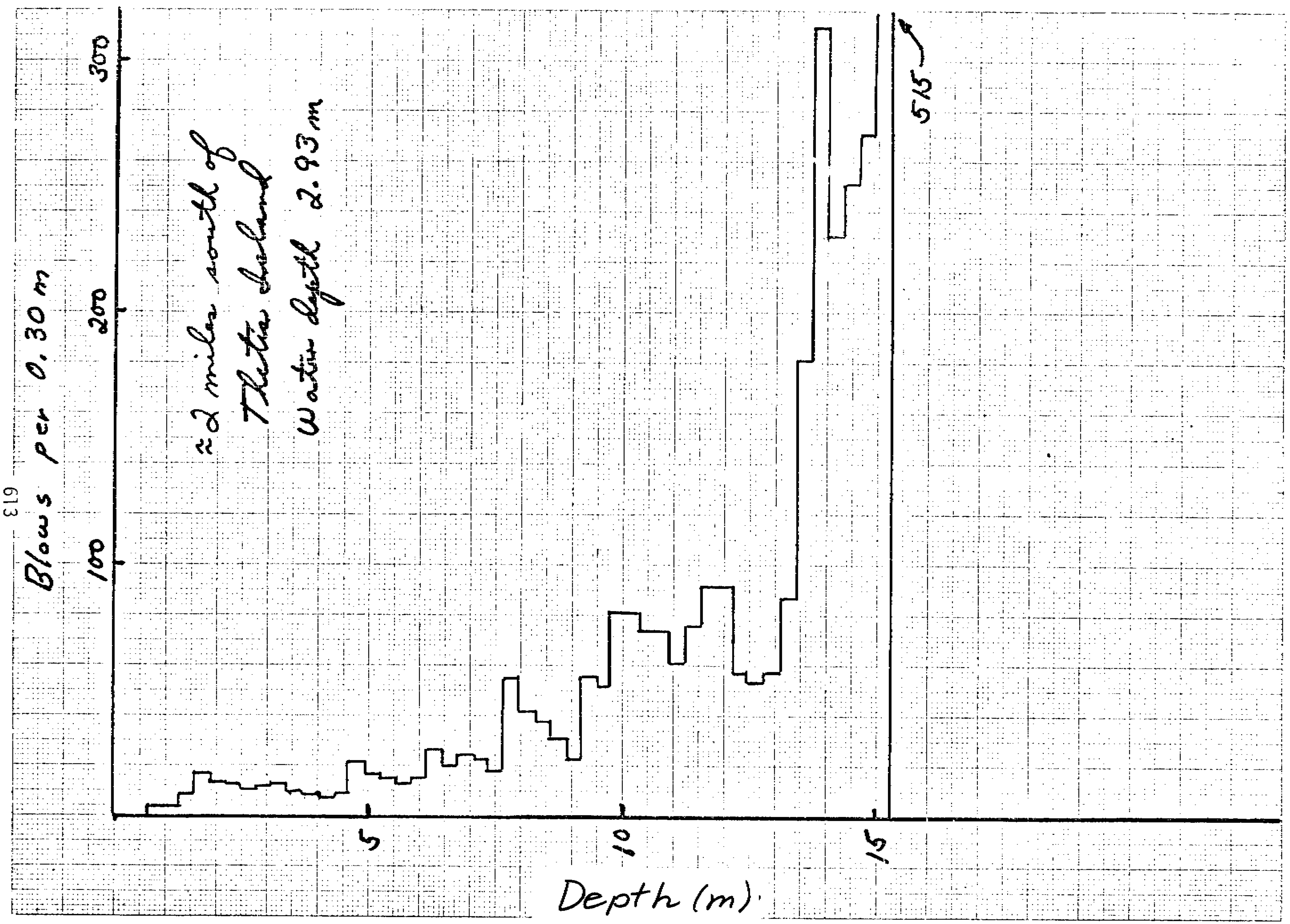


Figure 1



Blows per 0.30m
Rabbit Creek
≈75m offshore
Water depth 4m
100
200
300
5
10
15
20
Depth (m)

Figure 2



Blows per 0.30 m
300
200
100
≈2 miles south of
Thetis Island
Water depth 2.93 m
515
5
10
15
Depth (m)

Figure 3

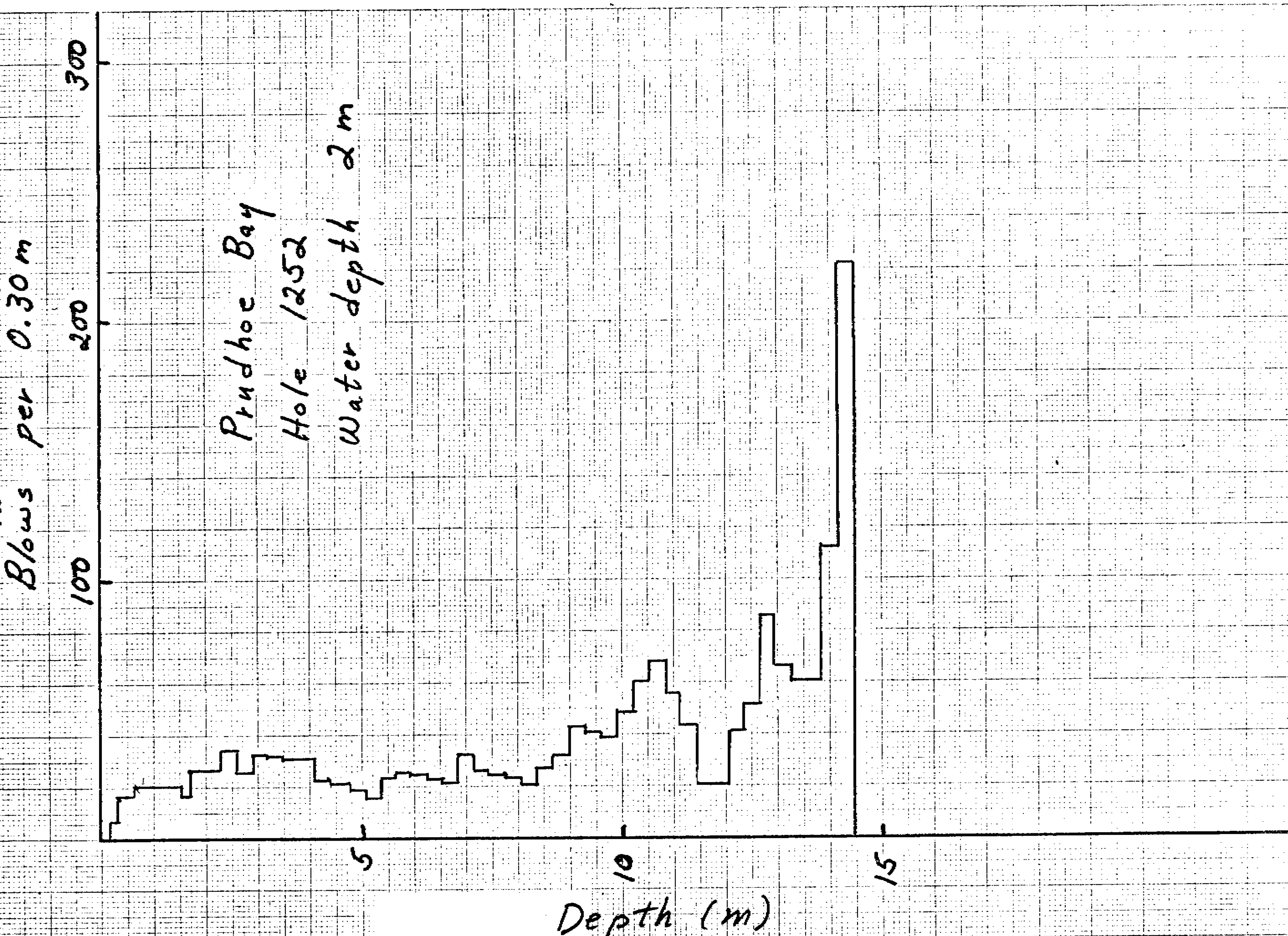

Blows per 0.30 m
300
200
100
Prudhoe Bay
Hole 1252
Water depth 2m
5
10
15
Depth (m)

Figure 4

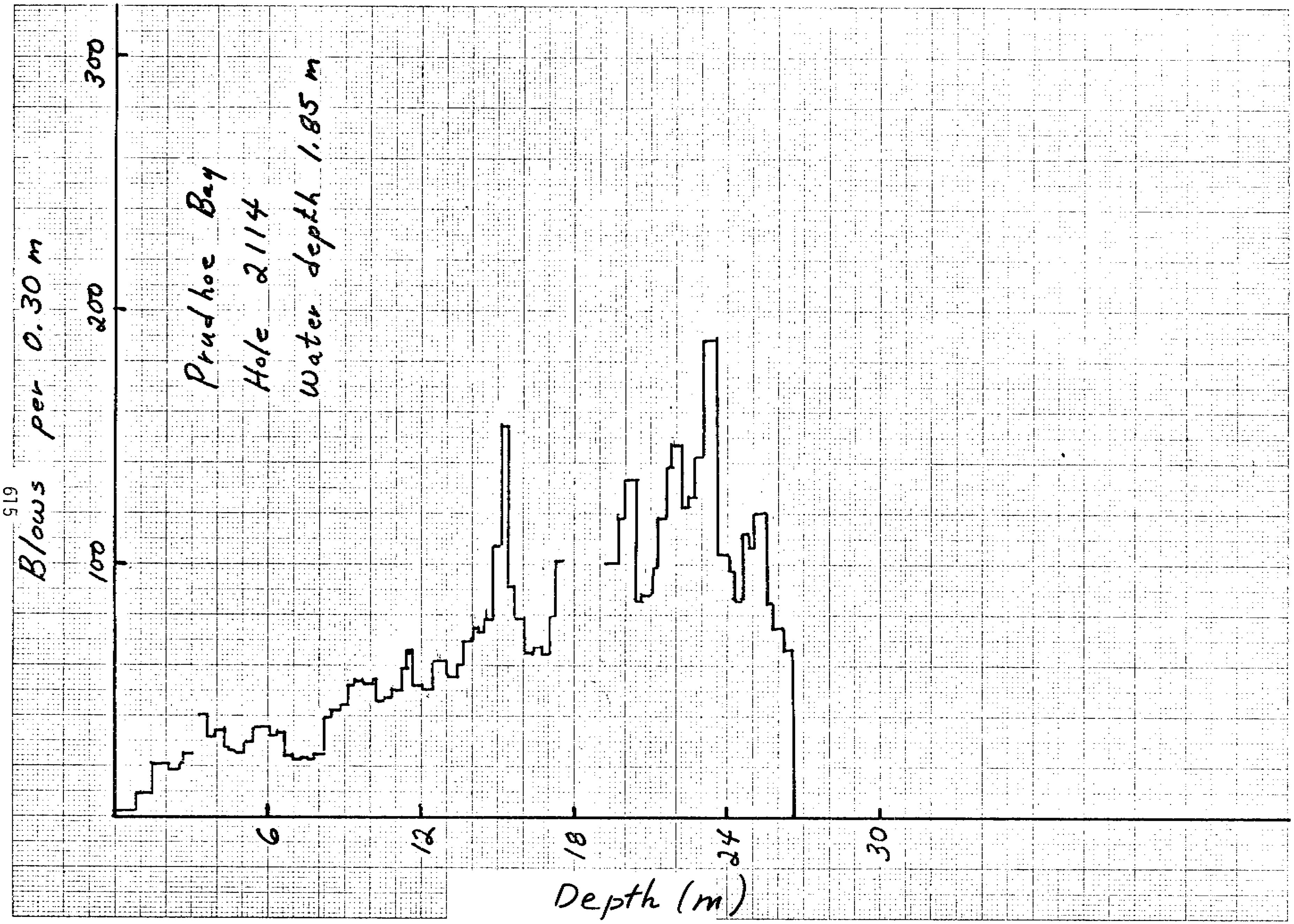

Blows per 0.30 m
Prudhoe Bay
Hole 2114
Water depth 1.85 m
300
200
100
6
12
18
24
30
Depth (m)

Figure 5

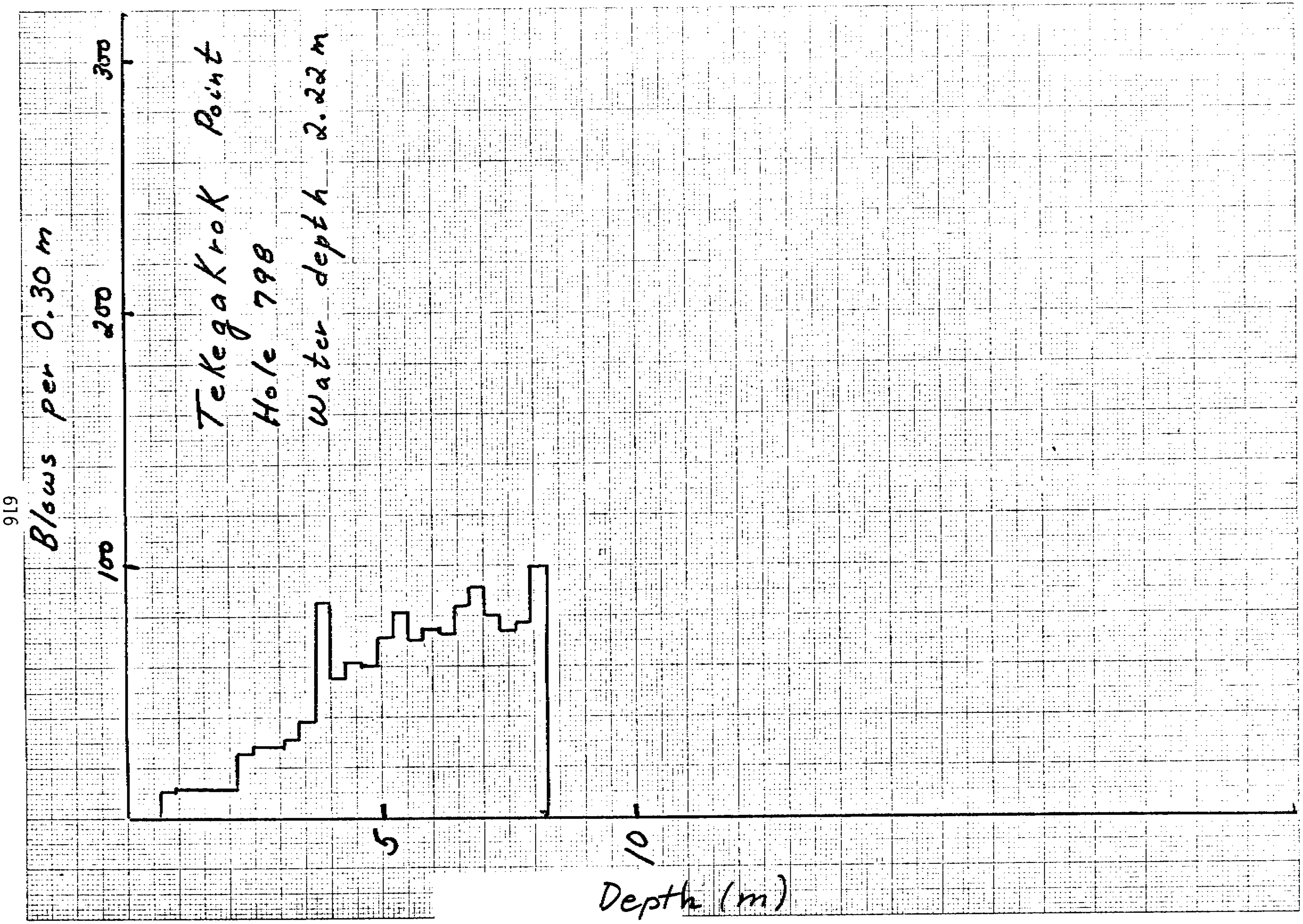

Blows per 0.30 m
Tekegakrok Point
Hole 798
Water depth 2.22 m
100
200
300
5
10
Depth (m)

Figure 6

Quarterly Report

Contract #03-5-022-55
Research Unit #271
Report Period: 10th Quarter
Ending Sept. 30
Number of Pages: 3

BEAUFORT SEACOAST PERMAFROST STUDIES

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(907) 272-5522

October 1, 1977

I. Task objectives: The objectives of this study are to develop an understanding of the nature and distribution of offshore permafrost along the Alaskan Beaufort Seacoast. Also of interest is the distribution of permafrost beneath the barrier islands. Emphasis is placed upon seismic methods but close cooperation with others using thermal, chemical and geological methods is an important part of the work.

II. Field work: Two types of seismic investigations were conducted during the month of August by J. C. Rogers and J. L. Morack. Marine work was conducted with the cooperation of the USGS aboard the "Karluk" and several seismic lines were run on the offshore islands using NOAA helicopter support. Approximately 80 km of lines were run from the "Karluk" and islands visited included Cross, Reindeer and Stump. The following figure indicates the area of investigation.

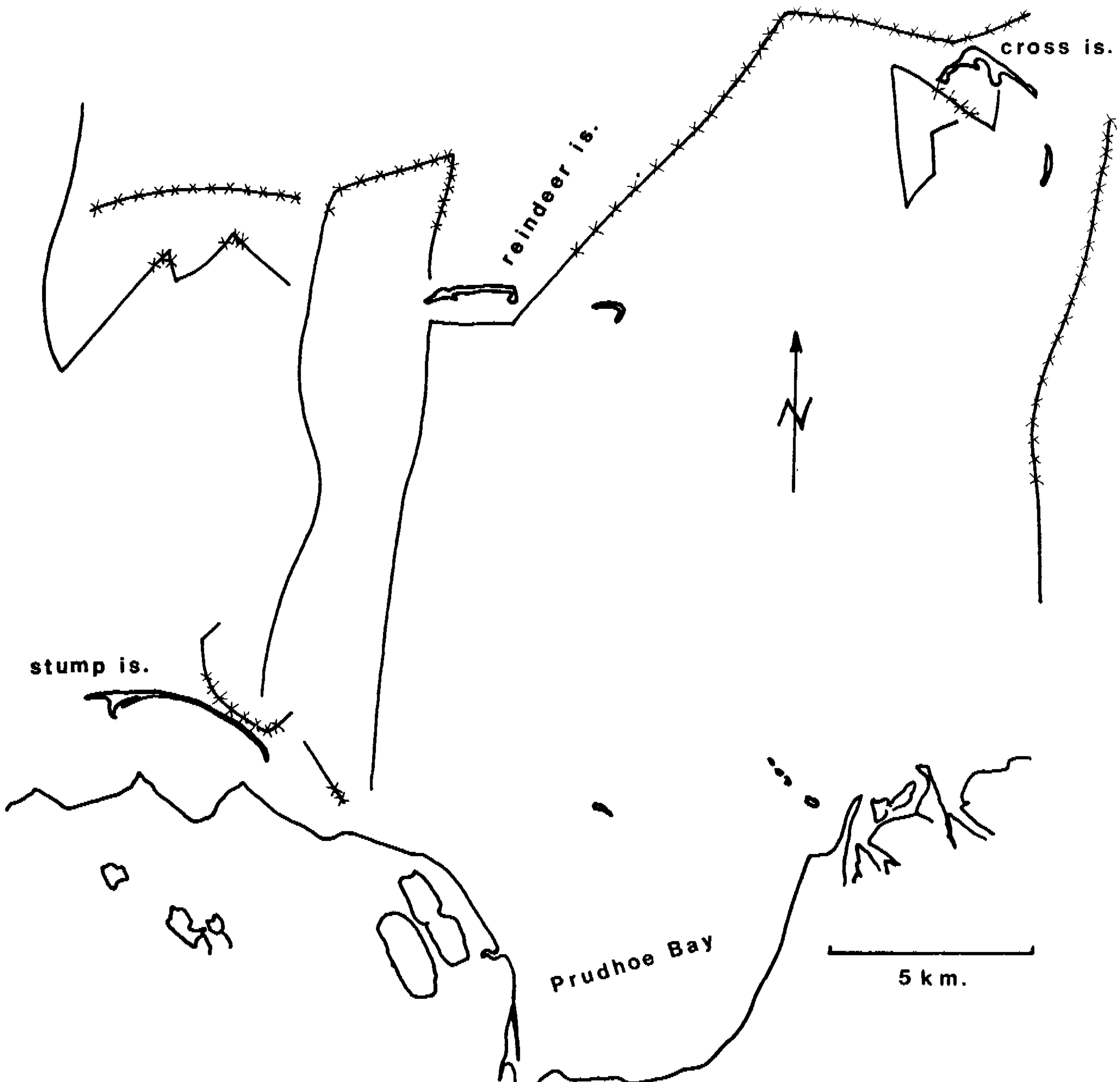
III. Results: Preliminary interpretation has indicated several interesting areas where seismic velocities corresponding to those expected in frozen sediments were observed. Near the new ARCO dock and adjacent to Stump Island a high velocity refractor which represents the upper part of the ice bonded permafrost was observed. (See Figure 1.) Further north of the mainland and south of Reindeer Island no high velocities were observed. However, north of Reindeer Island high velocities were observed. The portion of lines where high velocity refractors were observed are shown in the figure and are seen to extend to the east to Cross Island. Depths beneath the ocean surface to the refractors observed offshore ranged from about 15 meters to about 45 meters.

IV. Preliminary interpretation of results: A southern boundary of a shallow refractor interpreted at this time to be ice bonded materials has been observed to extend approximatley in an east-west direction several kilometers offshore at Prudhoe Bay. Such a refractor is not seen in Prudhoe Bay or in the area within 15 kilometers north of the bay. Hopkins (RU 204) has discussed the possibility of whether or not Prudhoe Bay is the site of an old thaw lake. Seismic information reported in our annual report (April 1977) supported this idea. Our present results indicate the possibility of a much larger region north of the bay that is free of bonded permafrost. Presently the northern extent of the high velocity refractor seen offshore is not known. Further correlation of the seismic results and drilling information is needed in order to interpret the data obtained to date in order to do this a more detailed analysis of the seismic data is required.

V. Problems encountered/recommended changes: Weather factors and limited availability of boat time continued to be a problem particularly for near island marine work. A dedicated small boat would greatly increase the productivity of the field season.

VI. Estimate of funds expended to date: $125,000.

Figure 1



Prudhoe Bay vicinity. Vessel tracks for summer field season are indicated by plain lines. Cross hatching over portions of these lines indicate areas where higher velocities were observed.

QUARTERLY REPORT

Contract #03-5-022-56
Research Unit #290
Task Order #3
Reporting Period 7/1/77-10/1/77
Number of Pages 5

BENTHOS-SEDIMENTARY SUBSTRATE INTERACTIONS

Dr. Charles M. Hoskin

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October 1977

I. TASK OBJECTIVES

This work is to provide grain size data for samples submitted by OCSEAP benthic biologists and chemists. These data will identify those places on the sea floor characterized by fine-grained sediment available for ingestion by benthic organisms and which may contain sorbed trace metals and hydrocarbons.

II. FIELD ACTIVITIES

None.

LABORATORY ACTIVITIES

Samples were submitted by Dr. D. C. Burrell for abbreviated grain size analysis; 32 samples from Norton Sound, Bering Sea, and 32 samples from Kotzebue Sound, Chukchi Sea, Alaska. These samples have been analysed according to the following scheme, which is a skeletonized version of the procedure given in;

Hoskin, C. M. 1976. Procedures and quality control for grain size analysis and data reduction of Bering Sea bottom sediments. Unpublished report to NOAA/OCSEAP, Institute of Marine Science, University of Alaska, 9 p.

The wet samples as received were each split into equal subsamples. One subsample was stored, the other subsample was digested in 50 percent hydrogen peroxide and distilled water to destroy organically-bound aggregates. This material was then wet seived through stainless steel mesh, 0.0625 mm, the particles passing the sieve were mud, those retained were gravel, sand, and an unknown amount of coarse silt. The mud was allowed to settle in water, and the clear supernate siphoned off. The mud was stored wet. Particles retained on the 0.0625 mm wet sieve were oven dried and were passed through nested sieves (2.00 and 0.0625 mm) by means of agitation for 15 minutes on a Ro-Tap shaker. Weight of particles retained on each sieve was recorded. Particles retained on the 2.00 mm sieve were gravel, those retained on the 0.0625 mm sieve were sand, and particles passing the 0.0625 mm sieve were coarse silt. The latter were added to the mud fraction obtained by wet sieving.

An aliquot of the stored wet mud was taken, and weight percent water was determined by before-and-after weighing following oven drying. The weight of dry mud was calculated, and the weights of gravel, sand and mud fractions were used to calculate the weight percentage of each of these grain size fractions.

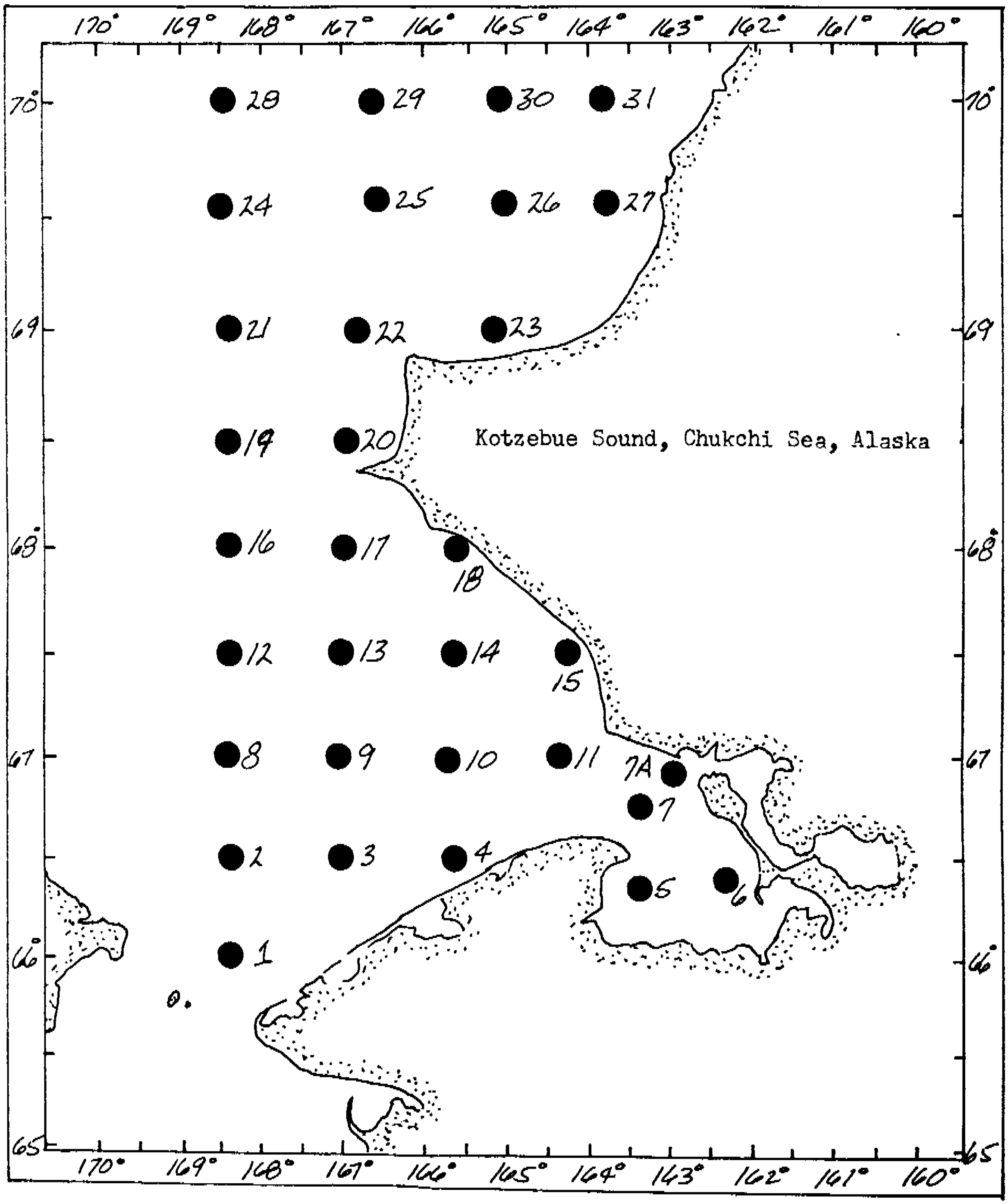
III. RESULTS

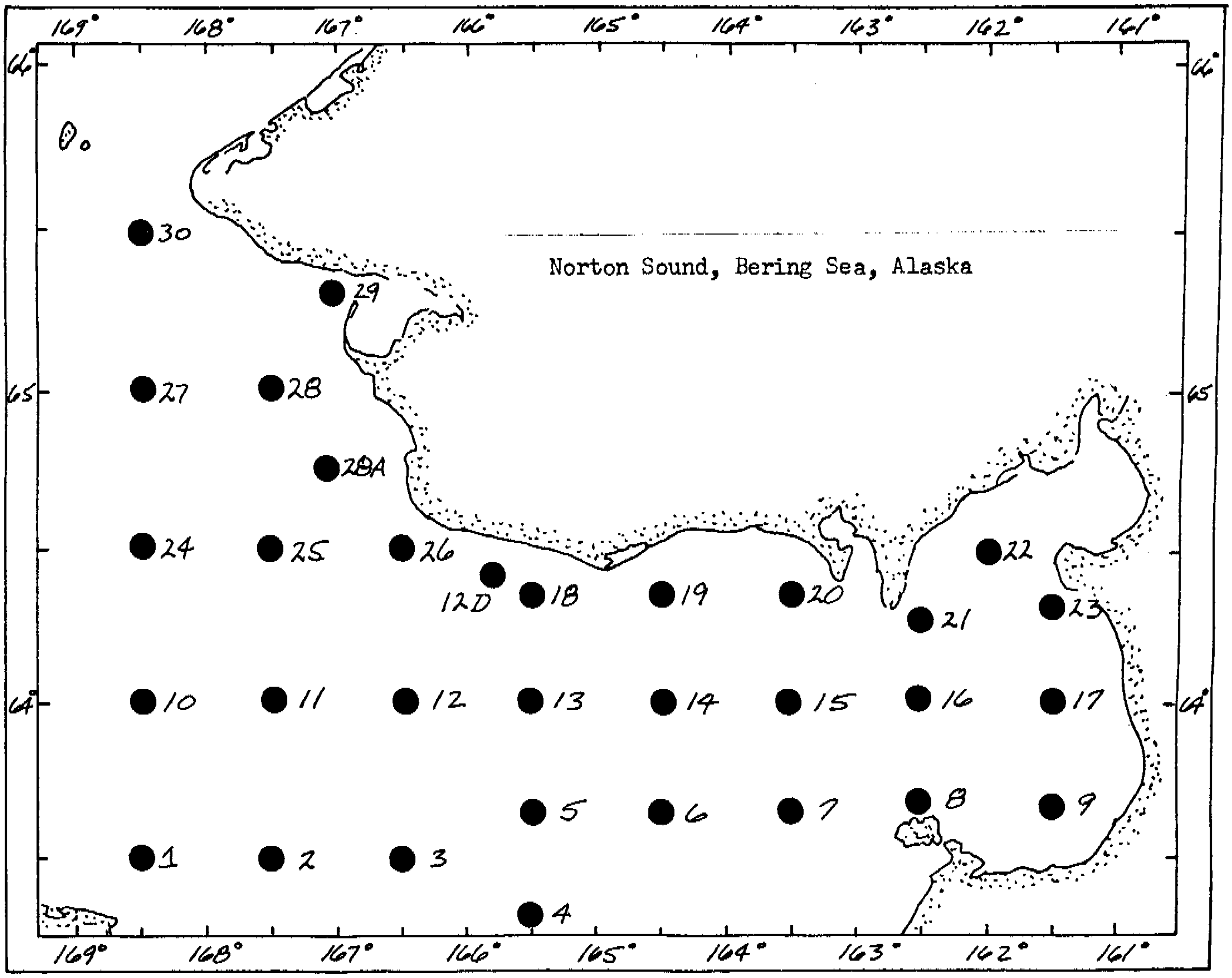
A summary of the data is given below. From frequency plots of each of these grain size parameters, there appears to be no characteristic groupings, except that 27 of 32 samples from Norton Sound had gravel contents between 0-1, and 26 of 32 samples from Kotzebue Sound had gravel contents between 0-1, percent by weight. Data for these analyses are being submitted to OCSEAP through Mr. Ray Hadley concurrently with this report. Ms. G. H. Kris Tommos performed the analyses with skill and conscientious effort.

	Norton Sound	Kotzebue Sound
Gravel	0-15.55, wt %	0 - 87.87
Sand	4.98 - 91.03	.84- 95.74
Mud	7.04 - 94.64	2.82- 98.98

IV. PROBLEMS ENCOUNTERED

Due to large number of weighings required by grain size analysis, it is inefficient to carry samples to a balance; the balance should be physically beside the sieves and sieve shaker. Funds sought to purchase a balance for this work were not approved, and this increased the time required for analysis.


170°
169°
168°
167°
166°
165°
164°
163°
162°
161°
160°
70°
69
68°
67
66°
65
28
29
30
31
24
25
26
27
21
22
23
19
20
Kotzebue Sound, Chukchi Sea, Alaska
16
17
18
12
13
14
15
8
9
10
11
7A
7
2
3
4
5
6
1


Norton Sound, Bering Sea, Alaska
169°
168°
167°
166°
165°
164°
163°
162°
161°
66°
65
64°
30
29
27
28
28A
24
25
26
12D
18
19
20
21
22
23
10
11
12
13
14
15
16
17
5
6
7
8
9
1
2
3
4

QUARTERLY REPORT

RESEARCH UNIT #327

Shallow faulting, bottom instability, and movement of sediments in lower Cook Inlet and western Gulf of Alaska.

Principal Investigators: Monty A. Hampton
Arnold H. Bouma
U.S. Geological Survey
Menlo Park, California

Principal investigators at sea, September and October, 1977. No quarterly report.

QUARTERLY REPORT

Contact: RK6-6074

Research Unit: 429

Reporting Period: 1 July, 1977 - 1 October, 1977

FAULTING, SEDIMENT INSTABILITY, EROSION AND DEPOSITION HAZARDS OF NORTON BASIN SEA FLOOR

Devin R. Thor

Hans Nelson

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345 Middlefield Road
Menlo Park, California 94025

October 1, 1977

The summer quarter of 1977 consisted mainly of the July cruise SEA 5-77-BS aboard R/V SEA SOUNDER in the northern Bering Sea and the complimentary orgainization, reduction and start of interpretation of data gathered during the cruise.

FIELD WORK

Data obtained this summer includes 2900 km of seismic reflection track line and 48 sampling stations (Fig. 1). Abstracts written this summer and fall which are based on data gathered during this cruise and last years cruise, are found in Appendix A. Summaries of cruise activities are outlined in the ROSCOP II general cruise inventory (Appendix B) and in the Preliminary Cruise Report for S5-77-BS (Appendix C).

The cruise was divided into three legs; each leg had a specific goal or concerned a topical research subject. Leg I investigated oceanographic properties of the water and sea floor bedforms west of Port Clarence and Bering Strait areas. During the cruise several of last years track lines were replicated. Changes in the geomorphology of shoal crusts, size and orientation of bed forms, and modification of ice gouges by ripples were observed on the seismic records of these replicated lines (Field, Nelson, and Cacchione, 1977, A.G.U. Abstract enclosed in Appendix A).

Leg II was concerned with gas in the surficial sediment shown by an onboard gas chromatograph, anomalies in high resolution profiles, and apparent gas pits or craters in sonographs of the sea floor in north-central Norton Sound (Fig. 1). In the western part of this area, which is known for unusually high concentrations of natural gas in the water column, vibracore sampling in 1977 indicates a new location of unusually high gas concentrations in the surficial sediment; this gas is considered to be thermogenic in origin (Nelson and Kvenvolden, 1978 OTC Abstract; Kvenvolden, Rapp, and Nelson, 1978 AAPG Abstract; Holmes, Cline and Nelson, 1977 GSA Abstract).

In the eastern part of the Leg II area in northern Norten Sound, Uniboom seismic lines were run to further map the distribution and density of acoustic anomalies and side scan sonar lines were run to increase the trackline coverage in areas of crater occurrence. The area of gas cratering is more extensive than mapped previously and greatest intensity of craters seems to be 50 km east of thermogenic seeps and related to biogenic sources.

Leg III consisted of reconaissance geophysical transects and sampling stations in western Norton Basin (Chirikov Basin of northern Bering Sea). This leg added new baseline information, and found relict beach and glacial deposits on the sea floor.

Research continues on general analysis of environmental geologic hazards in Norton Basin (Nelson and Thor, 1977 G.S.A. Abstract) and on specific physical and biologic sedimentary structures (Howard and Nelson, 1977 G.S.A. Abstract).

OFFICE WORK

Office work during this quarter consisted of:

1) Preparation of the previously referenced abstracts.

2) Processing of seismic data to prepare it for microfilm reproduction.

3) Preparation of subsamples to be sent out for paleontologic identification, radiocarbon dating, lead 210 dating, size analysis and minerology of sediments.

4) Continued reduction and interpretation of data, specifically that gathered during Leg II of SEA 5=77-BS.

APPENDIX A

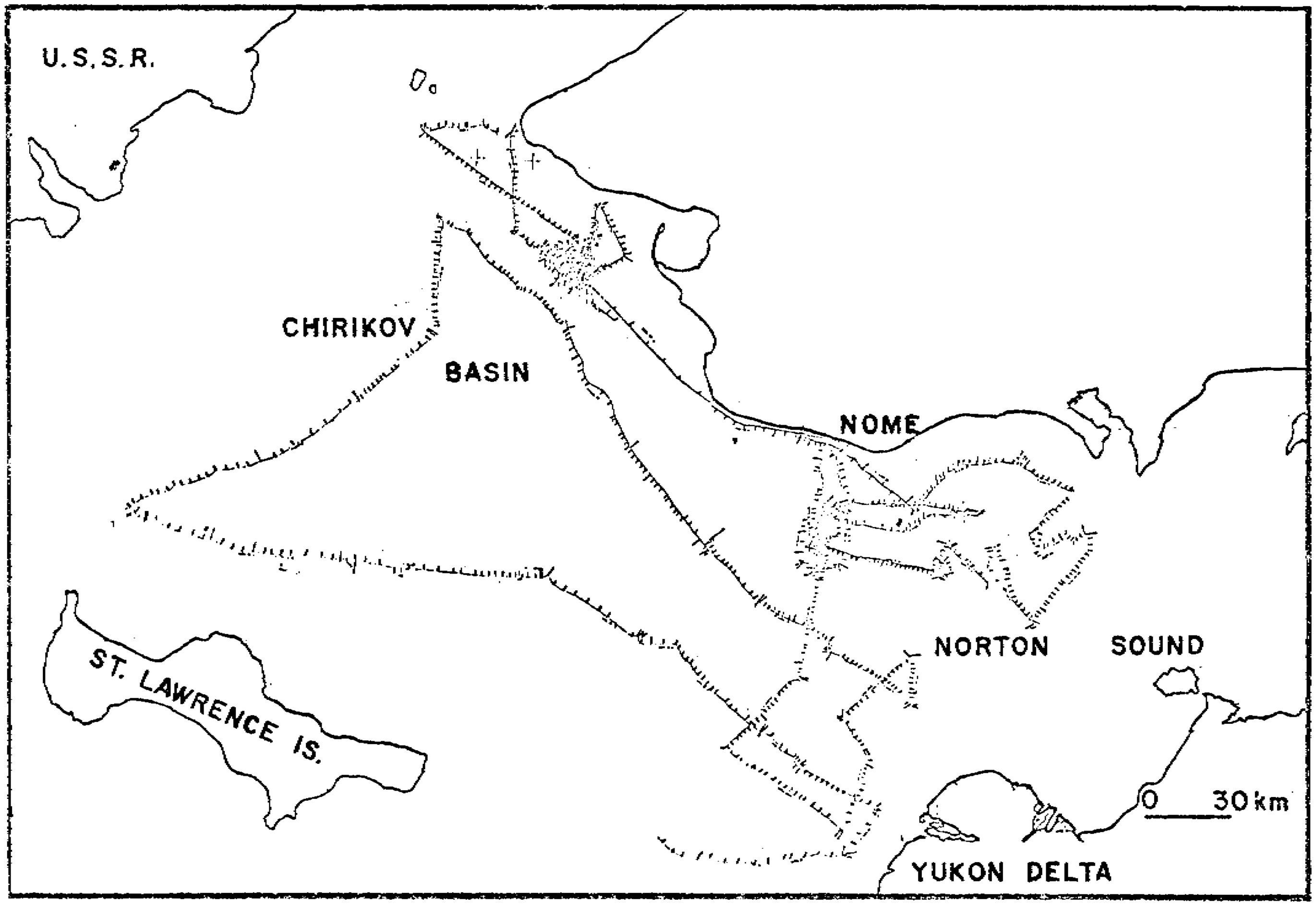

Figure 1. Index map and track lines in Norton Sound and Chirikov Basin.

DYNAMICS OF BEDFORMS ON AN EPICONTINENTAL SHELF: NORTHERN BERING SEA

M. E. Field, H. Nelson, D. A. Cacchione,
D. E. Drake, U.S. Geological Survey,
345 Middlefield Road, Menlo Park, CA 94025

Sand waves and ripples occupy the crests and some flanks of a series of large linear ridges (20 km x 5 km x 8 m high) lying west of Seward Peninsula and southeast of Bering Strait. Repeated detailed surveys using high resolution seismic reflection profiles, side scan sonar, underwater television, current meters, and suspended sediment samplers have provided some insight into the characteristics and dynamics of these bedforms. Sand waves are 1 to 2 m high and have crest spacings of either 10 to 20 m or 150 to 200 m. Super imposed on the sand waves are current and wave oscillation ripples with h $\simeq$ 4 cm and $\lambda \simeq$ 20 cm.

Surveys in September 1976 during a period of subsiding storm waves from the north showed only oscillatory movement of sand on ripple crests. A maximum speed of the north-flowing coastal current of about 15 cm/sec was measured near the bottom and no net bedload movement was observed. Fresh-looking ice gouges cutting inshore ripples indicated that bedload movement had been negligible in this zone since ice break-up in the spring. The second survey, in July 1977, was made during very calm weather, yet significant bedload movement was observed on ridge crests at water depths of 20 to 30 meters. Northward flowing bottom currents measured with the shipboard profiling current meter ranged from 20 to 40 cm/sec. Linguoid ripples were observed moving on the stoss slope of sand waves and straight-crested ripples in the troughs. Ice gouges on deeper ridge crests in varying states of preservation indicate active bedload transport.

Sand wave movement and bedload transport apparently occur during calm weather and maximum change occurs when major southwesterly storms generate sea level set-up in the eastern Bering Sea that enhances northerly currents. Strong north winds from the Arctic, however, reduce the strength of the continuous northerly currents and thereby reduce the amount of bedload transport.

1. 022743CACCHIONE
2. 1977 Fall Meeting
3. Oceanography
4. Shelf Sediment Dynamics
5. Yes, preferred
6. No
7. 0
8. Bill to: 022743CACCHIONE
9. To be provided

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CLASSIFICATION
You must specify one. If more than one category is appropriate, indicate your order of preference by numbers. Be specific.

ABSTRACT FORM

Exact format shown on instruction sheet must be followed.

ACOUSTIC ANOMALIES AND SEEPING GAS IN NORTON BASIN, ALASKA

HOLMES, Mark L., U.S. Geological Survey, 1107 N.E. 45th, Seattle, Washington 98105; CLINE, Joel D., Pacific Marine Environmental Laboratory, National Oceanic and Atmospheric Administration, 7600 Sand Point Way N.E., Seattle, Washington 98115; NELSON, C. Hans, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025

Evidence of submarine seepage of natural gas was discovered during a 1976 environmental survey of petroleum hydrocarbon levels in the waters of Norton Sound. The study, sponsored by BLM through an interagency agreement with NOAA, revealed relatively high concentrations of C_2-C_4 alkanes apparently emanating from a point source on the sea floor 40 km south of Nome. Preliminary estimates of the initial gas phase composition suggest that the gas may originate from a liquid petroleum source rather than represent a non-associated or biogenic natural gas.

Several steeply dipping faults which might provide favorable migration avenues for mobile hydrocarbons from deep reservoirs to the sea floor are evident on seismic reflection records in the vicinity of the seep. Also conspicuous on the single channel records are two distinctly different types of acoustic anomalies: reflector "pull-downs", and abrupt reflector terminations. The first type is indicative of a decrease in sound velocity over what may be local accumulations of gas in surface and near-surface sediment. Anomalies of the second type are larger and more widespread; many occur in the central portion of Norton Basin within an area of about 20,000 km^2. Although near-surface peat accumulations formed during times of lowered sea level may also cause such acoustic responses, these reflector termination anomalies bear a striking resemblance to some recorded elsewhere above gas caps associated with known major oil fields.

The discovered seep, the acoustic anomalies, and recently revised estimates of basin depth (5.5 km) together suggest that Norton Basin may present the petroleum prospector with significant opportunities.

☐ Oral ☒ Poster ☐ Either

☒ Poster Symposium Marine Geological Studies of the Bering Sea Outer Continental Shelf
(title of symposium)

Speaker ________________ ☐ Student paper ☐ GSA Student Associate

geochemistry

geology
archeologic
coal
economic

education
engineering
environmental
extraterrestrial
general
history of
marine
marine

Precambrian
Quaternary
structural

geomorphology

geophysics

geoscience information
hydrogeology
mineralogy/crystallography
paleomagnetism
paleontology/paleobotany

petrology
experimental
igneous
metamorphic
sedimentology
sedimentary petrology
stratigraphy
tectonics
OTHER

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ABSTRACT FORM

Exact format shown on instruction sheet must be followed.

PHYSICAL AND BIOGENIC SEDIMENTARY STRUCTURES OF NORTON SOUND, ALASKA

HOWARD, James D., Skidaway Institute of Oceanography, Savannah, Georgia 31406; NELSON, Hans, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025

Norton Sound, a large shallow embayment of more than 24,000 km^2, is bounded on the north by the Seward Peninsula and on the south by the Yukon-Kuskokwim Delta. The modern Yukon sub-delta dominates the south coast of Norton Sound, where significant shoreline progradation has occurred in response to deltaic sedimentation.

Forty-six box cores have been collected in Norton Sound to determine the primary physical and biogenic sedimentary structures that characterize this delta-influenced embayment. Only in the vicinity of the Yukon Delta, in water depths of less than 10 m, are primary physical sedimentary structures significant. Here are found ripple lamination and large-scale trough crossbedding with relatively little biogenic activity recorded in the storm-sand layers interbedded with mud. In the more protected easternmost part of Norton Sound, bioturbaed sands and clayey slits are most common. In the central part, in water depths of 10-20 m, fine- and medium-grained bioturbated sand and bioturbated silty fine sand are dominant.

Throughout most of Norton Sound, evidence of bioturbate textures is abundant and indicates continuous reworking of the substrate by burrowing organisms. Nearly all cores, however, still show some indication of recognizable specific burrow types. Of these, a variety of polychaete burrows are most common, although structures formed by amphipods and brittle stars are commonly present.

Interbedded fine sand and mud observed in areas of low bioturbation suggest that this bedding type is the precursor of the bioturbated units that characterize most of the sediments of Norton Sound. Although surface traces of ice gouging are a common feature of sonographs from Norton Sound, only two cores showed evidence of such structures.

☐ Oral ☒ Poster ☐ Either

☐ Symposium Marine Geological Studies of the Bering Sea Outer Continental Shelf
(title of symposium)

Speaker James D. Howard ☐ Student paper ☐ GSA Student Associate

geochemistry

geology
- archeologic
- coal
- economic

- education
- engineering
- environmental
- extraterrestrial
- general
- history of
- marine

- Precambrian
- Quaternary
- structural

geomorphology

geophysics

geoscience information
hydrogeology
mineralogy crystallography
paleomagnetism
paleontology/paleobotany

petrology
- experimental
- igneous
- metamorphic

sedimentology
- sedimentary petrology

stratigraphy
tectonics
OTHER

LAYMAN'S SUMMARY

Physical and Biogenic Sedimentary Structures of Norton Sound, Alaska

J. Howard - Skidaway Institute, U. of George, Savannah Georgia

H. Nelson - U.S.G.S., Menlo Park, California

Norton Sound, a large, shallow embayment of over 24,000 km^2 is bounded on the north by the Seward Peninsula and on the south by the Yukon-Kuskokwim Delta. Forty-six box cores have been collected in Norton Sound to determine the primary physical and biogenic sedimentary structures which characterize this delta influenced embayment. Biological structures are the most common in bottom sediments of the Sound. Only in the vicinity of the Yukon Delta, in water depths of less than 10 m are primary physical sedimentary structures significant in storm sand layers interbedded with mud. Here relatively little biogenic activity is recorded in the sedimentary record and physical processes are more prominent and hazardous. In the more protected easternmost part of Norton Sound, sands and clayey silts are most common. In the central sound, in water depths of 10-20 m, fine and medium-grained sand and silty fine sand are dominant.

Both areas are highly reworked by bottom dwelling organisms. Nearly all cores show some indication of recognizable specific burrow types. Of these, a variety of polychaete worm burrows are most common although structures formed by amphipods and brittle stars are commonly present.

Interbedded layers of fine sand and mud observed in areas of low bioturbation suggest that this bedding type is the precursor of the biologically disrupted sediments which characterize most of Norton Sound. Although surface evidence of ice gouging into the bottom surface is a common feature recorded from side-scan surveys of Norton Sound, only two cores showed preserved evidence of structures from such disruption.

KVENVOLDEN, KEITH A., JOHN B. RAPP, and HANS NELSON, U.S. Geological Survey,
Menlo Park, California 94025

Low Molecular Weight Hydrocarbons in Sediments from Norton Sound

Anomalous concentrations of low molecular weight hydrocarbons were found in silty, fine-grained sands from a 1.6 m vibracore taken at a water depth of 19 m about 50 km south of Nome, Alaska. The maximum concentrations of methane (C_1), ethane (C_2), propane (C_3), n-butane (n-C_4), and i sobutane (i-C_4) measured were 117, 8.64, 0.62, 0.24, and 1.00 μl/l of sediment (ppm by volume), respectively. The content of C_1 in the hydrocarbon gas phase reached a minimum value of 85 percent at the bottom of the core. Gasoline-range hydrocarbons containing five (C_5) to at least eight (C_8) carbon atoms, were also detected. In contrast, the concentrations of C_1, C_2, C_3, n-C_4, and i-C_4 in other samples from vibracores taken at sites 10 and 20 km away were significantly lower with maximum measured values reaching only 50, 0.11, 0.16, 0.04, and 0.02 μl/l of sediment, respectively. The C_1 content in the hydrocarbon gas phase always exceeded 98 percent. There was little or no evidence for hydrocarbons C_5 through C_8. The relative proportion of C_1 to total hydrocarbons has been considered an indicator of processes by which hydrocarbons are produced. A C_1 content greater than 98 percent may indicate predeominantly recent, biologic origin, whereas a C_1 content less than 98 percent suggests contributions from thermogenic alterations.

The anomalously high concentrations of hydrocarbon gases and the relatively low proportions of C_1 to total hydrocarbons suggest that thermogenic, and not biologic, processes were mainly responsible for the gases observed in this one core. Indeed, the hydrocarbon gases in these sediments may signal the presence of petroleum deposits at depth in this region.

PAPER TITLE Thermogenic Gas in Sediments of Norton Sound, Alaska

PRINCIPAL AUTHOR Hans Nelson TELEPHONE (415) 323-8111 X 2603
COMPANY US Geological Survey TELEX -
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NOTE: ATTACH SEPARATE SHEET FOR ADDITIONAL AUTHORS AAPG

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In 1976 hydrocarbon gases, assumed to be of thermogenic origin based on chemical compositions, were reported by Cline (NOAA) and Holmes (USGS). They found a plume of these gases in the water column of Norton Sound centering over a near-surface fault zone about 40 km south of Nome, Alaska. Detailed transects (2-5 km apart) were run throughout this 20-25 km region in 1977. High resolution seismic profiling equipment (bubble detector, 3.5 Khz, 12 Khz, and uniboom systems), side scan sonar, underwater TV, and gas chromatographic analyses on samples from cores did not provide evidence for the presence of thermogenic gas in sediments in the area of the reported gas plume. A new area was discovered, however, 9 km south of the plume epicenter and fault zone where both geophysical and geochemical evidence suggests the presence of thermogenic hydrocarbon gases in the sediments. These new data indicate that surface and near-surface environmental assessment studies of continental shelf areas can contribute significantly to petroleum-resource studies.

At this newly discovered location, acoustic anomalies, suggesting the presence of gas-charged sediments, show subbottom terminations of all reflectors under an area of about 2 sq. km. Analyses of hydrocarbon gases in samples recovered from a 1.6 m vibracore at this location showed anomalously high concentrations of hydrocarbon gases heavier than methane. For example, the ratio of methane to ethane plus propane reached minimum values of 7 at the bottom of the core. Also, the maximum concentrations of ethane, propane, n-butane, and isobutane, were 76, 3, 6, and 52 times greater, respectively, than the maximum concentrations of these same gases in three other vibracore samples taken at sites in the fault zone and 10 km north of it. The gases in the sediments 9 km south of the fault zone have a composition indicating origin from dominantly thermogenic processes.

Our geophysical and geochemical data, therefore, complement and extend the observations made earlier in the water column. The presence of apparent thermogenic hydrocarbons in near-surface sediments points to the possibility of petroleum deposits at depth in this region.

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ABSTRACT FORM

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Environmental geologic hazards in Norton Basin, Bering Sea

NELSON, Hans and THOR, Devin R.
U.S. Geological Survey, Menlo Park, California 94025

The Yukon prodelta and Bering Strait areas have the most severe combination of geologic hazards affecting petroleum development in northeastern Bering Sea. Gas cratering, ice gouging, bottom currents, and storm-surge activity are all intense in the extensive shallow area (20 m) off the modern Yukon Delta. Faulting and effects of strong bottom currents are most evident near Bering Strait. Holocene fault activity is difficult to determine there because current scour may be preserving or exhuming old scarps. Surface and nearsurface faulting south of Nome seem to be associated with thermogenic gas seeps.
The most intense ice gouging, cutting to sediment depths of 1 m, occurs in the south-central region of Norton Sound and southwestward around the modern Yukon Delta. Elsewhere, at water depths of 20 m or less, gouging is ubiquitous but of lower intensity, having less impact on development.
Widespread areas of apparent gas cratering on the sea floor, seen on sonographs, are associated with velocity anomalies on seismic profiles. Craters (3-5 m diameter) in north-central Norton Sound are underlain by freshwater peaty muds covered by 1-2 m of Holocene marine mud. Freshwater muds contain anomalously high amounts of organic carbon and biogenic methane. Storm waves may trigger outgassing from underlying muds causing craters and hazards for sea-floor platforms or pipelines.
Fields of sand waves have been outlined in many potential pipeline corridor routes to harbor and land-based facilities. Migration of waves takes place only intermittently under conditions of extreme storm-surge forcing, perhaps every few years.. Evidence from the most recent storm-surge event (1974) suggests that severe storms also cause major scour and movement of sand sheets over wide areas of Norton Sound.

geochemistry

geology
- archeologic
- coal
- economic

- education
- engineering
- environmental
- extraterrestrial
- general
- history of
- marine

- Precambrian
- Quaternary
- structural

geomorphology

geophysics

geoscience information
hydrogeology
mineralogy/crystallography
paleomagnetism
paleontology/paleobotany

petrology
- experimental
- igneous
- metamorphic

sedimentology
- sedimentary petrology

stratigraphy
tectonics
OTHER

☐ Oral ☒ Poster ☐ Either

☒ Symposium Marine Geological Studies of the Bering Sea Outer Continental Shelf.
(title of symposium)

Speaker Hans Nelson ☐ Student paper ☐ GSA Student Associate

APPENDIX B

FORM APPROVED: OMB NO. 41-R2765 - EXPIRES: 12-31-79

NOAA FORM 24-23 (1-76)

U. S. DEPARTMENT OF COMMERCE
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ENVIRONMENTAL DATA SERVICE
NATIONAL OCEANOGRAPHIC DATA CENTER

OCEANOGRAPHY - GENERAL CRUISE INVENTORY
(ROSCOP - II)

A00 DATA CENTER

A40 REFERENCE NUMBER

A01 EXPEDITION/PROJECT: OCSEAP - Norton Basin - NORSE 77

A11 CRUISE NUMBER OR NAME: SEA 5 - 77 - BS

A02 SHIP OR PLATFORM: R/V Sea Sounder

A12 PLATFORM TYPE: 01

	YES	NO	PART	
A91 Declared national program?	X			
A81 Exchange restricted?		X		
A92 Co-operative program?	X			A72 NAME: BLM-NOAA-USGS
A82 Co-ordinated internationally?		X		A62 BY WHOM?

A03 COUNTRY: USA

A04 ORGANIZATION: U. S. Geological Survey

A05 CHIEF SCIENTIST(S): Hans Nelson

A06 NAME AND ADDRESSES OF ORGANIZATIONS AND PERSONS WHOM TO QUERY	FINAL DISPOSITION OF DATA
A1 Faulting, sediment instability, erosion,	A2 Tom Chase
B1 and deposition hazards of Norton Basin (RU 429)	B2 Pacific-Arctic Branch of Marine Geology
C1 Hans Nelson	C2 U. S. Geological Survey 345 Middlefield Rd
D1 Pacific-Arctic Branch of Marine Geology U. S. Geological Survey	D2 Menlo Park, CA., 94025
E1 345 Middlefield Rd, Menlo Park, CA, 94025	E2

DATE	DAY		MONTH		YEAR	
A07 FROM	1	2	0	7	7	7
A17 TO	0	2	0	8	7	7

A03 GENERAL OCEAN AREAS: 55 (northern Bering Sea)

A09 TYPE(S) OF MARINE ZONE(S): 07 and 08

GEOGRAPHIC AREA
If all data were collected at a fixed station, fill in the co-ordinates

A10 LATITUDE ° ' '' N/S | A20 LONGITUDE ° ' '' E/W

A15 FEDERAL SUPPORT: BLM/NOAA/USGS

A25 REMARKS

DISCIPLINE AND TYPE OF MEASUREMENTS	Index 10° x 10° Qc	L	G	G	INDEX 1° x 1°	DISCIPLINE AND TYPE OF MEASUREMENTS	Index 10° x 10° Qc	L	G	G	INDEX 1° x 1°
A G02, G04, G08, G11 B	7	6	1	6		A B					
A G21, G23, G24, G25, G27, G28 B	7	6	1	6		A B					
A G29a, b, c, d B	7	6	1	6		A B					
A D01 B	7	6	1	6		A B					
A H10, H13, H33, H80 B	7	6	1	6		A B					
A B						A B					

G – GEOLOGY GEOPHYSICS

GL MEASUREMENTS MADE AT A SPECIFIC LOCATION	NUMBER	i	l	FORMAT
G01 Dredge				
G02 Grab	11	A1	A1	9,0
G03 Core rock *(no. of cores)*				
G04 Core–soft bottom *(no. of cores)*	39	A1	A1	8,9,0
G05 Sampling by divers				
G06 Sampling by submersible				
G07 Drilling				
G08 Bottom photography	42	A1	A1	8
G09 Sea floor temperature *(≤ 1 m from bottom)*				
G10 Accoustical properties of the sea floor				
G11 Engineering properties of the sea floor	16	A1	A1	0
G12 Magnetic properties of the sea floor				
G13 Gravimetric properties of the sea floor				
G14 Radioactivity measurements				
G70 Other measurements				
GU MEASUREMENTS UNDERWAY				
G21 Motion picture of sea floor *(No. of nautical miles)*	X	A1	A1	8
G22 Bathymetry-wide beam *(no. of nautical miles)*				
G23 Bathymetry-narrow beam *(no. of nautical miles)* 200KHZ	314	A1	A2	3
G24 Side scan sonor *(no. of nautical miles)*	864	A1	A2	3
G25 Seismic reflection *(no. of nautical miles)* 120 KJ	463	A1	A2	3
G26 Seismic refraction *(no. of nautical miles)*				
G27 Gravimetry	461	A1	A2	3,7
G28 Magnetism	853	A1	A2	7
G29 Other measurements				
Seismic reflection-Uniboom	1110	A1	A2	3
Seismic reflection-Minispark	38	A1	A2	3
Seismic reflection-3.5KHZ	1632	A1	A2	3

G – GEOLOGY GEOPHYSICS *(Continued)* GS TYPES OF STUDIES	NUMBER	i	l	FORMAT
G31 Physical analysis of sediments	50	A1	A1	0
G32 Chemical analysis of sediments	20	A1	A1	0
G33 Paleothermy				
G34 Paleomagnetism and rock magnetism	–		–	
G35 Paleontology	50	A1	A1	0
G36 Geothermy				
G37 Geochronology	10	A1	A1	0
G38 Mineral and fossil resources	80	A1	A1	0
G39 Litteral zone studies				
G90 Other measurements				

D – DYNAMICS

	NUMBER	i	l	FORMAT
D01 Current meters *(no. of stat.)*	38	A1	A1	0
D02 Current meters *(Average duration of measurement days)*				
D03 Currents measured from ship drift				
D04 GEK				
D05 Drifters *(number)*				
D06 Swallow floats *(number)*				
D07 Drift cards *(no. released)*				
D08 Bottom drifters *(no. released)*				
D09 Tidal observation *(duration)*				
D10 Sea and swell *(no. of observations)*				
D90 Other measurements				

M – METEOROLOGY

	NUMBER	i	l	FORMAT
M01 Upper air observations				
M02 Incident radiation				
M03 Air–sea interface studies				
M04 Ice observations				
M05 Occasional standard measurements				
M06 Systematic standard measurements				
M90 Other measurements				

H – HYDROGRAPHY

HS SURFACE	NUMBER	i	I	FORMAT
H01 Continuous temperature recording				
H02 Continuous salinity recording				
H03 Discrete temperature measurements				
H04 Discrete salinity measurements	30	A1	A1	0
NEAR SEA FLOOR (≤ 10 m)				
H05 Continuous temperature recording				
H06 Continuous salinity recording				
H07 Discrete temperature measurements				
H08 Discrete salinity measurements	30	A1	A1	0
HP PHYSICAL				
H09 Classical oceanographic stations				
H10 Vertical profiles (STD/CTD)	30	A1	A1	0
H11 Sub–surface measurements underway				
H12 Mechanical bathythermograph (No. of drops)				
H13 Bathythermograph–expendable (No. of drops)	13	A1	A1	3
H14 Sound velocity stations				
H15 Acoustic stations				
H16 Transparency				
H17 Optics				
H18 Diffusion (Dynamic)				
H80 Other measurements				
suspended sediment stations	31	A1	A1	0
HC CHEMICAL				
H21 Oxygen				
H22 Phosphates				
H23 Total–P				
H24 Nitrates				
H25 Nitrites				

HC CHEMICAL	NUMBER	i	I	FORMAT
H26 Silicates				
H27 Alkalinity				
H28 pH				
H29 Chlorinity				
H30 Trace elements				
H31 Radioactivity				
H32 Isotopes				
H33 Dissolved gases	50	A1	A1	0
H90 Other measurements				
heavy hydrocarbons	40	A1	A1	0
P – POLLUTION				
P01 Suspended solids				
P02 Heavy metals				
P03 Petroleum residues				
P04 Chlorinated hydrocarbons				
P05 Other dissolved substances				
P06 Thermal pollution				
P07 Waste water: BOD				
P08 Waste water: Nitrates				
P09 Waste water: Microbiology				
P10 Waste water: Other				
P11 Discolored water				
P12 Bottom deposits				
P13 Contaminated organisms				
P90 Other measurements				

B – BIOLOGY

	NUMBER	i	I	FORMAT		NUMBER	i	I	FORMAT
B01 Primary productivity					B31 Vitamin concentrations				
B02 Phytoplankton pigments					B32 Amino acid concentration				
B03 Seston					B33 Hydrocarbon concentrations				
B04 Particulate organic carbon					B34 Lipid concentrations				
B05 Particulate organic nitrogen					B35 ATP–ADP–AMP concentrations				
B06 Dissolved organic matter					B36 DNA–RNA concentrations				
B07 Bacterial and pelagic micro–organisms					B37 Taggings				
B08 Phytoplankton					B80 Other measurements				
B09 Zooplankton									
B10 Neuston					BS TYPES OF STUDIES				
B11 Nekton					B51 Identification				
B12 Invertebrate nekton					B52 Spatial and temporal distribution				
B13 Pelagic eggs and larvae					B53 Monitoring and surveillance				
B14 Pelagic fish					B54 Biomass determination				
B15 Amphibians					B55 Description of communities				
B16 Benthic bacteria and micro–organisms					B56 Food chains energy transfers				
B17 Phytobenthos					B57 Population and environments				
B18 Zoobenthos					B58 Population structures				
B19 Commercial demersal fish					B59 Taxonomy, systematics, classification				
B20 Commercial benthic molluscs					B60 Physiology				
B21 Commercial benthic crustacean					B61 Behaviour				
B22 Attached plants and algae					B62 Pathology, parasitology				
B23 Intertidal organisms					B63 Toxicology				
B24 Borers and foulers					B64 Gear research				
B25 Birds					B65 Exploratory fishing				
B26 Mammals and reptiles					B66 Commercial fishing				
B27 Deep scattering layers					B67 Aquaculture				
B28 Acoustical reflections on marine organisms					B90 Other measurements				
B29 Biologic sounds									
B30 Bioluminescence									

APPENDIX C

PRELIMINARY CRUISE REPORT
(NAVIGATION PENDING)

OF THE
BRANCH OF MARINE GEOLOGY
U.S. GEOLOGICAL SURVEY, MENLO PARK, CA

FOR

CRUISE - S5-77-BS-

GENERAL CRUISE INFORMATION

AREA: BERING SEA / NORTON SOUND, NORTHERN BERING

SHIP: R/V SEA SOUNDER

CHIEF SCIENTIST(S): C. HANS NELSON

TYPE OF DATA
COLLECTED: GEOPHYSICAL , GEOLOGICAL , HYDROGRAPHIC

CRUISE DATES:	LOCAL DATE/TIME*	TIME(JD/GMT)	PORT
START CRUISE:	12 JUL 2130 HRS	194/0830	LEAVE NOME AK, START CRUZ
END CRUISE:	2 AUG 0900 HRS	214/1715	AR DUTCH HARBOR ED CRUZ

PORT STOPS:

1.	ARRIVE:	16 JUL 630 HRS	197/1730	ARRIVE AT NOME, ALASKA
	LEAVE:	16 JUL 1235 HRS	197/2335	LEAVE NOME ALASKA
2.	ARRIVE:	20 JUL 19 0 HRS	202/ 6 0	ARRIVE AT NOME ALASKA
	LEAVE:	21 JUL 1112 HRS	202/2212	LEAVE NOME ALASKA

* EXPRESSED IN LOCAL STANDARD TIME.

	HOURS	DAYS & HOURS
TOTAL UNDERWAY TIME:	449	18 DAYS 17 HRS
TOTAL PORT TIME:	22	0 DAYS 22 HRS

PERSONNEL LIST

NAME	AFFIL	DUTIES	ABOARD	ASHORE
MCCLENAGHAN, ALAN		SHIP CAPTAIN		
SHEPPARD, HOWARD		CHIEF ENGINEER		
JOHANASSEN, ORNULF		CHIEF MATE		
NELSON, HANS	UGS	CHIEF SCIENTST	194/ 1 0	214/19 0
WIBERG, PAT	UGS	DAFE CURATOR	194/ 1 0	197/1730
LARSEN, MATT	UGA	DAFE CURATOR	197/18 0	214/19 0
THOR, DEVIN	UGS	GEOLOGIST	194/ 1 0	214/19 0
FIELD, MIKE	UGS	GEOLOGIST	194/ 1 0	197/1730
MASTERS, CHUCK-RESTON	UGS	GEOLOGIST	197/18 0	202/ 6 0
HOWARD, JIM -U.GEORGIA	UGA	GEOLOGIST	197/18 0	214/19 0
JOHNSON, JAN -SEATTLE	UWA	GEOPHYSICIST	194/ 1 0	214/19 0
WHITNEY, JOHN-ANCHORAGE	UGS	GEOPHYSICIST	194/ 1 0	202/ 6 0
HOLDEN, KEN -ANCHORAGE	UGS	GEOPHYSICIST	202/ 630	214/19 0
KVENVOLDEN, KEITH	UGS	GEOCHEMIST	197/18 0	202/ 6 0
RAPP, JOHN	UGS	GEOCHEMIST	197/18 0	202/ 6 0
SANDSTROM, MARK -UCLA	UCL	GEOCHEMIST	202/ 630	214/19 0
CACCHIONE, DAVE	UGS	OCEANOGRAPHER	194/ 1 0	197/1730
DRAKE, DAVE	UGS	OCEANOGRAPHER	194/ 1 0	197/1730
NICHOLSON, JIM	UGS	ELECTRONICS T	194/ 1 0	197/1730
SALADIN, JOHN	UGS	ELECTRONICS T	194/ 1 0	214/19 0
WILSON, BOB	UGS	MECHANICAL T	194/ 1 0	214/19 0
BRADY, ROLAND	UGS	MECHANICAL T	194/ 1 0	214/19 0
TOTMAN, CHUCK	UGS	WATCH STANDER	194/ 1 0	214/19 0
RICHMOND, BILL	UGS	WATCH STANDER	194/ 1 0	197/1730
BROKAW, RICK- U.GEORGIA	UGA	WATCH STANDER	197/18 0	214/19 0
WILLIAMS, RON	UGS	WATCH STANDER	202/ 630	214/19 0
PATRY, JEFF	UGS	WATCH STANDER	202/ 630	214/19 0
GIBBONS, HELEN	UGS	NAVIGATOR	194/ 1 0	214/19 0
GARLOW, RICH	UGS	NAVIGATOR	194/ 1 0	214/19 0
HIROZAWA, CAROL	UGS	NAVIGATOR	202/ 630	214/19 0
CLUKEY, ED	UGS	UNSP INVESTIGATR	194/ 1 0	202/ 6 0

EQUIPMENT SYSTEMS USED

NAVIGATIONAL	GEOPHYSICAL	GEOLOGICAL	HYDROGRAPHICAL
NAV SATELLITE	DIGITRACK	VIBRATING CORE	WATER BUCKET
LORAN C	UNIBOOM	BOX(SHIP) CORE	VAN DORN BOTTLE
MINIRANGER	MINISPARKER	GRAVITY CORE	TEMP/SALINOMETER
RADAR	SIDE SCAN SONAR	SOUTAR GRAB	EXP BATHY THERMO
	3.5KH BATHYMETRY	SEAFLOOR CAMERA	HYD CURRENT METR
	12KH BATHYMETRY	TELEVISION	CTD METER
	200KH BATHYMETRY		
	SHIPBOARD GRAVTY		
	SHIPBOARD MAGGY		

DATA COLLECTED

GEOPHYSICAL

DATA TYPE OR SYSTEM	RECORDING MEDIUM	TRACKLINE KILOMETRS	TRACKLINE N. MILES	RECORDING TIME(HRS)	ROLL/REEL LIST QTY
SNGL CHANL ARCER	ANL PAPER ROLL	858.4	463.5	92.7	2
UNIBOOM	ANL PAPER ROLL	2056.5	1110.4	222.1	29
MINISPARKER	ANL PAPER ROLL	70.3	38.0	7.6	1
SIDE SCAN SONAR	ANL PAPER ROLL	1600.0	863.9	172.8	59
3.5KH BATHYMETRY	ANL PAPER ROLL	3022.5	1632.0	326.4	26
12KH BATHYMETRY	ANL PAPER ROLL	2794.0	1508.6	301.7	26
200KH BATHYMETRY	ANL PAPER ROLL	582.1	314.3	62.9	18
MAG/BATHYM/NAVIG	DIGIT MAG TAPE	1580.4	853.3	170.7	2
	PRINTR LISTING	1907.9	1030.2	206.0	3
SHIPBOARD GRAVTY	DIGIT MAG TAPE	854.7	461.5	92.3	6
	PRINTR LISTING	904.7	488.5	97.7	2
	ANL PAPER ROLL	861.2	465.0	93.0	4

**NOTE: NAVIGATION PENDING, THEREFORE, TRACKLINE DISTANCES ARE BASED ON RECORDING TIMES MULTIPLIED BY AN ESTIMATED SHIP SPEED OF 5.0 NAUTS.

GEOLOGICAL/HYDROLOGICAL SAMPLES

SAMPLING DEVICE	SAMPLING ATTEMPTS	SAMPLES RECOVERED	NUMBER OF SAMPLES FROM A GIVEN WATER DEPTH INTERVAL: 0-100M	100-3000M	≥3000M
GRAVITY CORE	1	0	0	0	0
BOX(SHIP) CORE	32	29	29	0	0
VIBRATING CORE	18	10	10	0	0
SOUTAR GRAB	12	11	11	0	0
VAN DORN BOTTLE	31	31	31	0	0
WATER BUCKET	31	30	30	0	0
EXP BATHY THERMO	14	13	13	0	0
TOTALS	139	124	124	0	0

GEOLOGICAL/HYDROLOGICAL (ANALOG)

DATA TYPE OR SYSTEM	RECORDING MEDIUM	RECORDING TIME(HRS)	NUMBER OF TAPES, ROLLS, LISTS, ETC.
TELEVISION	ANLOG MAG TAPE	18.1	16
SEAFLOOR CAMERA	PHOTOGRAPH	18.6	6

TEMP/SALINOMETER	ANL PAPER ROLL	402.3

NUMERICAL OBSERVATION

DATA TYPE OR SYSTEM	NUMBER OF READINGS	TAKEN OVER HOW MANY STATIONS
PENETROMETER	16	12
HYD CURRENT METR	38	38
CTD METER	30	30

NAVIGATIONAL

DATA TYPE OR SYSTEM	RECORDING MEDIUM	NUMBER OF TAPES, ROLLS, LISTS, ETC.
MINIRANGER	PRINTR LISTING	5

OPERATIONS INFORMATION

STATION DATA   STATIONS OCCUPIED: 48,   TOTAL TIME ON STATION: 120.8 HRS.

TRACKLINES   TRACKLINES RUN: 80,   TOTAL TRACKLINE TIME: 313.7 HRS,

CUMULATIVE TRACKLINE DISTANCE: 2904.8 KM / 1568.5 N. MILES

**NOTE: NAVIGATION PENDING, THEREFORE, TRACKLINE DISTANCES ARE BASED ON RECORDING TIMES MULTIPLIED BY AN ESTIMATED SHIP SPEED OF 5.0 NAUTS.

QUARTERLY REPORT

Contract RK6-6074
Research Unit: 430
Reporting Period:
1 July 1977 -
30 Sept 1977

Bottom and Near-Bottom Sediment Dynamics in Norton Basin

David A. Cacchione
David E. Drake

Pacific-Arctic Branch of Marine Geology
U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

October 1, 1977

I. Task Objectives

A. Development of quantitative relationships between bottom velocity shear and induced sediment entrainment for specific sites in Norton Sound.

B. Estimation of near-bottom sediment flux at various locations in Norton Sound, with particular attention to the movements of Yukon River materials.

C. Comparison of bottom sediment movements during quiescent and stormy periods at specific sites in Norton Sound.

D. Monitoring of bottom currents and light scattering/transmission (within two meters of the sea floor) to enable prediction of sediment and pollutant flux vectors at future times.

E. Measurement of near-surface and near-bottom suspended sediment distribution in Norton Basin.

II. Field and Laboratory Activities

A. Schedule

1. dates: 7 July 1977 - 12 July 1977 (6 days)
2. vessel: R/V SEA SOUNDER
3. location: Norton Sound, Northern Bering Sea

B. Scientific party

1. D. Cacchione - USGS - Chief Scientist
2. D. Drake - USGS - Geologist
3. D. Thor - USGS - Geologist
4. E. Clukey - USGS - Soils Engineer
5. W. Richmond - USGS - Geologist
6. P. Wiberg - USGS - PST
7. G. Tate - USGS - PST
8. C. Totman - USGS - PST
9. R. Brady - USGS - MT
10. R. Wilson - USGS - MT
11. J. Johnson - Univ. of Washington - Geophysicist
12. H. Gibbons - USGS - PST
13. J. Nicholson - USGS - ET
14. J. Saladin - USGS - ET
15. R. Muench - NOAA - Physical Oceanographer
16. J. Haslett - NOAA - Oceanographer

C. Methods

1. Special instrumentation: 2 GEOPROBE tripod systems were deployed at 64°00.1'N, 165°30.0'W and 64°09.0'N, 163°21.0'W on July 8 and July 10, respectively. The GEOPROBE systems will operate for about 90 days; recovery is scheduled for mid-October, 1977 using R/V LEE. Measurements of bottom currents (4 levels), bottom pressure, bottom temperature (2), near-bottom

light transmission and scattering will be obtained hourly. Currents and pressure are also sampled in bursts of 60 samples, at a rate of one sample every second, taken each hour.

2. Three NOAA (PMEL) current meter moorings were deployed by NOAA investigators in cooperation with USGS scientists from R/V SEA SOUNDER. Two of these moorings were recovered by a NOAA vessel in August, 1977. The third was not recovered due to a malfunction in the acoustic release; it remains in Norton Sound.

Mooring Location	Water depth (m)	#current meters
1. 64°08.4'N, 163°15.2'W	23	2
2. 63°59.7'N, 165°29.4'W	17	2
3. 63°40.8'N, 162°59.5'W	12.5	1 (not recovered)

3. Twenty-seven (27) shipboard sampling stations were occupied in Norton Sound. At each station profiles of conductivity and temperature (C-T-D), light transmission, and horizontal current speed and direction were measured. Water samples were also collected and filtered to obtain suspended sediment samples.

4. Navigation: computer-integrated satellite and Loran C; mini-ranger.

D. Sample Locations - Figure 1 (attached).

Tracklines connect the stations marked in Figure 1.

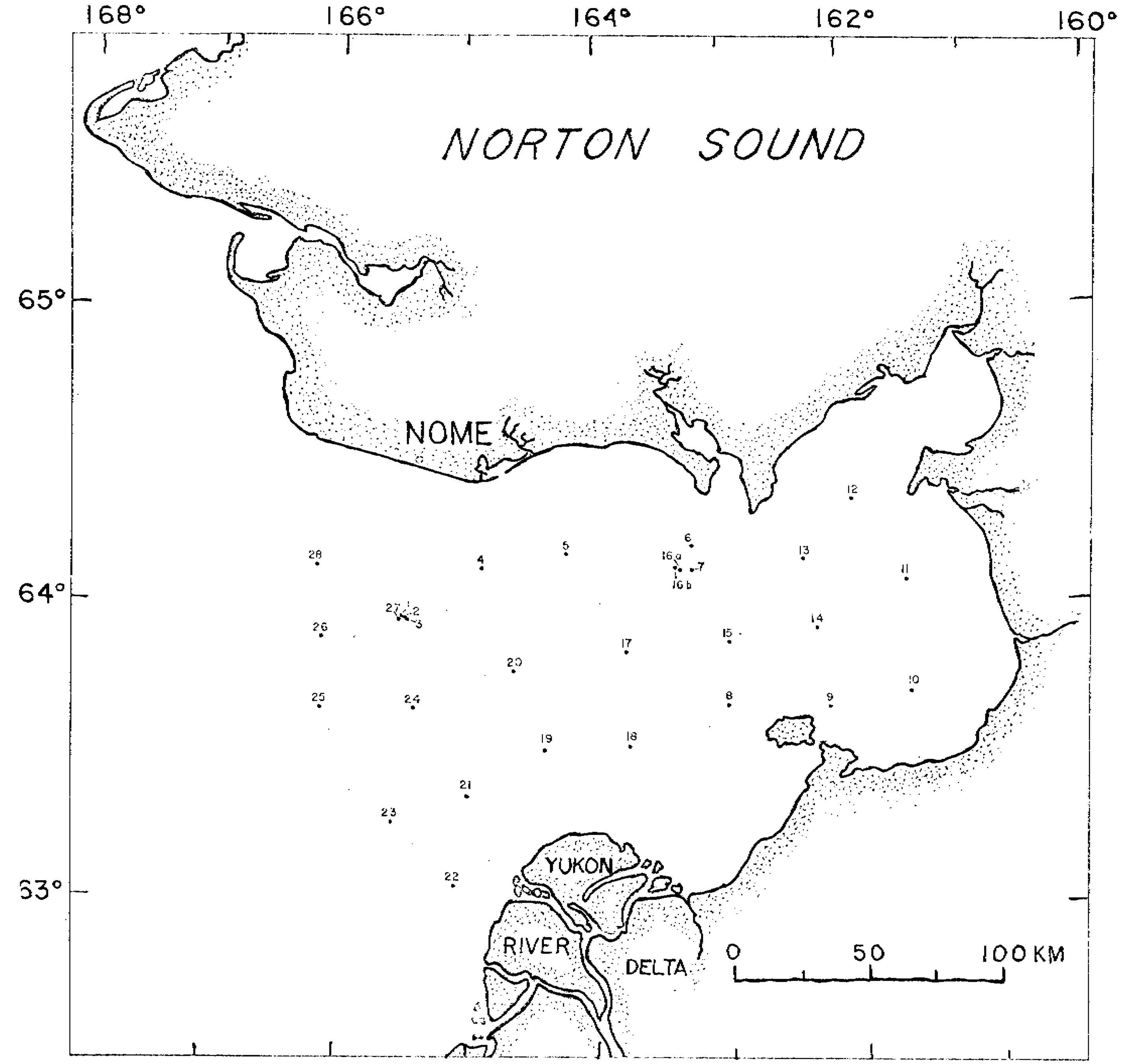
E. Data collected

1. geological:

Instrument	No. samples	No. stations
penetrometer	11	6
box corer	6	5

2. geophysical:

System	Tracklines (kilometer)
uniboom	39
3.5 kHz	582
12.0 kHz	573
side scan	38
gravimeter	772



168°
166°
164°
162°
160°
65°
64°
63°
NORTON SOUND
NOME
YUKON
RIVER
DELTA
0
50
100 KM

III. Results

Shipboard data are presently being analyzed, and a presentation of results would be premature now. The two GEOPROBE systems are not scheduled for recovery until October 1977. Charts showing the distribution of suspended sediment concentration in near-surface and near-bottom waters are nearly completed. Also, horizontal variability of light transmission, C-T-D, and horizontal currents will be presented in pictorial formats.

IV. Preliminary interpretation

The Yukon river sediment discharge is easily discernible in the raw data (filters and light transmission). The effects of the Yukon river input are also recognizable along the southern edge of the sound.

Bottom currents were generally low, between 5 cm/sec and 10 cm/sec, with lowest readings in the eastern section of the sound.

V. Problems encountered:

None. An excellent scientific cruise was accomplished during this quarter.

VI. Estimate of funds expended:

About $60,000 of project funds were expended during this quarter.

QUARTERLY REPORT

RESEARCH UNIT #: 431
REPORTING PERIOD: July 1, 1977 - September 1, 1977
NUMBER OF PAGES: 3

COASTAL PROCESSES AND MORPHOLOGY OF THE ALASKA BERING SEA COAST

PRINCIPLE INVESTIGATORS: Asbury H. Sallenger
John R. Dingler
Ralph Hunter

U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

I. Highlights

On September 13 the largest storm to affect coastal regions in the northeast Bering Sea in over two years occurred. Winds from the south gusted to over 64 km/HR and sea level rise was estimated to a greater than 1.5m (storm surge elevations will be provided once data is reduced). Wave heights were estimated to be greater than 2m and created a surf zone approximately 150m wide (surf zone widths in the area are commonly 1m or less under non-storm conditions). Twenty-four beach profiles in the Nome area were measured immediately following the storm and when compared to previous surveys, should yield the amount of coastal change.

II. Task Objectives

1. Measurement of coastal erosion from comparisons of vertical aerial photography taken before and after the November, 1974 storm in the Nome area.

2. Computer simulations of wave characteristics during the November, 1974 storm.

3. Remonitor the beach/nearshore profiles established between the Bering Strait and Yukon Delta at the beginning and end of the field season.

4. In situ measurement of wave characteristics in the Nome area.

5. Remonitor beach profiles established in the southern portion of the Bristol Bay coast of the Alaska Peninsula during 1976.

III. Field Trip Schedules

A. 1. Date: July 4-18

2. Scientific Party: A. Sallenger, J. Dingler, C. Peterson, D. Drucker, C. Fletcher

3. Activities:
   a. Remonitored beach/nearshore profiles established between Bering Strait and Yukon Delta in 1976.
   b. Set wave sensors in 20′ of water 2km west of Nome.

4. Sample Locations
   a. 24 beach/nearshore profiles in the Nome/Safty Lagoon areas.
   b. 8 beach/nearshore profiles in the Port Clarence Spit/Brevig Lagoon areas.
   c. 5 beach/nearshore profiles in the Unalakleet area.

5. Data Collected
   a. 41 beach/nearshore profiles; these will be compared to 1976 data.
   b. Wave data recorded every six hours until instrument failure on or about September 4.

B. 1. Dates: August 13-21

2. Scientific Party: A. Sallenger, D. Drucker, C. Fletcher, C. Morales.

3. Activities:
   a. Checked wave recorders in Nome.
   b. Remonitored beach/nearshore profiles in the Nome area.

4. Sample Locations
   a. 24 beach/nearshore profiles in the Nome area.

5. Data Collected
   a. 24 beach/nearshore profiles

C. 1. Dates: August 22-27 (aboard NOAA, UH1H helecopter)

2. Scientific Party: A. Sallenger, R. Hunter, D. Drucker, C. Fletcher.

3. Activities:
   a. Remonitored beach profiles in the southern portion of the Bristol Bay coast of Alaska Peninsula.
   b. Coastal morphological reconnaissance of Pavlov and Cold Bays.

4. Sample Locations
   a. 10 beach profiles between Unimak Island and Port Moller
   b. 14 beach profiles and sediment sample stations distributed around Cold Bay.
   c. 16 beach profile and sediment sample stations distributed around Pavlov Bay.

5. Data Collected
   a. Remonitored 10 profiles on the Bristol Bay side of the Alaska Peninsula.
   b. Established 14 stations in Cold Bay and 16 in Pavlov Bay where beach profiles were measured and sediment samples gathered.

D. 1. Dates: September 10-15

2. Scientific Party: A. Sallenger, J. Dingler, C. Peterson

3. Activities:
   a. Wave sensors failed on or about September 4; attempts were made to bring the instruments back on line, but with no success; wave instruments were removed.
   b A moderately large storm occurred on September 12; beach profiles in the Nome area were remonitored following the storm.

4. Sample Locations
   a. 24 beach profiles in the Nome area.

5. Data Collected:
   a. 24 beach profiles.

IV. Results

Data are presently being reduced.

V. Problems

Wave sensors failed approximately six weeks after recording began. Unfortunately, this occurred prior to the mid-September storm, which was the first high intensity event in the Nome area in two years. We have, however, data on coastal change and sea level rise during the storm.

VI. Estimate of Funds Expended

$80,000.

QUARTERLY REPORT

RESEARCH UNIT #: 473
REPORTING PERIOD: July 1, 1977 to September 1, 1977
NUMBER OF PAGES: 8

SHORELINE HISTORY OF CHUKCHI AND BEAUFORT SEAS AS AN AID TO PREDICTING OFFSHORE PERMAFROST CONDITIONS

Scientists: D. M. Hopkins
R. W. Hartz
R. E. Nelson
P. A. Smith

Research Unit #473: Quarterly Report, July-August-September, 1977

SHORELINE HISTORY OF CHUKCHI AND BEAUFORT SEAS AS AN AID TO PREDICTING OFFSHORE PERMAFROST CONDITIONS

I. Abstract of Highlights

During a six-week field season in late July and August, 1977, we established that the barrier islands of the Beaufort Sea originated from multiple sources and are mostly derived from hillocks of Pleistocene sediments that have been drowned and left as tundra-covered islands. Some of the source-hillocks have been completely removed by erosion, and these barrier islands are a residuum, slowly migrating westward and landward from original source areas that are now submerged. If the islands were quarried for gravel they would not be replaced by natural processes.

On the other hand, there are many areas on the mainland coast where gravel is now accumulating in spits and accretionary bars. Gravel can be removed from these sites with a minimum of adverse impact; these spits and accretionary bars would ultimately be rebuilt by the natural and continuing processes of coastal erosion.

Gravel is almost universally distributed at depths of 10 m or less in the subsurface of the Beaufort Sea coastal plain from the Kuparuk River to the Canning. It is not necessary to mine gravel beneath river bars and channels if mining in these sites has adverse environmental consequences. Pits can as well be developed in upland sites or, if preferred, by deepening existing thermokarst lakes. Gravel mining beneath the lakes would have the advantage that the gravel is probably unfrozen, and the abandoned pits could be used as year-round water reservoirs.

II. Task Objective: D-9

III. Field and Laboratory Activities

A.1. Field Activities

Reconnaissance of coastal bluffs, beaches, and barrier islands between Brownlow Point (near west edge of Arctic Wildlife Range) and Point Barrow and between Point Barrow and Skull Cliff during period July 15-September 3rd. Objectives were (1) to determine sources of gravel and directions of longshore transport with special attention to the problem of origin and renewability of the barrier islands; (2) to determine factors affecting ice content of sediment comprising coastal bluffs and in particular to determine rate of ice-wedge growth and thus the relationship between age of surface and ice content of soil and sediments; and (3) to collect data for determination of climatic (especially thermal) history of North Slope and continental shelf during the past 100,000 years.

III. Field and Laboratory Activities (Continued)

A.2. Laboratory Activities

Identify mollusks collected on beaches of Chukchi Sea and also fossil mollusks in Pleistocene sediments from exposures along Chukchi Sea coast.

Identify fossil microfaunas in sediments from exposures along Chukchi Sea coast.

Identify recent and fossil pollen floras from samples collected at various points along Beaufort Sea coast.

B. Scientific Party:

Field party: David M. Hopkins, Roger W. Hartz, Robert E. Nelson, and Peggy A. Smith.

Additional laboratory studies by Louie Marincovich (determination of mollusks), Kris McDougall (identification of fossil foraminifera), and Gifford Miller (Univ. Colorado) (amino-acid racemization studies).

C. Methods of Analysis

Study and sample natural and excavated sections of coastal bluffs and artificial gravel pits in order to establish sedimentological and climatic history of coastal part of North Slope.

Combine these studies with map analysis to establish paleogeography of ancient alluvial and outwash fans and barrier bars in order to identify major bodies of gravel.

Study size and configuration of ice wedges and content of other types of ground ice in coastal bluffs.

Sample modern pollen rain in order to facilitate interpretation of ancient pollen spectra.

Analyze fossil pollen, marine mollusks, and microfaunas, and undertake radiocarbon dating and amino-acid racemization studies in order to establish dating of various Pleistocene climatic events and to confirm correlation of important paleogeographic features.

Sample river bars, coastal bluffs, and modern beach in order to establish role of various sources of nourishment to individual beaches and barrier bars and to determine directions of sediment transport.

D. Sample Localities

About 200 data-collection sites were visited between Skull Cliff, Point Barrow, and Brownlow Point.

E. Data Collected or Analyzed.

1) Collected about 100 samples for lithologic pebble counts, mostly (ca. 90) from beaches, but including a few (ca. 5 each) from modern rivers and from exposures of gravelly Pleistocene sediments.

2) Collected samples for granulometric analyses from about 25 beach profiles.

3) Collected about 30 modern and 80 ancient pollen samples, about 50 radiocarbon samples, and about 20 samples of fossil mollusks for identification and possible amino-acid racemization studies.

4) Compiled map of limits of 1970 storm surge between Brownlow Point and mouth of Sagavanirktok River.

5) Incidental to above, set out traps to sample modern ground beetle fauna at about 6 localities (beetles were collected at the request of and will be submitted for identification to Dr. John V. Matthews, Geological Survey of Canada, Ottawa).

6) Also incidental to above, collected, recorded, and reported drifters and dye drogues released by various USGS and OCSEAP investigators during the summer of 1977 (see attached letter, Hopkins to Brian Matthews).

IV. and V. Results and Interpretation

A. Sources of Gravel Feeding Beaches and Barrier Bars

Rodeick (1975) has observed and we have confirmed that gravel from two sources of sharply contrasting lithology reaches the beaches and offshore islands of the Beaufort Sea. One suite, which we shall term the Brooks Range suite, consists predominantly of chert, graywacke, and quartz wacke; similar gravel is found on the river bars and in the alluvial and outwash fans of streams leading down to the coast from the Brooks Range. The other suite, which we shall term the Flaxman suite, is dominated by dolomite, but also includes red quartzite, red granite, pyroxenite, and diabase, none of which occur in the Brooks Range suite. The Flaxman suite occurs as ice-rafted pebbles in Pleistocene marine deposits exposed at many points along the Arctic coast and has been brought by ice bergs on more than one past occasion from sources in either northwestern Canada or Ellesmere Island. It is conceivable that ice-rafted pebbles of the Flaxman suite are still being brought to parts of the Alaskan coast of Beaufort Sea by present-day ice islands, although I do not think that this is the case.

IV. Results

A. (Continued) The presence of these contrasting pebble suites permits us to identify sources of gravel in individual beach and barrier island systems and to draw some preliminary conclusions on the limits of individual longshore transport cells. For example, the beaches and barrier islands extending from Brownlow Point to Reindeer Island are composed almost 100% of the Flaxman Suite: the barrier island chain extending from Stump Island to Thetis Island is composed of a mixture of the Flaxman and Brooks Range Suites; and the eastern beaches and islands near Cape Simpson are composed almost entirely of the Flaxman Suite, but the central and western Plover Islands are composed of mixtures of the Flaxman and Brooks Range Suites.

B. Sources of Gravel for Directions of Longshore Transport on, and Status of the Flaxman Island-Reindeer Island Barrier Chain

Analysis of our data is well advanced only for the beaches comprising the island chain extending from Brownlow Point through Flaxman Island to Reindeer Island (fig. 1). Pleistocene gravelly sediment comprises an area of about 50 square kilometers along the coast between the eastern and western outlets of the Canning River and an area of a few square kilometers on eastern Pingok Island (Qfx on fig. 1). We sought evidence as to (1) whether the island chain consists of material that has been carried westward by longshore drift from the recognized gravel sources at Brownlow Point and Pingok Island; (2) whether the western islands might represent a gravelly residuum derived from other former hillocks of Pleistocene sediments which have now been completely obliterated by wave erosion; or (3) whether the western islands may consist of material being dumped on the outer continental shelf by grounded and ablating ice islands during the present era.

Study of trends in direction of fining of sediments indicates that the individual island groups in the Flaxman-Reindeer chain (Flaxman Island and the Maclure, Stockton, McGuire, and Midway Islands) now constitute mutually isolated sediment systems. Historical studies as well as analysis of island forms, and observation of directions in which sediments fine show that the individual islands act as single, coherent sediment cells; i.e., sand and gravel migrate from one island to another only within island groups. Sand and gravel do not now move and have not recently moved across the wide, deep passes such as Mary Sachs Entrance and Newport Entrance. Furthermore, very coarse material is found on the beaches of eastern Flaxman Island, the western Stockton Islands and central Narwhal Island, while finer material is found on the intervening islands and on the islands to the westward. This indicates that the material comprising the Flaxman-Reindeer Island chain has been derived from multiple sources. The deep passes are ancient features which have long served to isolate the island groups from one another.

IV. Results

B. (Continued) This indicates that the western islands did not originate by longshore migration of material from Flaxman Island and Brownlow Point.

The coarse material adjoining fresh exposures of Pleistocene sediment on Flaxman Island includes many glacially striated boulders, indicating that the material in the adjoining bluffs is ancient glaciomarine sediment. However, these glacial boulders on the modern beach are soon broken down to sharp-edged fragments by present-day frost splitting; after they are reduced to smaller sizes, they become rounded by wave erosion. The coarse material on the beaches of Pole, Narwhal, and Cross Island is angular, and no faceted, glacially striated clasts could be found. This argues against their recent derivation from grounded ice islands and suggests that, instead, the boulders and finer gravel represent a residuum derived from wave erosion of hillocks of Pleistocene gravel which have now completely disappeared.

The offshore islands are migrating rapidly westward and landward (Wiseman and others, 1973; Barnes and others, 1977; Lewellen, 1977; Reimnitz and others, 1977). Thus the original Pleistocene hillocks probably lay somewhere seaward and eastward from the present islands that represent their residuum.

The deep pass between Brownlow Point and Flaxman Island can be shown to represent the drowned valley of the western mouth of the Canning River. Other wide and deep passes may also have originated as wide river valleys which became drowned during the Holocene rise in sea level. The rapid westward migration of individual islands and island groups may have displaced the passes some distance westward from the positions they occupied when they were river mouths.

The practical implication of these conclusions is that the offshore islands of the Flaxman-Reindeer chain (and probably other offshore islands, too) are <u>not</u> a renewable resource. If they should be quarried for gravel, they will not be replenished with gravel by longshore transport; instead, the islands will simply become smaller and more fragmentary. Gravel mining will hasten their disappearance and reduce the shelter that they presently offer to the lagoons and the mainland coast.

C. Potential of Mainland Beaches as Sources of Gravel--Brownlow Point to Prudhoe Bay

The mainland coast between Brownlow Point and Prudhoe Bay (fig. 1) consists of a series of small, more or less mutually independent longshore transport cells ranging from one to fifteen km in length. Each cell includes one or more sources of gravel and a down-drift sediment sink.

IV. Results

C. (Continued) Each cell thus consists of an updrift reach fronted by an erosional bluff with little or no associated beach material, a central reach in which sand and gravel gradually thickens in a down-drift direction, reaching widths of a few tens of meters and thicknesses of a few meters, and a terminal section in which sand and gravel is accumulating in a set of accretionary beach ridges or a recurved spit.

Very little gravel is available at the heads of these systems. Some gravel is available in the intermediate portions, but gravel mining in these places would cause rapid and unacceptably accelerated shoreline erosion. The sediment sinks that mark the termini of the systems, however, contain substantial amounts of sand and gravel that could be removed with little or no impact on adjoining shores and with very little environmental damage. These small mainland gravel spits and points are probably among the least damaging sources of sand and gravel along the Beaufort Sea coast.

D. Sources of Gravel on the coastal lowlands between the Arctic Wildlife Range and the Kuparuk River

All of the gently sloping region extending northward from the Brooks Range to the Beaufort Sea coast between the Canning and Kuparuk Rivers appears to be underlain at depths no greater than the 10 meters by sand and gravel. Sand and gravel is presently being mined only beneath stream channels in, for example, the Sagavanirktok, Putulagayut, and Kuparuk Rivers, to the detriment, apparently, of anadromous and freshwater fish populations.

The gravel pits along the Put River extend far below the channel gravel associated with that river and into gravel that is part of a sheet of similar material extending for many tens of kilometers eastward, westward, and seaward. The same may be true for the deepest gravel mined beneath the Sagavanirktok and Kuparuk Rivers. Thawed gravel of this same quality could be obtained by deepening local thaw lakes, and frozen gravel could be obtained from upland sites. If gravel pits beneath the rivers are seriously detrimental to fish populations, serious consideration should be given to the alternative of developing gravel pits away from the streams, with gravel pits beneath lakes perhaps being the best alternative sites.

VI. Problems encountered and recommended changes: None.

VII. Estimate of funds expended to date: All.

VIII. Bibliography

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Appendix I

UNITED STATES
DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY
Branch of Alaskan Geology
345 Middlefield Road
Menlo Park, California 94025

September 26, 1977

Dr. Brian Matthews
Institute of Marine Sciences
University of Alaska
Fairbanks, AK 99701

Dear Brian:

In the course of our fieldwork, we found a number of University of Alaska yellow parasol-drifters evidently released by you. All of these were found during the period 8/17/77-8/28/77. I assume that it is useful for you to know locations and numbers, and so they are shown on the enclosed copy of the Harrison Bay 1:250,000 Quadrangle.

The heavy blue lines following the coast delineate stretches of the shoreline that we walked during this period. Perhaps as important as our observations of drifters is the fact that we saw no drifters within Kogru River nor on the coast north and west of Garry Creek. Also, we saw none on the eastern Eskimo Island.

Drifters 980 and 1,000 were found on the "mainland" shore of the little spit-enclosed lagoon at the east end of Saktuina or west Eskimo Island. This must indicate that a high water had been high enough to carry the drifters over the spits that enclose the lagoon.

At Saktuina Point, we also found a weathered orange UA drift card, number illegible. Also, as noted on the enclosed map, we found orange torpedo-shaped, dye-containing drogue floats with whip antennae on Saktuina Point and on the north bank of the Garry River estuary and a red-and-white drogue float, similar in other respects, on the north shore of Saktuina Island. I have a feeling that these may have been floats that Roy Hahn was tracking around August 10th, but inform you in case they're yours.

Did you know that Larry Toimil (USGS) released a bunch of parasol-drifters near the mouth of the Colville, earlier in the summer? We found a few of his drifters, too.

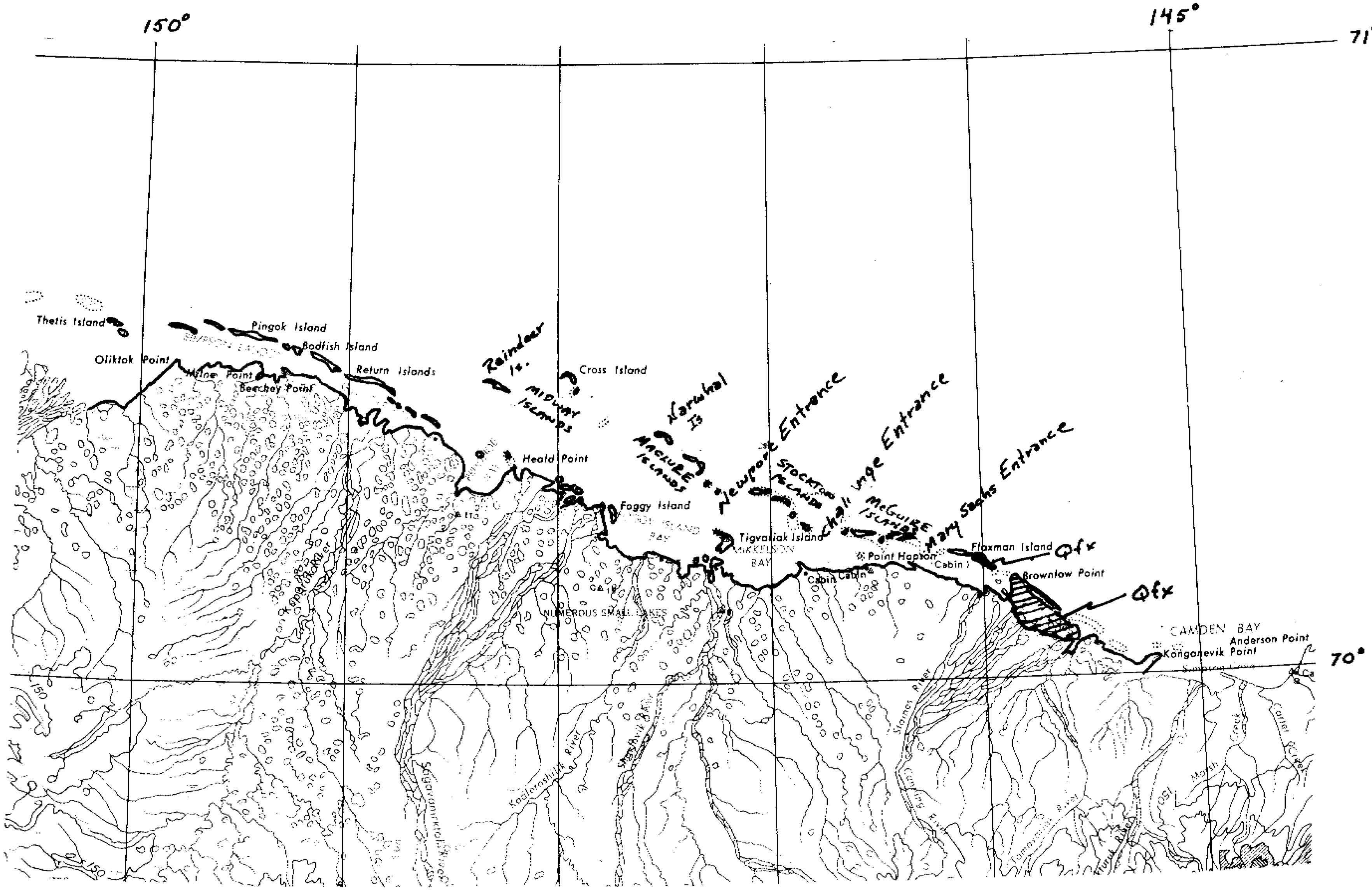
Best regards,

David M. Hopkins

Enclosure

cc: Dr. Roy Hahn

Figure 1. Coast of Beaufort Sea between Colville and Canning Rivers showing places discussed in text. Cross-hatched areas (Qfx) near Canning River and on Flaxman Island are exposures of Flaxman Formation which supply boulders and gravel to nearby beaches. Other exposures of Flaxman Formation are present along the mainland coast but are not shown on this map.



Quarterly Report

Contract # 03-05-022-55
Research Unit # 483
Task Order # 12
Reporting Period: 7/1/77 - 9/30/77
Number of Pages: 3

EVALUATION OF EARTHQUAKE ACTIVITY AROUND NORTON AND KOTZEBUE SOUNDS

N. N. Biswas and L. Gedney
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

October 1, 1977

OCS COORDINATION OFFICE

University of Alaska

Quarterly Report for Quarter Ending September 30, 1977

Project Title: Evaluation of Earthquake Activity Around Norton and Kotzebue Sounds.

Contract Number: 03-05-022-55

Task Order Number: 12

Principal Investigators: N. N. Biswas and L. Gedney

I. Task Objectives:

1. Service all field sites of the seismographic network.

2. Recalibrate the stations to obtain the system response.

3. Add two horizontal components (north-south and east-west) to the operational single component (vertical) station at Kotzebue.

4. Install the remaining station of the network at Savoonga on Saint Lawrence Island.

II. Field and Laboratory Activities:

A. In order to improve the capability to studying icequakes, the operational vertical component seismographic station at Kotzebue was converted to a 3-component (vertical, north-south and east-west) station. The seismographs and associated electronics used for the two horizontal components are identical to the vertical component system.

B. Due to the non-availability of microwave data telemetry link, the seismographic station on St. Lawrence Island could not be installed during the 1976 field season. During the present field season this has been achieved and a vertical component station has been installed at Savoonga on St. Lawrence Island. The addition of this station considerably improved the seismic coverage, particularly, for the Norton Sound.

C. The only remotely operated station (REM) of the network was relocated at a site closer to the coast on Devil Mt., to improve the signal-to-noise ratio. The data from this station is telemetered by VHF to Kotzebue as was done from the earlier site.

D. All stations of the network were recalibrated to check whether or not any changes introduced to system response by the field parties.

E. Microwave telemetry of the data to the central recording site at Fairbanks is continued to maintain without any difficulty.

F. The daily data (160 ft.) in form of 16mm film recorded during the contract period have been scaled and punched on cards for processing on computer. For a visual representation of the epicenters of the earthquakes on a Marcater projection of the study area, continued improvement of the computer plot program was carried out.

II. Results: None

IV. Preliminary Interpretation: None

V. Problems Encountered: None

VI. Estimate of Funds Expended: $67,153.

QUARTERLY REPORT

A GEOGRAPHIC BASED INFORMATION MANAGEMENT SYSTEM FOR PERMAFROST IN THE BEAUFORT AND CHUKCHI SEAS.

Michael Vigdorchik

Institute of Arctic and Alpine Research
University of Colorado
Boulder, Colorado 80309

July - September 1977

Prepared for:

U. S. Department of Commerce
National Oceanic and Atmospheric Administration
Environmental Research Laboratories
Outer Continental Shelf Environmental Assessment Program
Research Unit Number: 516
Contract Number: 3-7-022-35127

CONTENT OF QUARTERLY REPORT

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* Chapters included in Annual Report (October 1976 - April 1977)

** Chapter included in Quarterly Report (April - June 1977)

*** Chapter included in Quaterly Report (July - September 1977)

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* Chapters included in Annual Report

*** Chapters included in this Quarterly Report

I. Task Objectives

The content of this Quaterly Report includes two independent parts according to the two principal objectives of the work.

The first principal objective is to develop a computerized system which will aid in predicting the distribution and characteristics of offshore permafrost. The approach to solving this problem involves the gathering and study of all the source data about direct and indirect indicators of permafrost in the given area (depth, temperature and salinity of water, topography, bottom deposits, ice conditions, etc.)

The second objective is to undertake a comprehensive review and analysis of past and current Soviet literature on subsea permafrost and related natural processes. The available materials related to problems of the submarine permafrost origin and development such as Quaternary Arctic history, especially Quaternary transgressions and regressions in Eurasiatic arctic shelf are under consideration.

II. Summary of Results

According to the first objective connected with the data management system, we continued to compile the source data maps of the bottom topography, salinity and temperature of the sea water in the maximal sampling depth for the Beaufort Sea (70°-71° 30' north latitude and 142°-160° east longitude). The distribution of the data we use is shown on Fig. 1 and Table 1. According to the milestone chart, these source data maps for both Beaufort and Chukchi Seas will be submitted in the Fourth Quarter of 1977.

FIG. I DATA DISTRIBUTION MAP: BEAUFORT SEA

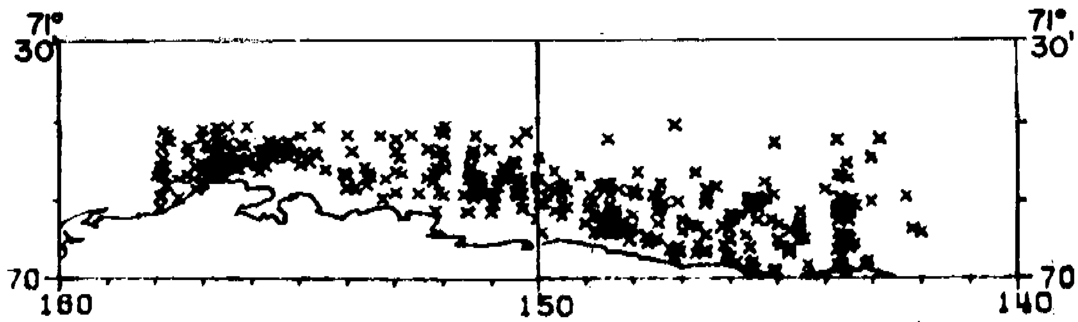


TABLE I DISTRIBUTION BY MONTH

MONTH	NUMBER	SAMPLING DEPTH M	BOTTOM M	TEMP. C°	SALINITY ‰
1	2	2	1	2	2
2	1	1	1	1	1
3	1	1	1	1	1
4	—	—	—	—	—
5	3	3	—	3	2
6	—	—	—	—	—
7	28	28	18	18	17
8	358	358	351	355	352
9	85	85	81	83	84
10	13	13	13	8	12
11	1	1	1	1	1
12	2	2	2	2	2
TOTALS	491	491	469	472	472

Submarine Permafrost on Arctic

Shelf of Eurasia

(Continuation)

The structure of the "analysis" content was reconsidered partly in the process of the materials collection and re-evaluation. We have decided to single out the section "Thermal Regime and genesis" (No. 4 of Chapter C) in the original Chapter (H) and to place it after the chapters connected with history of the permafrost development, its hydrological, physical and chemical peculiarities (D-G).

D. History of Development. Paleogeographical Conditions (changing of the ocean level; regressions and transgressions; Pleistocene and recent tectonics ; paleoclimatic data).

An important and urgent scientific problem is if the Quaternary emergence-submergence history was the same for the Arctic Ocean as for the World Ocean, or during some stages the Arctic Ocean developed separately. This question could seem to be strange for the geologists accustomed to considering the Arctic Ocean as a constant (in Pleistocene) and "unseparable" part of the World Ocean. But during the last decade or two most of the Soviet geologists studying Pleistocene deposts in Northern Eurasia (including primarily western and northern Siberia and the northeastern part of Europe) believe it proved these deposits were formed mainly by repeated marine transgressions which were simultaneous to major glaciation stages in northern Europe and America. These scientists so called "marinists" are represented by the people of the All-Union Scientific Oil Research Institute in Leningrad, Scientific Research Institute of the Arctic Geology also in Leningrad, USSR Geologic Survey, Moscow University (Geographical Department), and some other institutes. The most well known works connected with "marinistic" conception are written by: G. Lazukov (202-205), A. Popov (270-273), I. Kusin (193-194), I. Zagorskaya (397-398),

O. Suzdalsky (327-332), V. Zubakov (408-410), and many others. Their opponents or "glaciologists" are represented mostly by the scientists of the Novosibisk branch of the Academie of Sciences of USSR: S. Troitskyi (358-359), S. Strelkov (322-325), V. Saks (291-292), and partly by S. Archipov (19-21).

Some of the "marinists" or "antiglacialists" following the extreme point of view exlude the role of the glaciations in the development of the Siberian plains and consider only the marine and glacial marine activity. Some of the "glaciologists" exclude the role of the "cold" marine transgressions. The critical analysis of the "marinistic" conceptions was published in 1975 by S. Troytskyi (359). The author himself summarizes the ideas and assumptions of his book the following way:

> "The book Modern Anti-Glacialism, Critical Essay is concerned with the first in the Russian geological works critical analysis of the modern antiglacialism conception, i.e. the scientific trend that contradicts the theory of Quaternary glaciation of the plains in the moderate and subarctic belts. The author consistently examines general ideas, assumptions, and data of antiglacialists. He reveals the internal contradictions in their conceptions and comes to the conclusion about a very great significance of the sheet glaciers for lithogenesis and morphogenesis on the North Siberian plains."

Sometimes the discussion about the role of the glaciations and marine transgressions in the development of northern Eurasia during the Pleistocene was very sharp. But the results of these discussions are the new data and new ideas connected with basic problem of the Arctic Basin geological history that time.

We have tried to summarize the data and ideas of the World Ocean level changes during the Pleistocene and also data and assumptions of the Arctic Ocean level changes during that time. As a result of this work we made a conclusion that it is possible to get agreement between "marinistic" and "glaciologistic" conceptions of course if we do not follow the extreme ones.

D.1. Summary of the data and ideas of the World Ocean level changes during the Pleistocene.

Figure 30 provides a summary of the World Ocean level changes during the Pleistocene of cause as is typical for Russian literature (376). If the Russian geologists made a considerable input in the knowledge of the Arctic Ocean history, using their own data, the basic assumptions on the World Ocean development in Pleistocene were made by them according to the data gathered by western scientists. Usually, studying the glacial period, we are primarily concerned with glacio-eustasy, realizing, however, that glacio-eustatic changes of sea level may have been superimposed on a speculative long-term fall in sea level that commenced in the Tertiary and earlier (Fig. 31). In the "western" geological literature J.T. Andrews (1975), for instance, noted that part of the fall in sea level was probably related to the glacierization of Antarctica, Greenland, and other parts of the world in the period of the early to mid-Teriary; but this glacierization can account for only a sea-level drop of about 80 m. From our point of view the main trend in lowering of the ocean level is connected with regular periods of the earth extention (according to P. Dirak theory). Anyway, the glaciation of Antarctica commenced long before the Pleistocene perhaps even in the early Teriary. Mercer (1968) suggests that the East Antarctic ice sheet developed first, followed by Greenland, and finally by the West Antarctic. Depending on which value one accepts for the volume of the existing ice sheets, the glacio-eustatic sea level lowering led to a 100-m drop in ocean level; partial mitigation of this drop resulted from

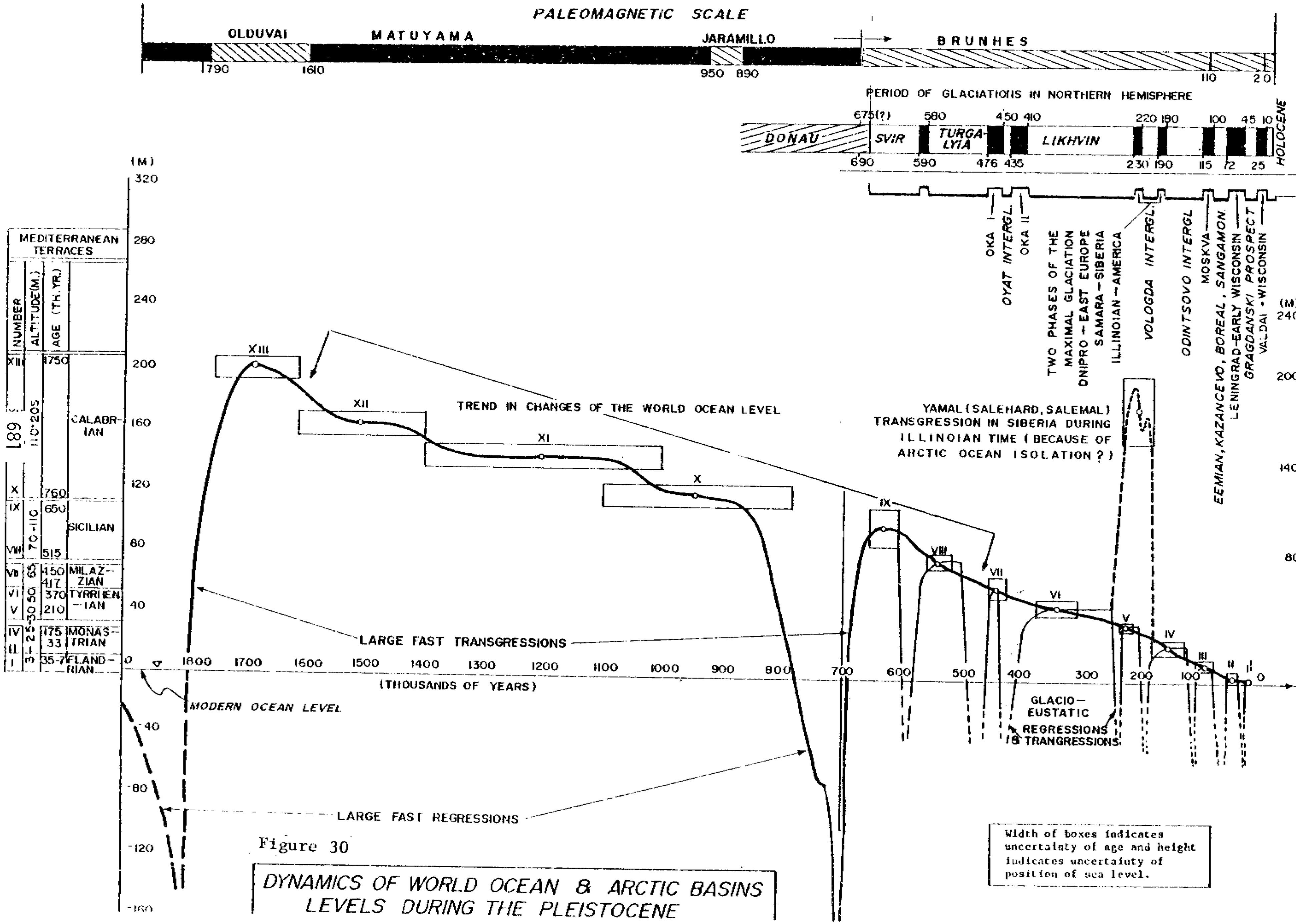


Figure 30

DYNAMICS OF WORLD OCEAN & ARCTIC BASINS LEVELS DURING THE PLEISTOCENE

FIGURE 30a

SCHEME FOR THREE GENERATIONS OF VOLGA RIVER VALLEYS (CENTRAL VOLGA BASIN – EAST EUROPE) BURRIED BY DEPOSITS OF UPPER PLIOCENE AND PLEISTOCENE, AFTER OBIDIENTOVA 1971.

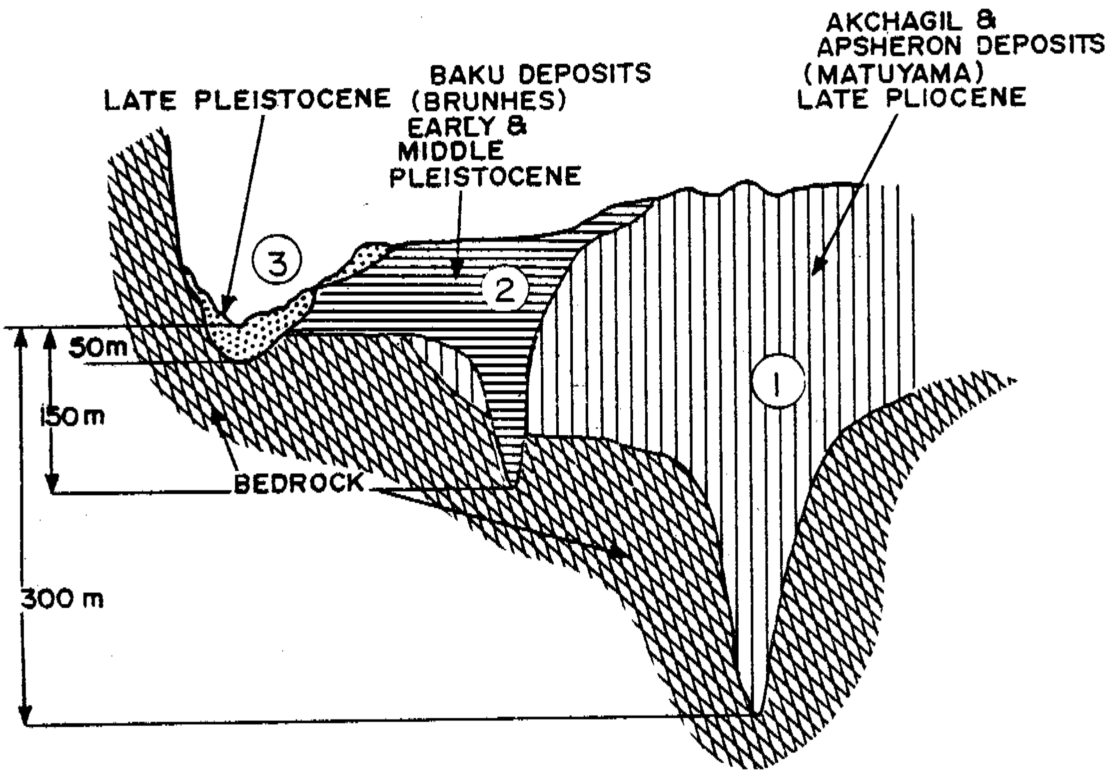
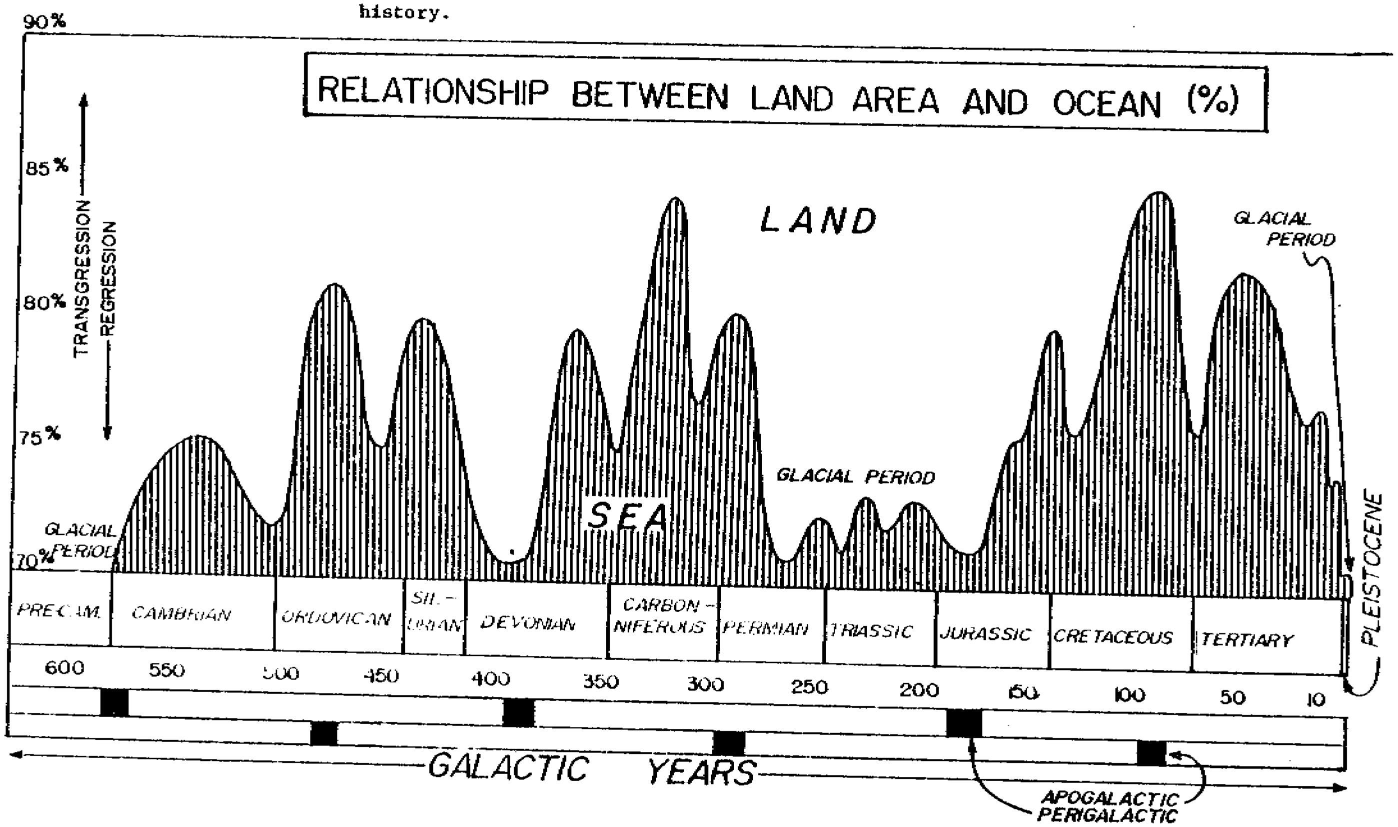


Figure 31 Regressions and transgression of the World Ocean in the Earth history.



isostatic compensation of the ocean basins, yielding a net reduction of about 70 m. The most significant drop of the ocean levels took place about 700,00 years ago (Matuyama-Brunhes boundary). The evidence of this event is the numerous ancient valleys especially in coastal and shelf zones of the ocean; the bottom of these valleys reach minus 150-300 m. They have typical canyon forms and are usually buried by the Pleistocene deposits (Fig. 32). The pictures of the network of these canyons are shown on Figs. 33-35. We see that all these data give evidence of the ocean level drop with a magnitude of about 250-300 m at the time of Matuyama-Brunhes boundary.

Pleistocene sea level oscillaltions are best preserved along coasts that are slowly rising, thereby carrying earlier sea levels and associated deposits beyond the reach of later wave action. The classical sequence of supposed glacio-eustatic terraces is that described by Deperét (1918) from the shores of the Mediterranean Basin and for the Russian geologists, it is typical to use his scheme. The terraces were considered to represent world-wide former sea levels and the general fall of sea level was explained by the progressive enlargement of the ocean basins. There were also many attempts to fit observed sea-level changes into the classical European and North American four-stage glacial/interglacial sequence (Table 12). Recent work now shows evidence that few coasts and land areas are stable and in part because evidence from ocean cores indicates that the Quaternary has been characterized by at least eight temperature oscillations compared with the Wisconsin glacial maximum (Fig. 36, Andrews, 1975).

Some guide as to whether a former sea level terrace represents simply a high eustatic sea level or a tectonic uplift can be derived from the knowledge that much of the Antarctic ice sheet has remained quasi-stable during the Quaternary, with the possible exception of the West Antarctic ice sheet

That is grounded below sea level; if that portion of the ice sheet melted, sea levels would rise about 5 m. Emiliani argues that world sea level may rise to a maximum more than once during each interglacial age in response to the melting of the Greenland ice sheet during general interglacial conditions when the northern summer solstice occurs at perihelion. If this argument is correct, sea level would rise by an additional 7 to 10 m. Thus, any marine terrace over 15m a.s.l. (the combined sea level storage of water in Greenland and West Antarctica) undoudtedly reflects uplift of the coast. Another possible explanation for former high sea levels of 10 to 17 m above present is suggested by Hollin (1976) who calculated that a surge of the Antarctic ice sheet would raise sea level by that amount. Sea level records older than 200,000 years BP exist at numerous sites including Alaska (Hopkins, 1968, 1973). Of course the absolute dating is very difficult. The knowledge of marine changes in the interval between 250,000 and 45,000 year BP in Soviet Union recently increased owing to the development of the uranium-series methods of dating marine carbonates and thermoluminescent method of dating the mineral deposits.

Summerizing the data J. Andrews (1975) notes that the evidence for glacio-eustatic low sea levels during the Pleistocene (Grunhes time) is off New England, where five submerged shorelines have been described between 23 and 144 m lower than present. Oolitic beach ridges at 70 to 90 m lower than present were formed off eastern Florida during the Holocene gransgression. The maximum amount of glacio-eustatic sea level lowering during the Pleistocene is not known. Estimates range from 100 to 159 m below present, the latter on the basis of estimated ice volume during the Illinoian glaciation. Calculated ice volumes are usually maximum estimates of sea level lowering because of the isostatic compensation

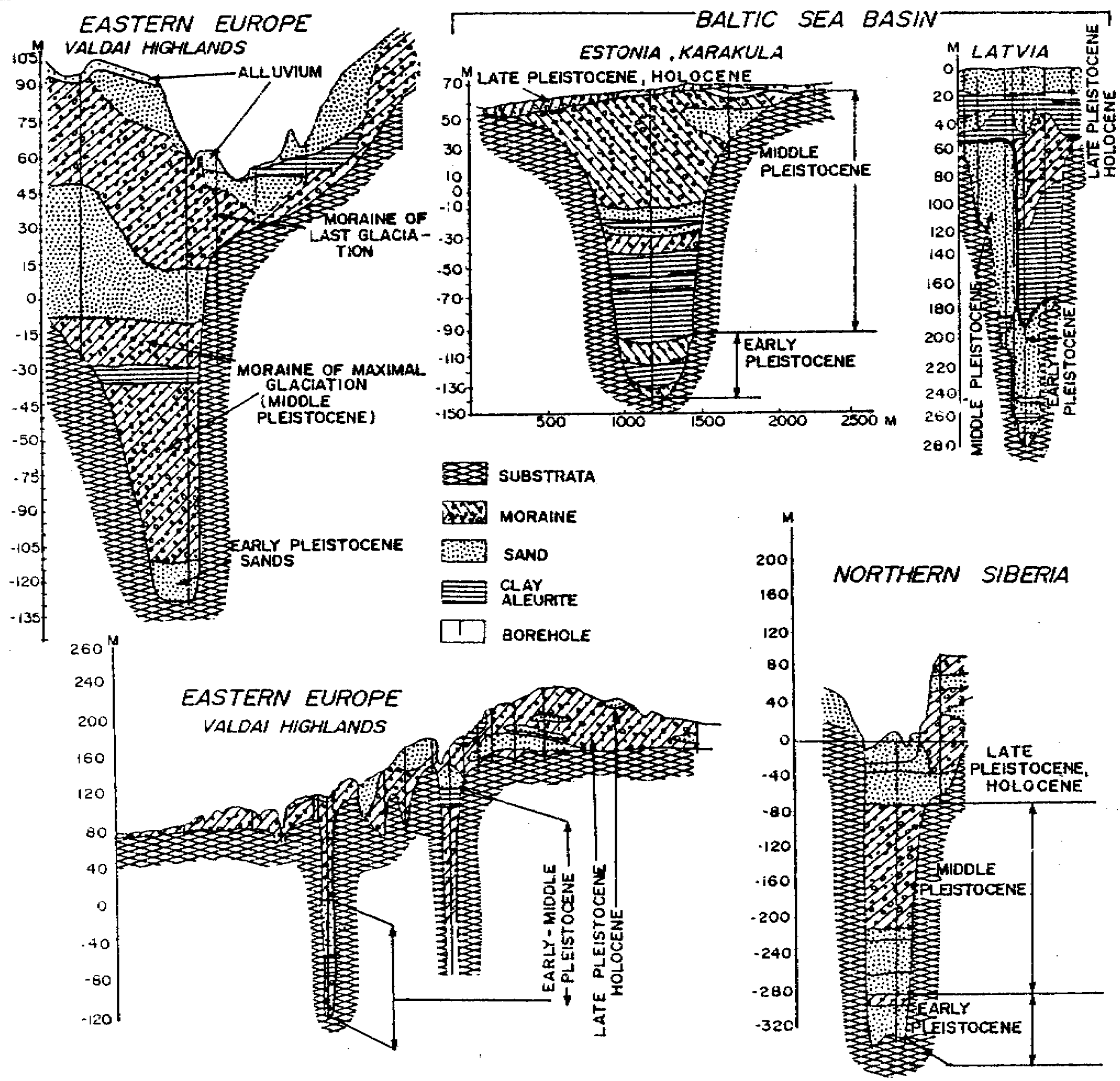
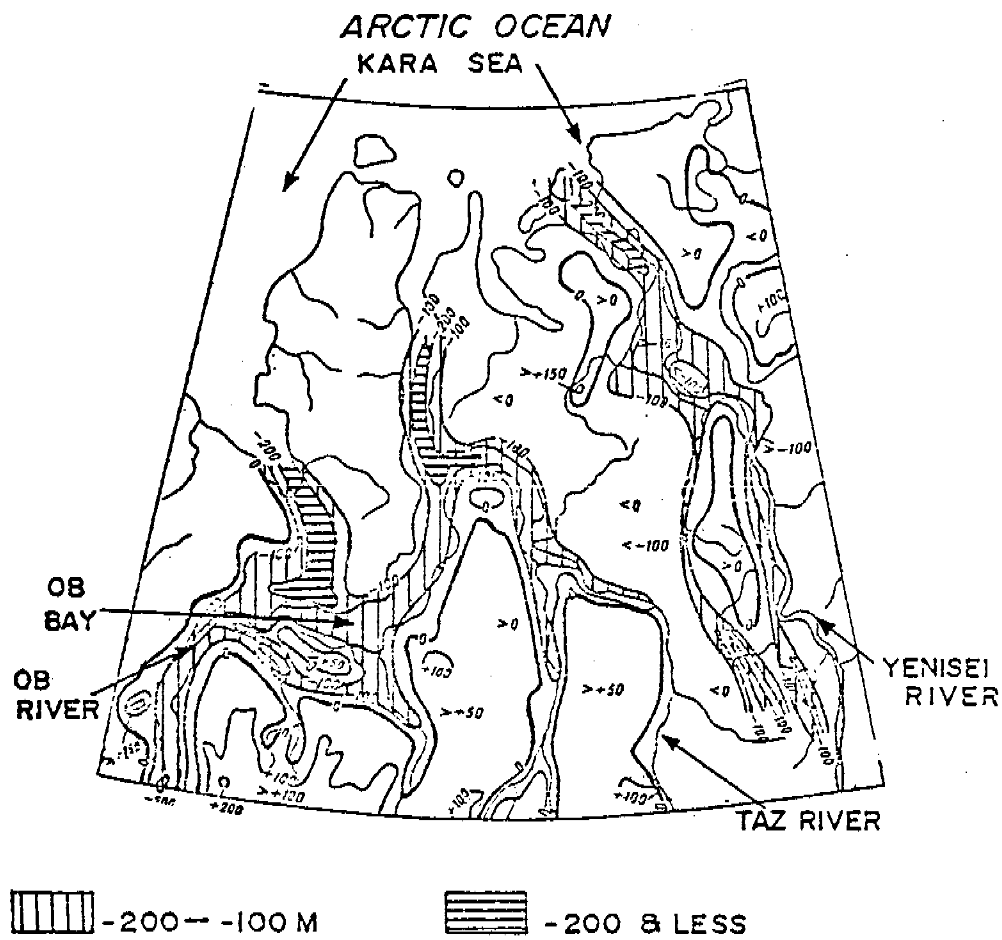
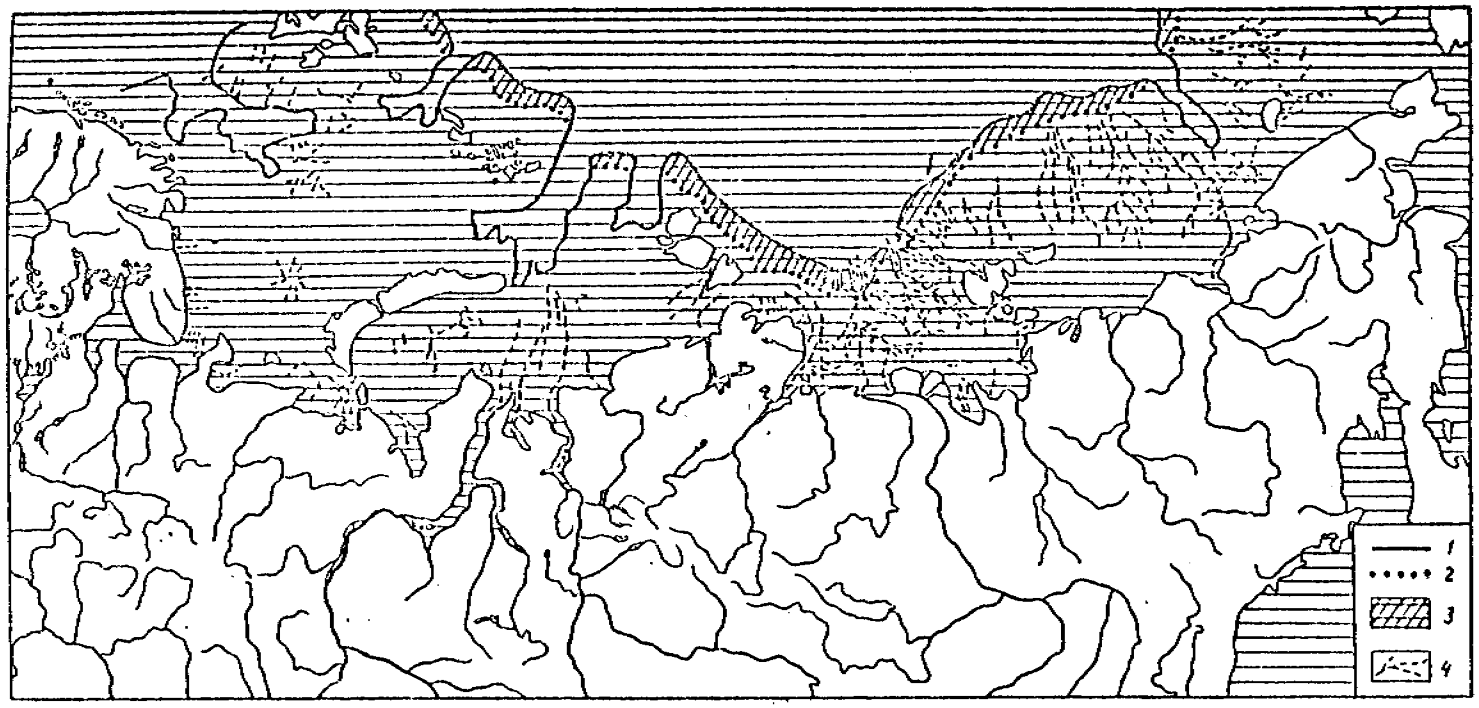


Figure 32
The ancient canyons buried by Early, Middle and Late Pleistocene deposits in Northern Eurasia.

Figure 33 The map of the ancient valleys (cretaceous and paleogen rocks roof) in western Siberia according to Suzdulski (1972).





1. BOUNDARY OF THE CONTINENTAL SLOPE 2. BOUNDARY OF THE SHELF 3. CONTINENTAL SLOPE
4. SUBMARINE CANYONS

Figure 34 The network of the ancient submarine canyons on the Arctic Shelf according to Lindberg (1970).

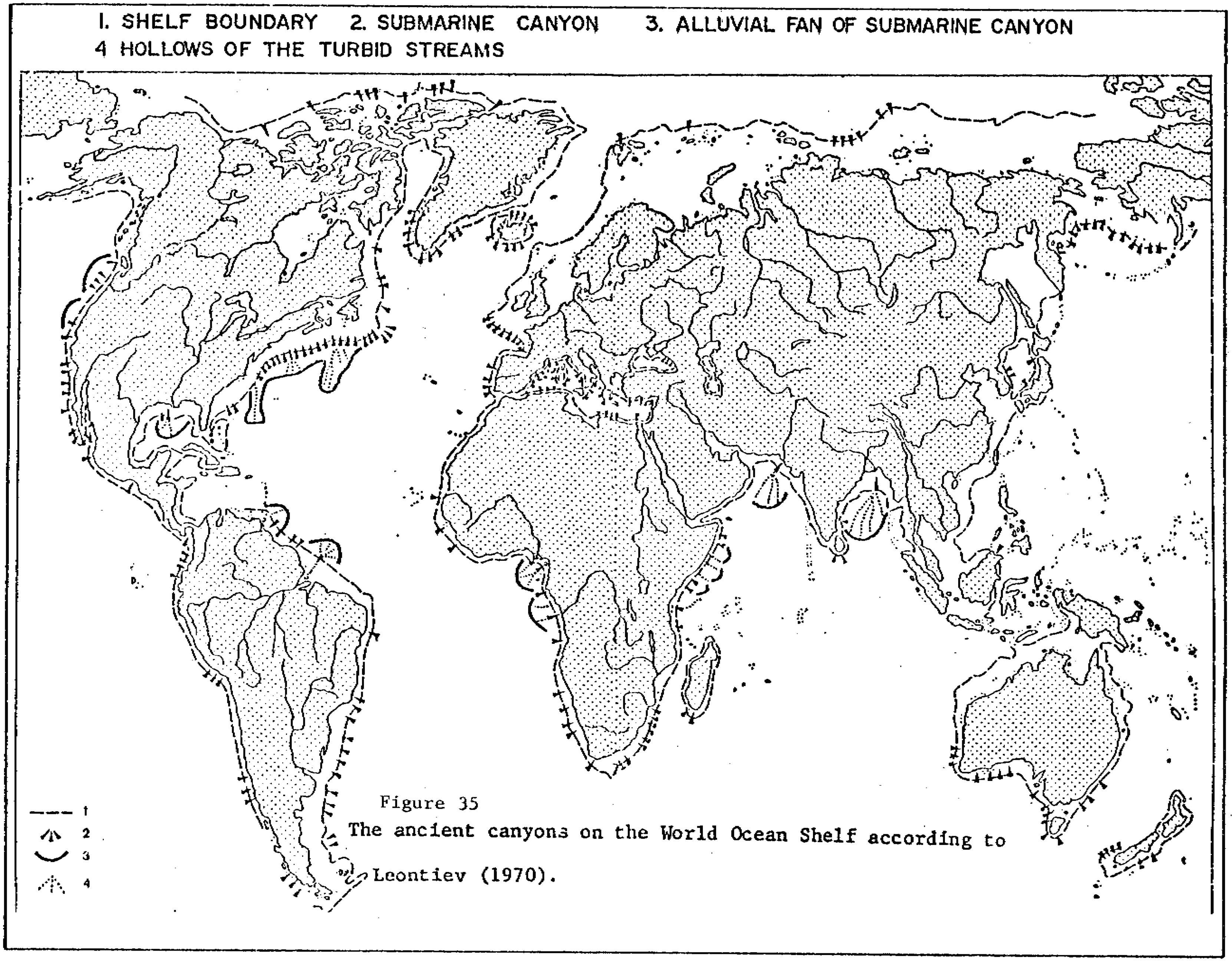


Figure 35
The ancient canyons on the World Ocean Shelf according to Leontiev (1970).

Figure 36

A COMPARISON OF THE OCCURRENCE, ELEVATION, AND AGE OF MARINE TERRACES FROM VARIOUS REGIONS AND DATA ON THE TERRACES WITH THE COINCIDENCE OF THE SUMMER SOLSTICE AND PERIHELION. AFTER ANDREWS, (1975)

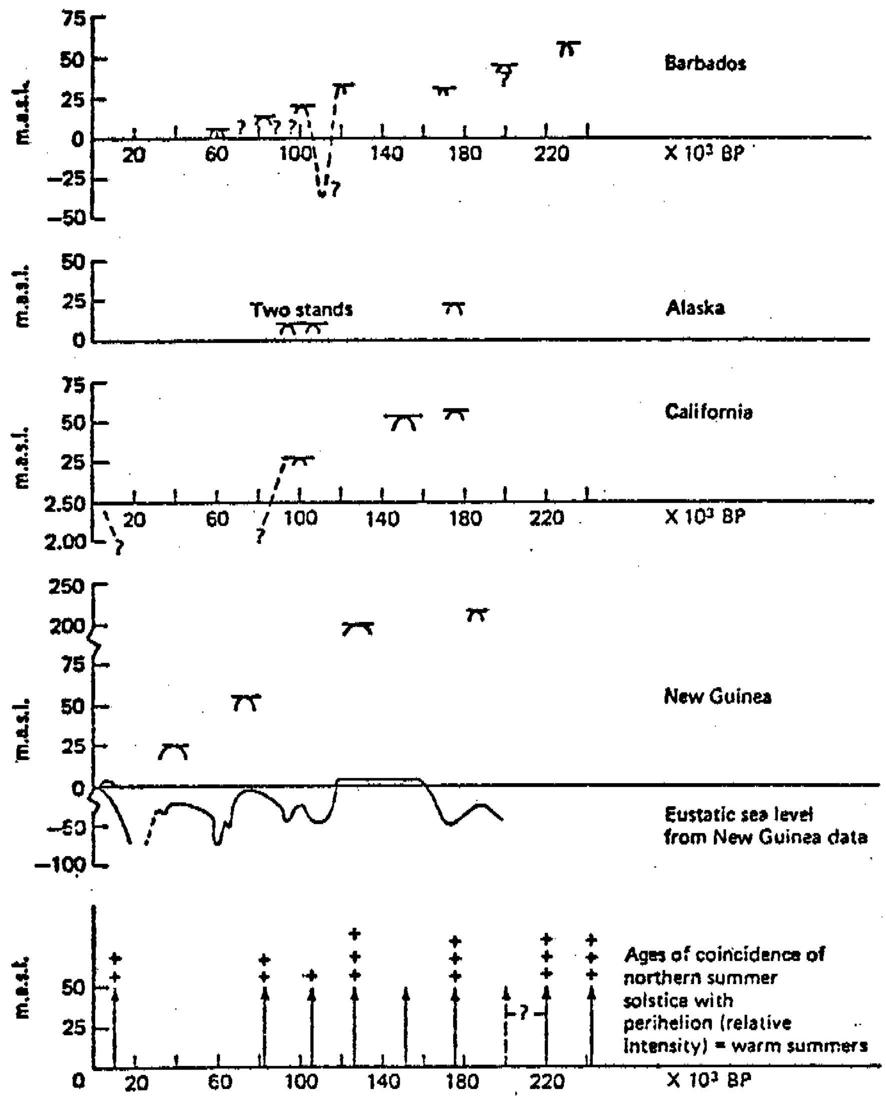


Table 12 Mediterranean Terraces--Age and Present Elevation.

Terrace	Elevation (m)	Glacial Stages	Interglacial Stages
		Nebraskan	
Sicilian	80-100		Aftonian
		Kansan	
Milazzian	55-60		Yarmouth
Tyrrhenian	30-35		
		Illinoian	
Monastirian	15-20		Sangamon
	0-7		
		Wisconsin	

Sources: According to Deperét, 1918; and Guilcher, 1969.
According to J.T. Andrews, 1975.

of the ocean basins; thus the estimate of 100 to 159 m should lead to an estimated lowering of sea level relative to the present of about 100 m. Best estimates for the Wisconsin glaciation place sea level between 100 and 135 m below the present (Andrews, 1973).

The geologists are now once again turning their attention to the core-relation between variations in the incoming solar radiation and glacial/interglacial sequences. This trend has led to the re-examination of the Milanovitch hypothesis, that glaciations are triggered by variations in solar radiation. Several authors have considered the relationship between high sea level stands and various refinements of the Milankovitch insolation curve. In particular, the three Barbados terraces at approximately 80,000, 100,000, and 120,000 BP correlate with three strong insolation maxima. The insolation peak at 150,000 BP is not strong and there is no evidence of a reef at this age in Barbados, Alaska, or New Guinea. These sea level fluctuations should, of course, match the sequence of glaciations, interglaciations, and interstades.

D.2. The summary of the ideas of the Arctic Ocean level changes during the Pleistocene.

D. Hopkins presents a detailed sequence of the Quaternary marine transgressions that are discernible on the Alaskan coasts in Beringia (Fig. 37). The Kotzebuan transgression is dated about 170,000 BP, whereas the succeeding Pelukian event is dated about 100,000 BP and comprises two distinct sea level stands for Alaska (1967). O'Sullivan (1961) developed a sequence of depositional history based on various land surfaces and lithologies and suggested at least four major marine transgressions. McCulloch (1967) investigated the depositional history of the northwestern part of the Arctic

Figure 37 Sea level history in Beringia during the last 250,000 years according to Hopkins (1973).

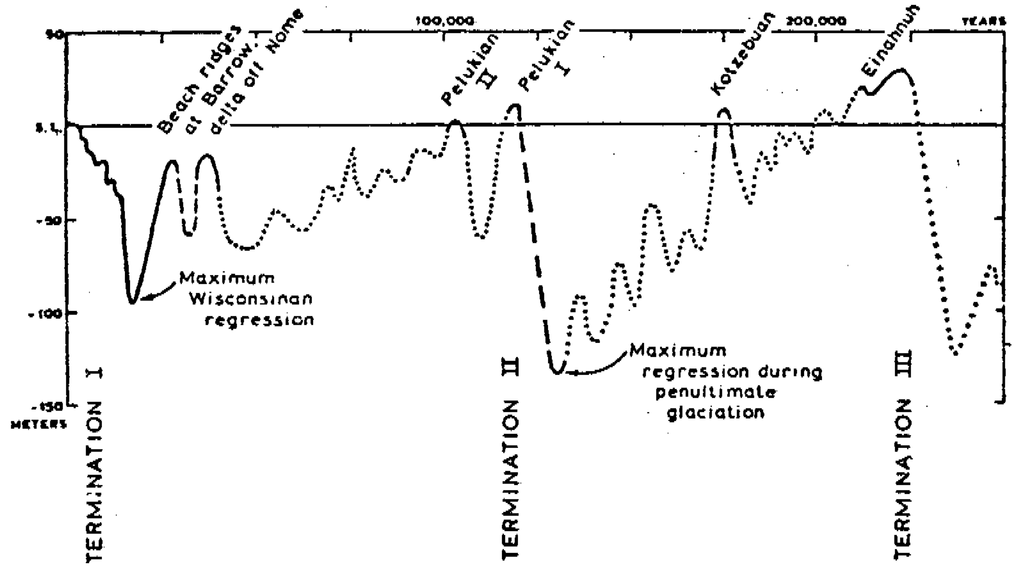
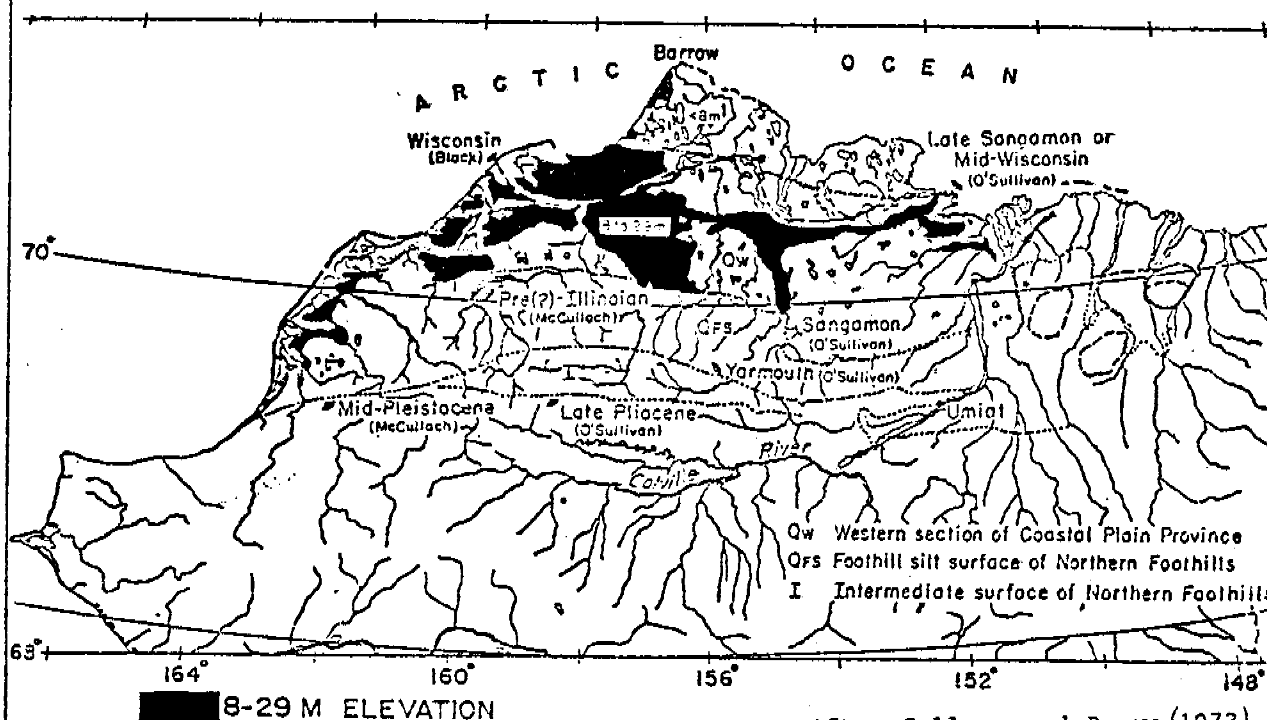


Figure 38 Map of northern Alaska summarizing the major transgressions and their extent on the Arctic coastal plain.



After Sellman and Brown (1973)

Coastal Plain and reported evidence for five transgressions. Hopkins' (1967, 1973) reviews of the Arctic Coastal Plain investigations and their correlation with other parts of coastal Alaska proposed that there appeared to be evidence for as many as seven transgressions during the Quaternary. The new data on the stratigraphy and diagenesis of perennially frozen sediments of the Barrow area is given in 1972 by P. Sellman and J. Brown (Fig. 38, Table 13). T. Péwé (1976) gave the summary of the Quaternary geology of Alaska including the problems of the Arctic ocean transgressions and regressions history.

Figure 39 shows the extent of the cold * marine transgression (Ya-Mal transgression) and the last interglacial warm marine transgression (Sangamon, Eemian, Boreal or Kazantevo) in eastern Europe and Siberia. The greater extent of the cold marine transgression compared to the warm interglacial one is clear. Figure 40 shows the boundaries of the Ya-Mal cold marine transgression and the areas covered with simultaneous glaciation on the Eurasiatic part of the Arctic basin after A. Popov and A. Kostyaev (Markov, 1965) (226). On Figs. 41 and 42 we can see the cross-sections with the cold marine transgression's deposits between the two series of warm marine transgression (interglacial) deposits--Holstein and Eemian (Boreal, Sangamon). One cross-section is from the confluence of the Irtish and Ob Rivers about 800-1000 km to the south of the modern Arctic ocean, the second one is from 100-200 km to the south of the ocean, near the Ob river.

The age and the facies relationship between the areas of transgression and glacial deposits are shown on Fig. 43. The marine and glacial marine

---

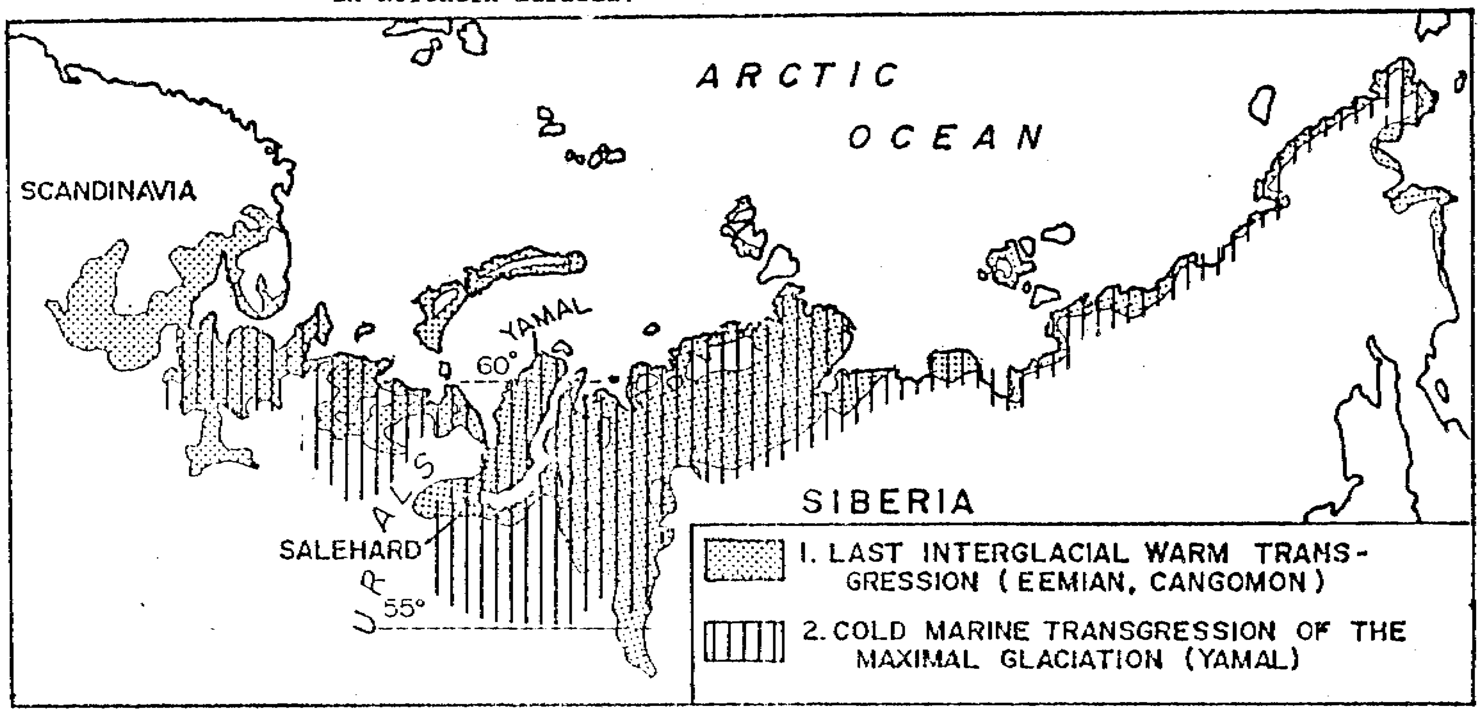
* The organic remains associated with these transgressions (shells, diatoms, foraminifera, pollen) were clearly indicative of sea and air temperatures colder than during the Holocene and Boreal (Eemian/Sangamon) hypsithermals.

TABLE 13 Summary of Quaternary Transgressions for Alaskan Coastal Regions / According to P. Sellman and J. Brown (1973)

Late Pliocene
Early Pleistocene

Years: 2 200 000	1 900 000	700 000	300 000	175 000	170 000	100 000	50 000	25 000	10 000	5 000	2 000–Present	Investigators
			Einahnuhtan. Probably about +20 m									
Beringian. Two levels higher than present but lower than Anvilian.	Anvilian. Probably much higher than Kotzebuan and Einahnuhtan <+100 m and >+20 m.			Kotzebuan. Probably about + 20 m. Shorelines at about 33 m on western coastal plain.		Pelukian. Two highs at +7–10 m.	Mid-Wisconsin. Probably a few meters below present.		Krusensternian. Within 2 m of present sea level for deposits <4 000 years old.			Hopkins
Marine transgression. Sediments on wavecut bedrock platform at Kivalina.	Mid-Pleistocene. Transgression–uplift south central part of coastal plain-elevating marine sediments at least 100 m.			Pre-Illinoian. Trangressive beach deposits.		Sangamon. Marine sed. on wave-cut terrace along coast.	Mid-Wisconsin. Marine sed. and ice rafted boulders--deposits raised at least 8 m by later uplift.					McCulloch[illegible]
Marine transgression. 95–160-m escarpment at the 320-m elevation at southern margin of intermediate surface.				Yarmouth. Escarpment north of intermediate surface correlated with 95-m terrace near Umiat.		Sangamon. Inner margin of coastal plain causing alluviation of major drainages.	Mid-Wisconsin. Midway on coastal plain.					O'Sullivan
				Illinoian. Skull Cliff unit.		Sangamon. Meade River unit.	Wisconsin. Barrow unit.					Black
						Pelukian. Possible transgression indicated by more silty sediment under Mid-Wisconsinan unit.	Mid-Wisconsin. Marine sediment dated near Barrow–suggests extensive transgression on portions of Coastal Plain, to present 8-m level and possible deposition of inland ridge.		Krusensternian. Small fluctuations in sea level in last 2 000 years forming and modifying present Barrow spit.			Sellmann, Brown and others[illegible]

Figure 39 **The spreading of the two transgression deposits: last interglacial warm one (Eemian, Sangamon) and "cold" marine transgression (Yamal) during the maximal glaciation (Illinoian time) in Northern Eurasia.**



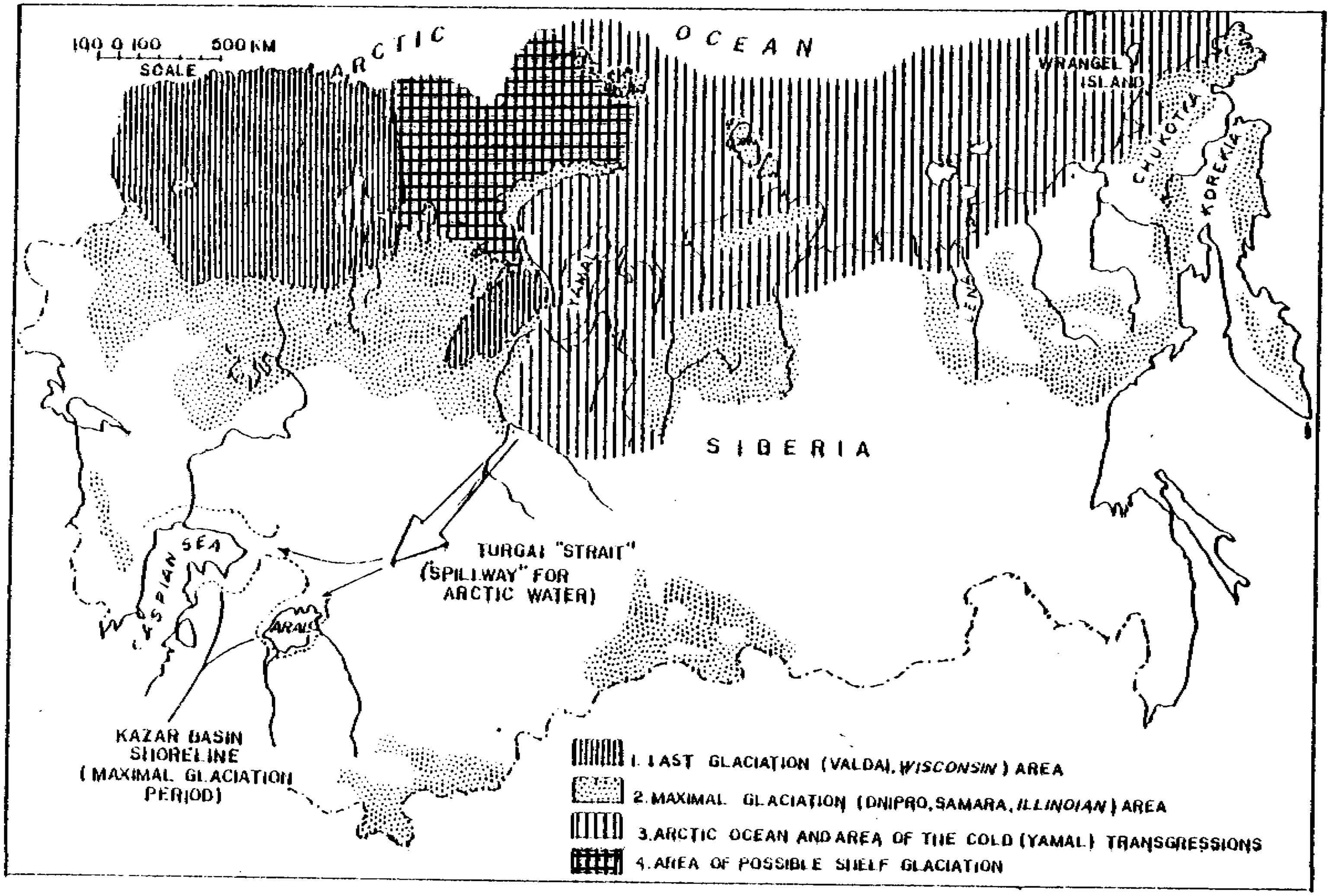


Figure 40 The boundaries of the Yamal cold transgression and the areas covered with simultaneous glaciation

Figure 41 The cross section of the Quaternary deposits at the Ob River basin about 100-200 km to the south from the Arctic Ocean according to Lazukov (1965).

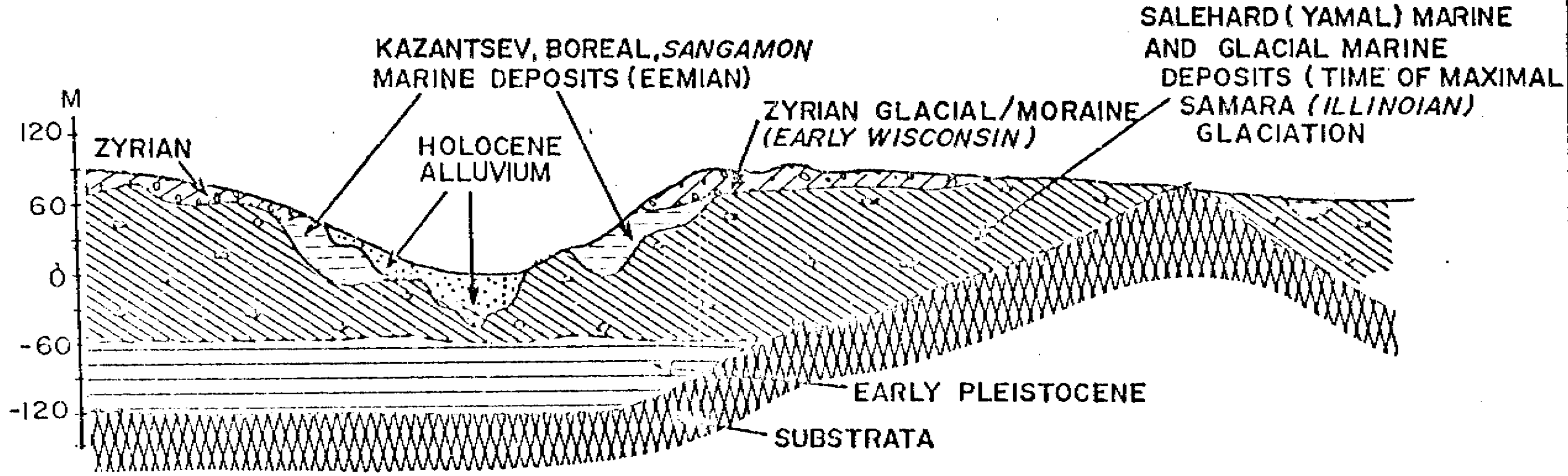


Figure 42 The cross section of the Quaternary deposits at the mouth of the Irtish River about 800-1000 km to the south from Arctic Ocean according to Lazukov (1970).

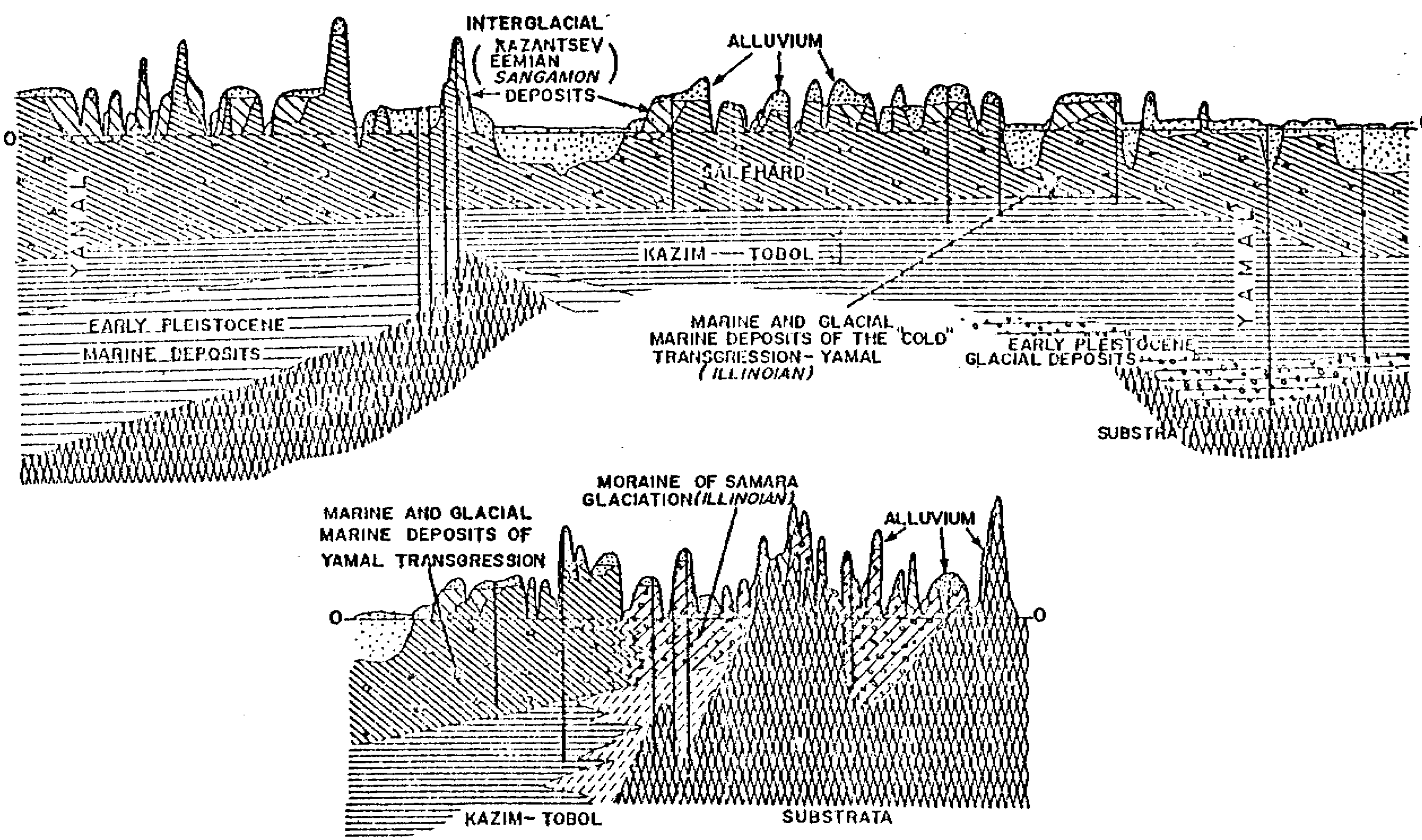
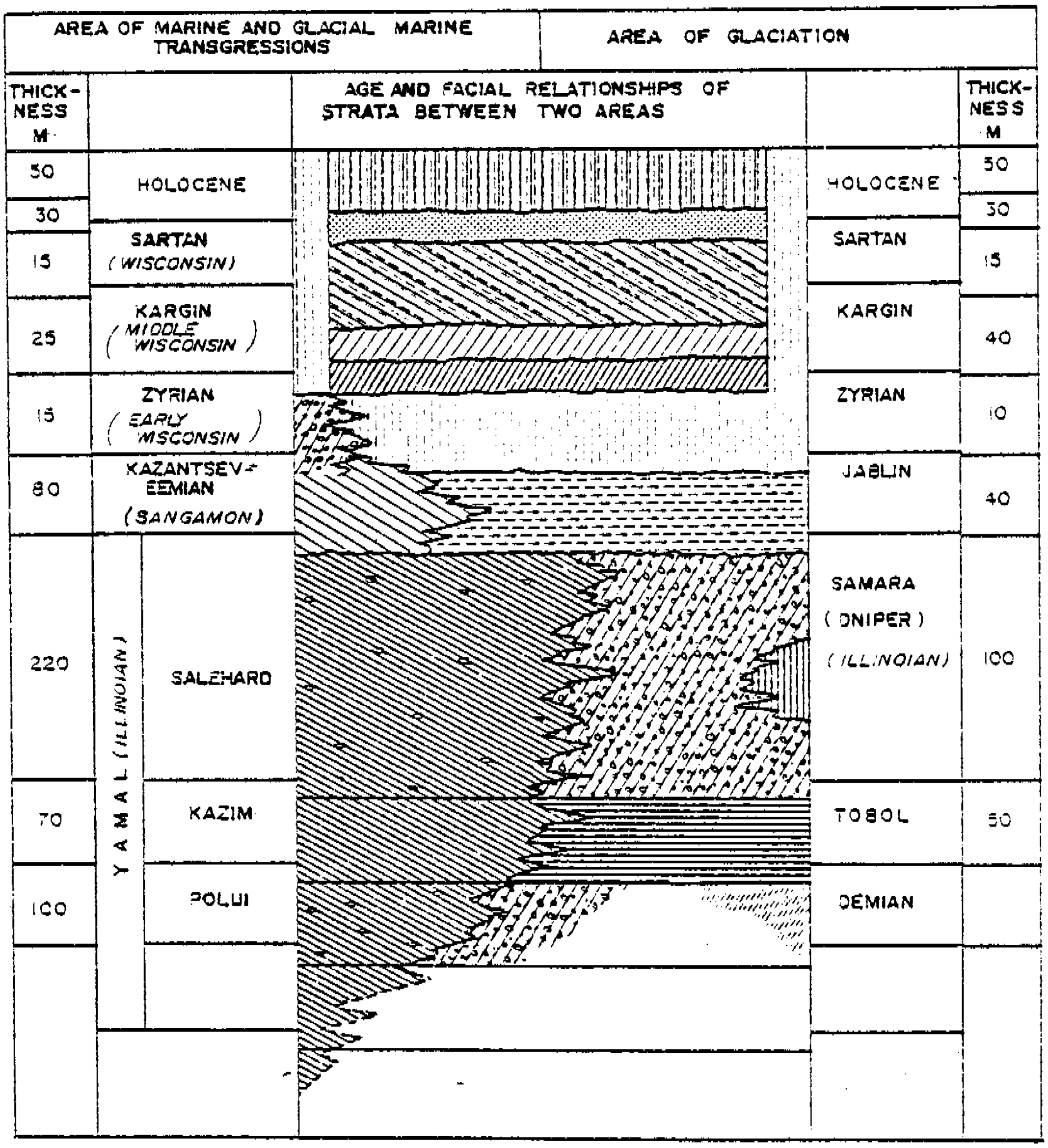


Figure 43 The relationship between deposits of the transgression's area and the glaciation's area in Siberia according to Lazukov (1970).



deposits are clay, loam, sandy loam and sand. Their absolute age is 285-213,000 years ago, according to U^{234} and the thermoluminiscent analysis (Zubakov et al., 1974) (411). Their thickness reaches about 220 m. The deposits have a normal magnetic polarity. The marine molluscs and cirripeds are: Balanus hameri, Nucula tenuis, Leda pernula, Macoma calcarea, Mya truncata, Saxicava arctica, Astarte crenata, A. montagui, Portlandia arctica, Joldiella lenticula, Propeamussium groenlandicum, Cardium ciliatum. Foraminifera are: Quingueloculina arctica, Glandulina laevigata, Cibicides rotundatus, Cr. brononion obscurus, Globigerina bullo des, G. conglomerata, C. involuta, Protelphidium orbiculare, Elphidium granatam, E. obesum, E. subslavatum, Pursens na concava, Planocassidulina norcrossi, P. teretis, Cassilamellina islandica. Diatoms are fresh and brackish, water taxa, both planktonic and benthic. The dominant forms are cold arcto-boreal with little boreal taxa (Aleshinskaya, 1964)*. Figure 44 shows the diagram of the diatom changes in Siberia during the Pleistocene; on the diagram we can see the correlation of the maximal cooling with transgression of the Arctic basin. This idea was expressed first by G. Lazukov in 1961 (202-205), and it is shown on Fig. 45. The pollen diagram (Fig. 46) also shows the cooling that took place during the maximal transgression in Siberia. We see that the sums of trees, shrubs and grass pollen are equal. Betula nana, Alnaster and Pinus siberica show that arctic desert, periglacial tundra and forest-tundra, partly northern Taiga landscape (lichen woodland) were the most characteristic types of vegetation along the coastal zone that was not covered by glaciation. For

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* "Severny Ledovity ocean I Yego Poberezie V Kaynozoye." Moscva, Nauka, 1970.

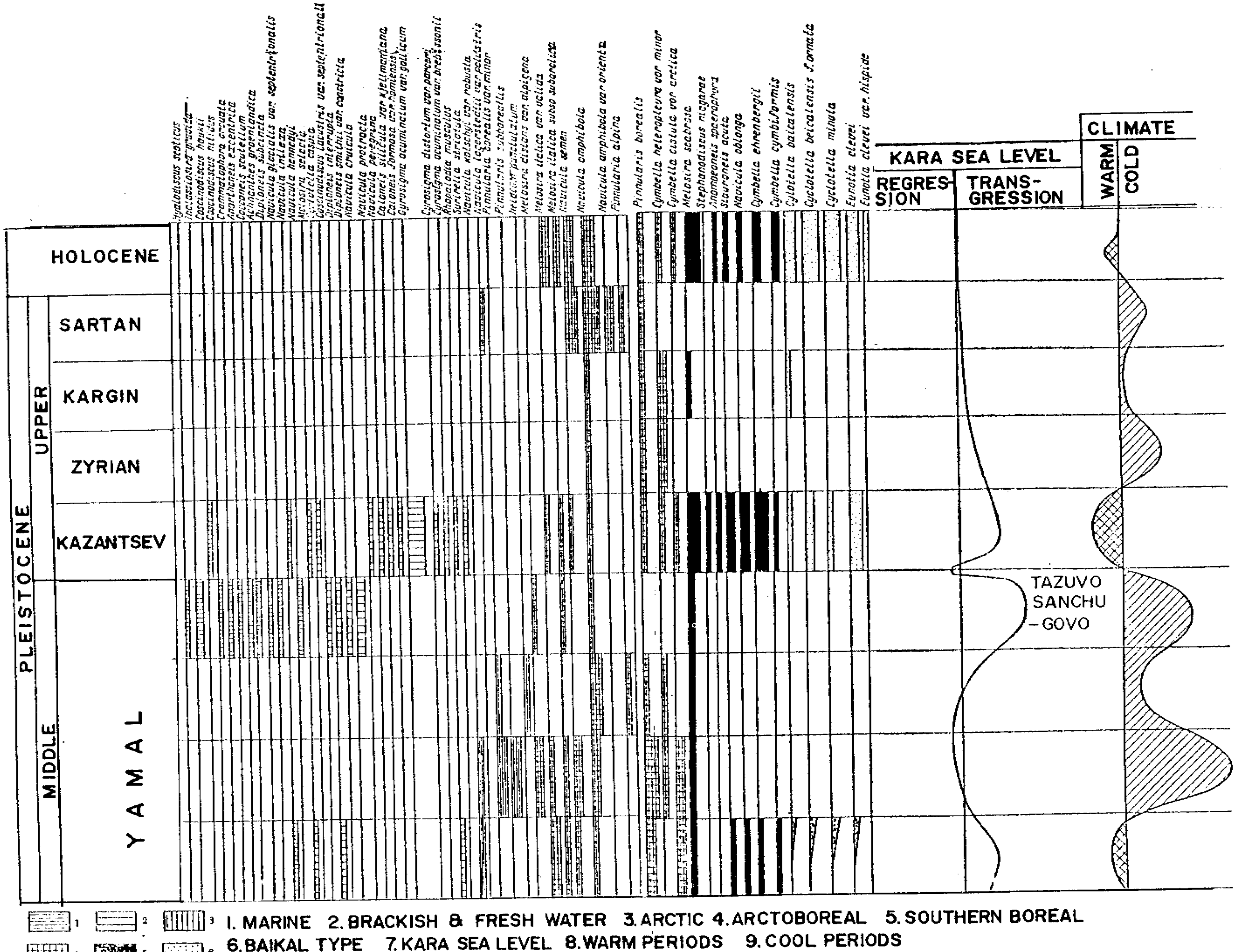
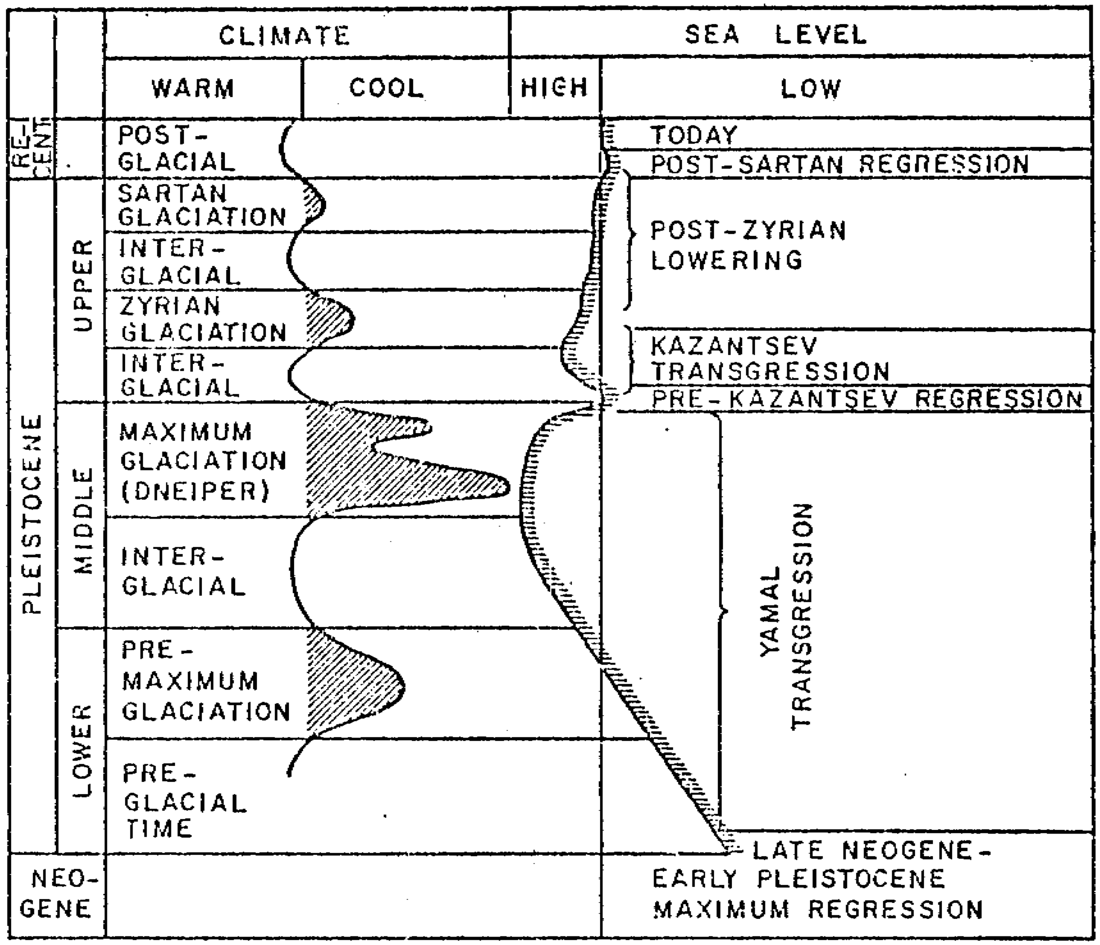
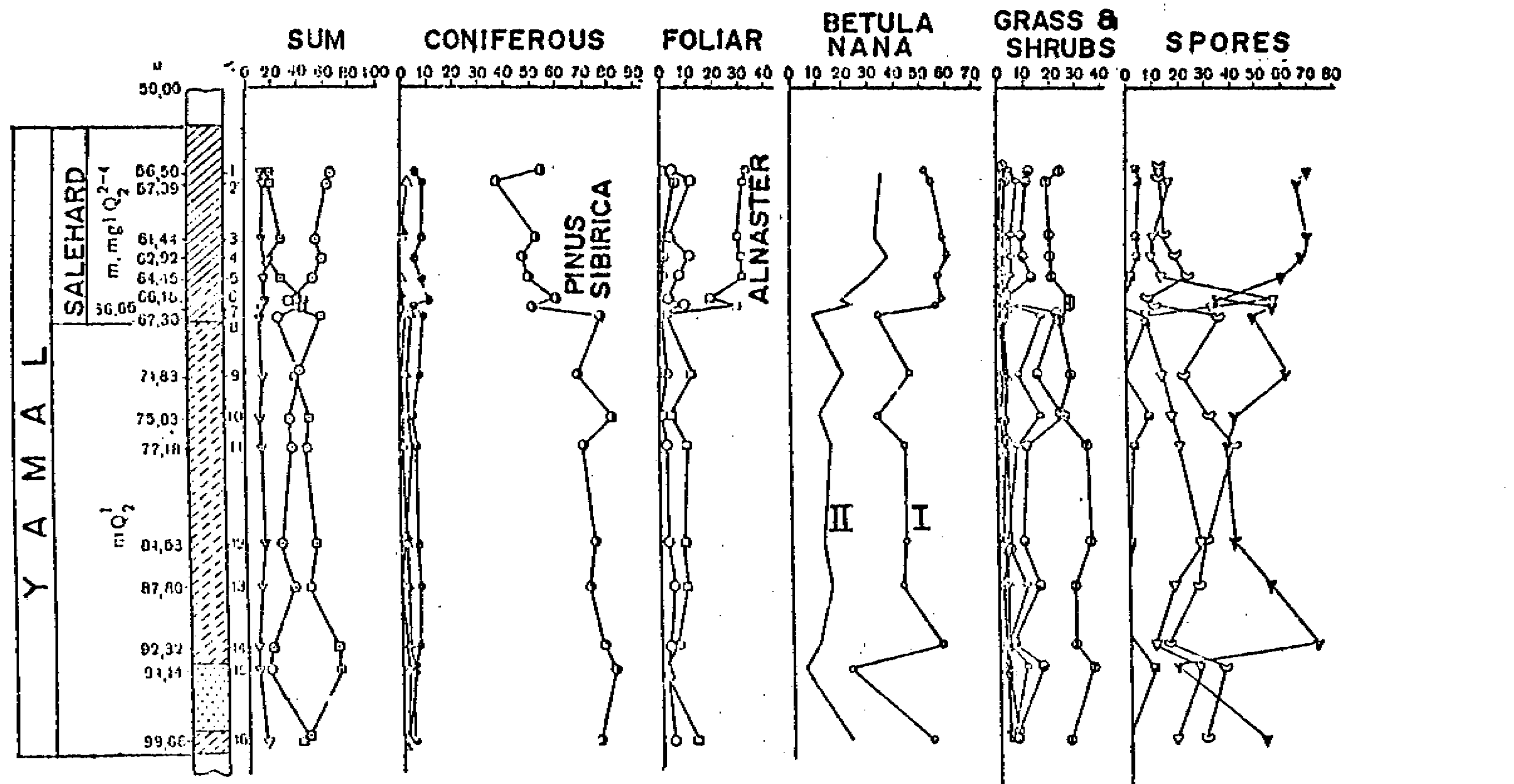


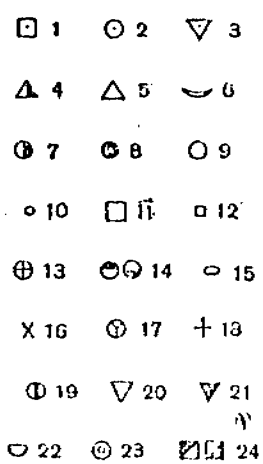
Figure 44 The diatomea diagram of the quaternary deposits in western Siberia according to Aleshinskaya (1964).

Figure 45 **The climatic changes and ocean level oscillations in western Siberia during Pleistocene**



(AFTER LAZUKOV, 1961)





I. % Betula nana from total sum of grass and shrubs.

II. % Betula nana from total sum of pollen grains.

1 AP; 2 NAP; 3 Spores; 4 Abies; 5 Picea; 6 Larix; 7 Pinus sibirica; 8 Pinus silvestris; 9 Betula Sect. Albae; 10 B. sect. Nanae; 11 Alnus; 12 Alnaster; 13 Salix; 14 Gramineae; 15 Cyperaceae; 16 Chenopediaceae; 17 Ericales; 18 Artemisia; 19 varia; 20 Bryales; 21 Sphagnum; 22 Filicales; 23 Equisetum; 24 Lycopodium.

Figure 46

The pollen diagram of the marine deposits of the maximal cold transgression in Siberia near Salehard according to Lazukov (1970).

the Chukotka peninsula we have similar results in the Kiestov transgression. The maximal cold transgression there took place during the time of the maximal glaciation according to data gathered by Petrov (1965) (262-263), (Fig. 47) and Khoreva (1974) (152)(Fig. 48). Position and altitudes of the marine terraces of the Arctic basin in Siberia and Chukotka are very similar (Figs. 49 and 50) and typical for the arctic coastal areas in Eurasia. The Yamal and Krestov terraces are the result of cold marine transgression (Lazukov, 1970 (205), Petrov, 1965 (262-263)), and they are higher than interglacial Boreal marine terrace of this very large region. We see that the data from the Eurasiatic part of the Arctic basin, including geological and geomorphological evidence, paleontological and palynological materials provide the basis for the conclusion that the time of the maximal cold transgression of the Arctic basin took place during the maximal glaciation (Illinoian, Dnipro, Samara). The absolute age dating also supports this conclusion (Zubakov et al., 1974 (411).

There are some differences in the explanation of this fact. Some scientists (Degtyarenko et al., 1971 (70-71) try to explain it as a result of tectonic movements (Fig. 51), acting more intensively along the coastal areas close to the Ural Mountains, dividing Europe and Asia (northeast Europe and western Siberia). The weakness of this point of view is that new facts about the marine terraces of Chukotka peninsula contradict this idea. Other scientists (Archipov, 1971 (21), Troitsky, 1975 (359)) think that most of the marine deposits were formed in the latest periods of glaciation. There is a good reason to agree with this, and in the model of the Arctic Ocean level changes (see below) we will try to show it. The third possible explanation of the cold marine transgression was used by Grosswald et al. (1973 (114)). These geologists proposed a great extension of the

Figure 47

The climatic changes and ocean level oscillations in the Chukotka peninsula during the Pleistocene according to Petrov (1965)

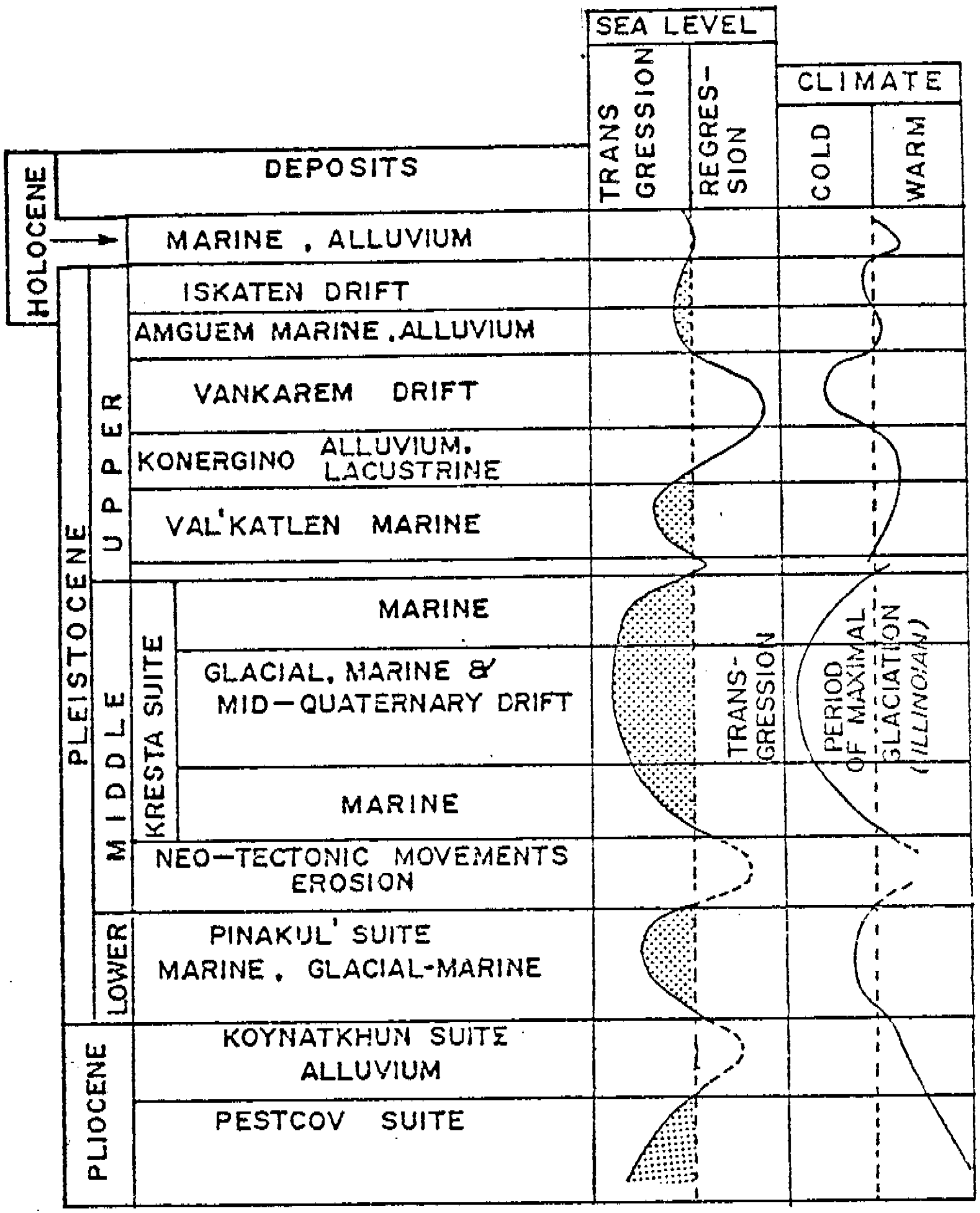


Figure 48 Foraminifera in the Pleistocene deposits of Chukotka peninsula according to Khoreva (1974).

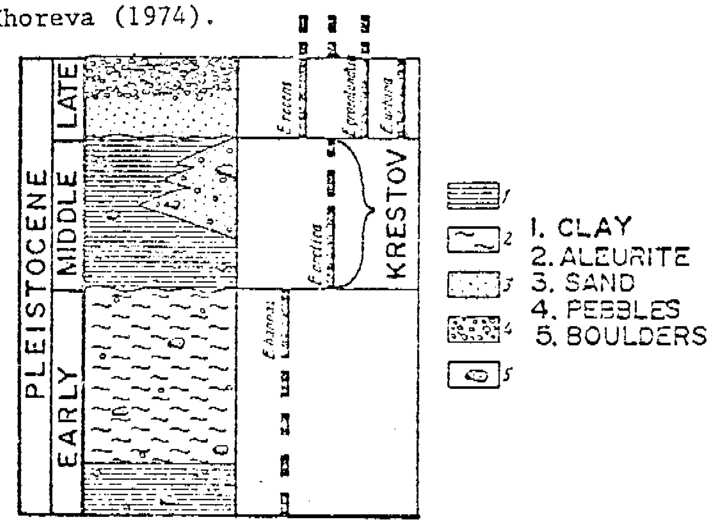


Figure 49 Marine terraces of Siberia according to Arhipov (1971).

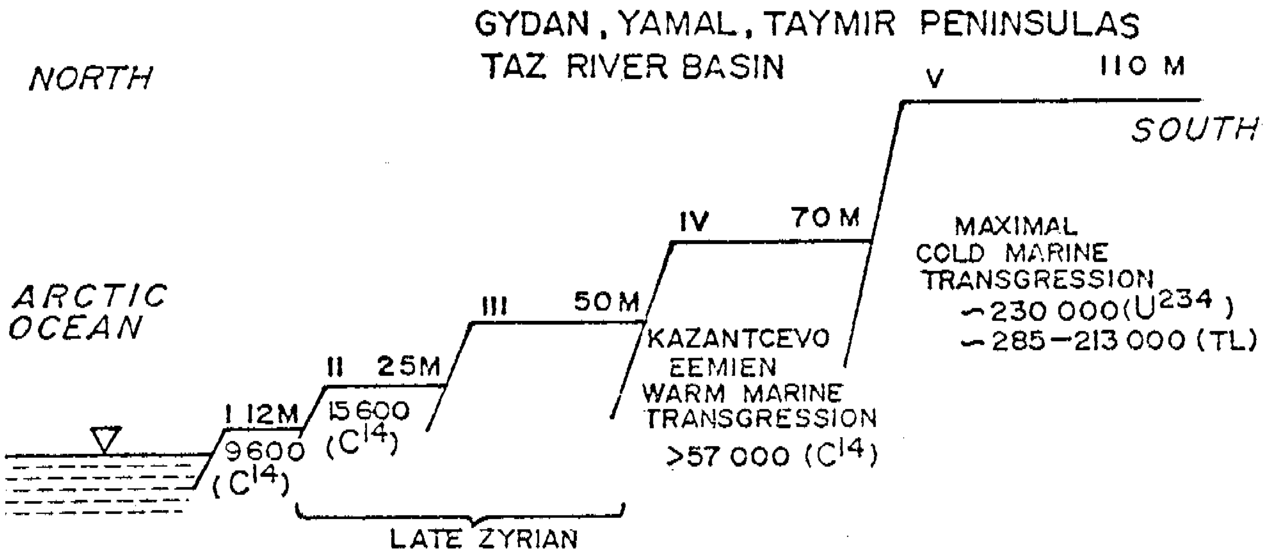


Figure 50 **Marine terraces of Chukotka peninsula according to Petrov (1965)**

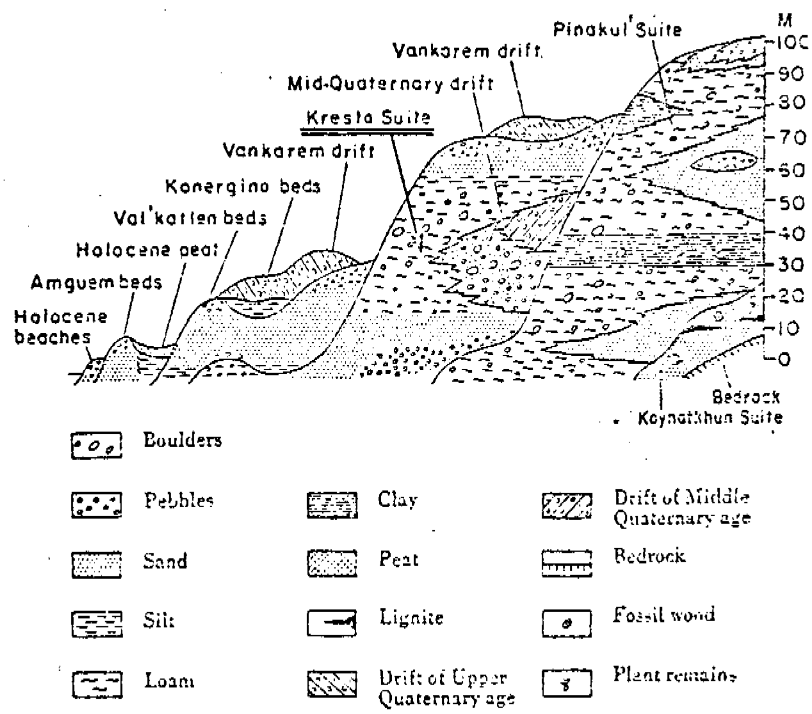
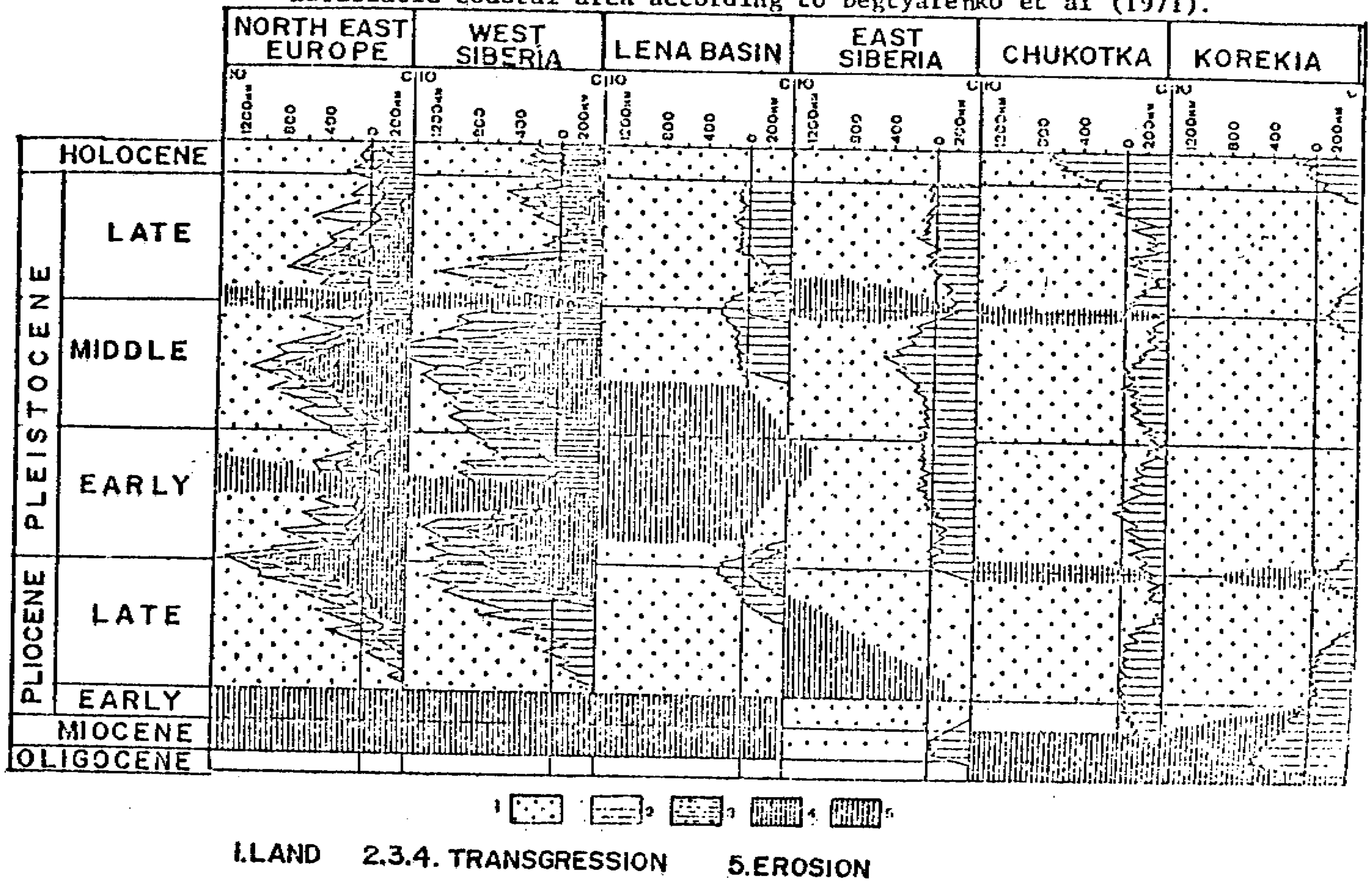


Figure 51 The development of the Pleistocene transgressions on the Eurasiatic coastal area according to Degtyarenko et al (1971).



shelf glaciation in Barents Sea and to the east from the Urals (Fig. 52), and we agree with the possibility of glaciation partly on the Arctic shelf. The isolation of the Arctic Ocean from the warm water of the Atlantic created the possibility for such glaciation, but it is difficult to suppose that all the shelf was covered by an ice sheet for two reasons:

(1) some of the islands in the Arctic Ocean especially to the east from the Kara Sea never have been glaciated at all (Isl. Vrangel, according to Yurtsev, 1971 (394));

(2) the widespread development of shelf glaciation could change the marine character of the transgression and make it resemble a fresh water transgression; the data from the marine transgressions are against it.

We can see that all these hypotheses have contradictions and do not satisfactorily explain the origin of the cold marine transgression which took place during the Illinoian (Dnipro, Samara) time.

The only alternative appears to be the isolation of the Arctic basin at that time, involving barriers along both the Bering Strait and North Atlantic areas.

D.3. The attempts to get agreement between "marinistic" and "glaciologistic" conceptions.

Figure 53 shows the extent of the Quaternary glaciation in Alaska according to T. Péwé (1976)*. We see that Bering Strait was closed by Illinoian glaciation. Glaciers from the Chukotka Peninsula (USSR) adjacent to the Bering Strait once extended southward and eastward more than 100 km

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* Modified from Coulter, Hopkins, Karlstrom, Péwé, Wahrhaftig, and Williams (1965). Additional information on Seward Peninsula and Bering Strait from D.M. Hopkins and C.L. Sainsbury (written commun., 1968) and Nelson and Hopkins (1972).

Figure 52 Shelf's glaciation in the Barents Sea according to Grosvald et al (1973).

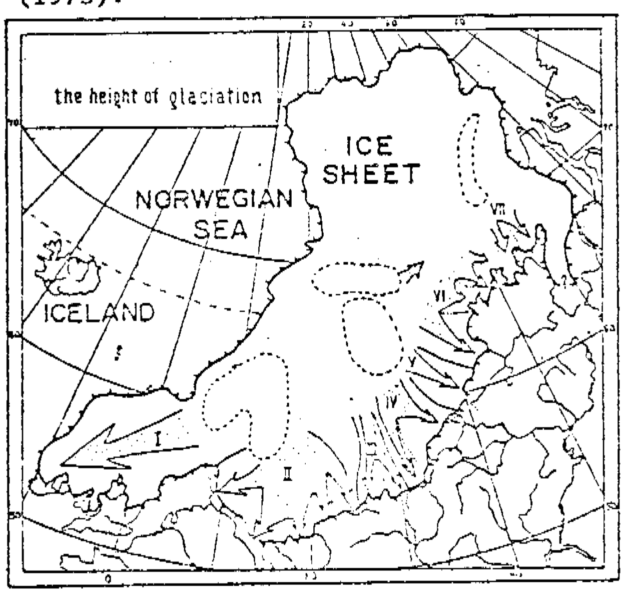
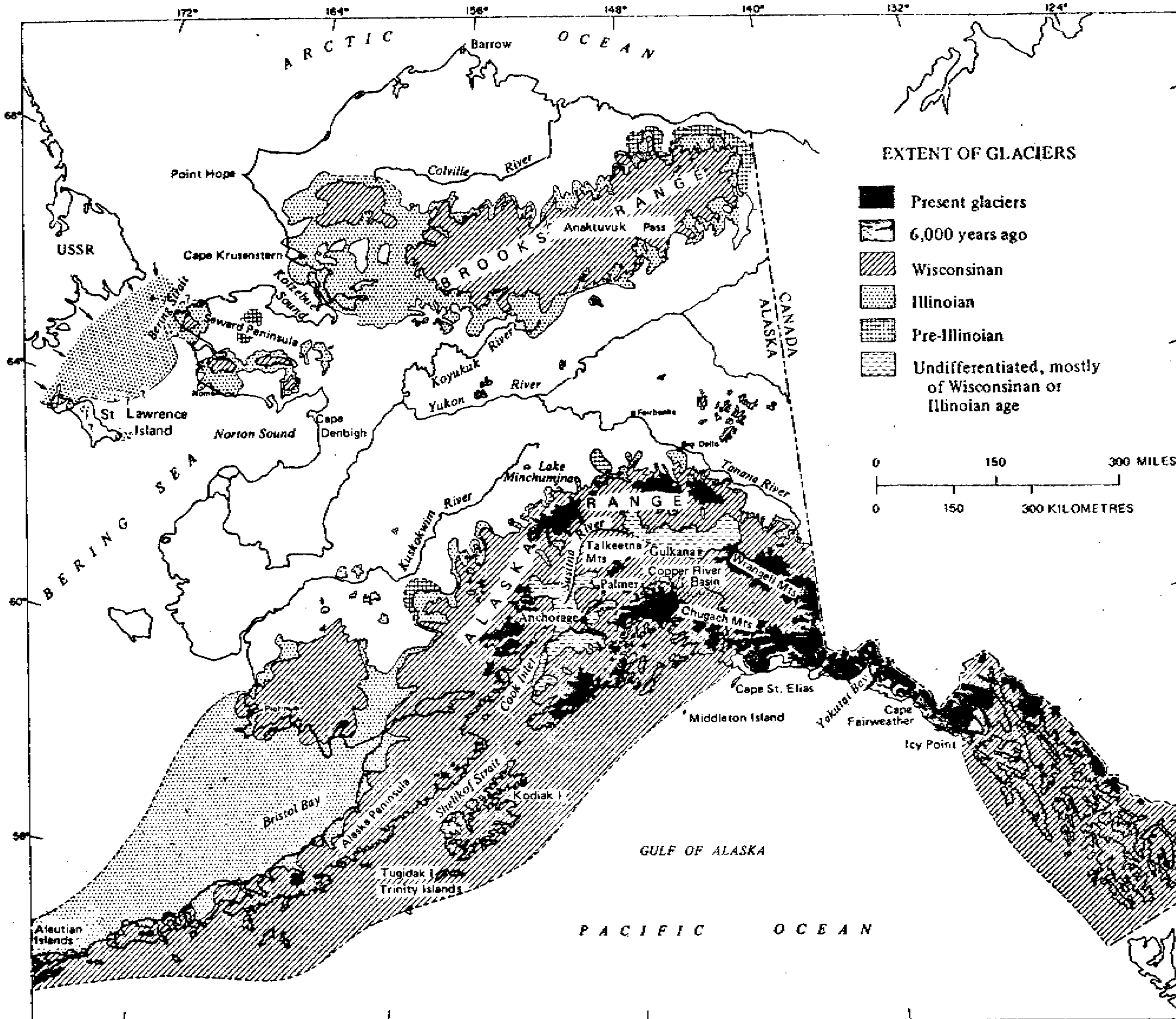


Figure 53 Extent of Quaternary glaciation in Alaska according to Péwé (976).



onto the Bering shelf, reaching St. Lawrence Island (Hopkins and others, 1972, p. 125). Hopkins (1972) believed that the glaciers could hardly have extended this far if it were a time of high sea level when glacial margins must have been afloat, as suggested by some Soviet workers. Péwé notes that Grim and McManus (1970) found large-scale deformation structures on the sea floor probably caused by glacial ice in contact with the ground surface. Hopkins (1972) further concluded that this extent of Siberian ice may have occurred during Illinoian time rather than during a time of high sea level, the Kotzebuan transgression. New work by Hopkins has extended the limits of the Nome River Glaciation in the southern part of teh Seward Peninsula and in Bering Strait (cited in Péwé, 1976).

On the map of the Atlantic barriers (Fig. 54) we see that the water depth here now is not more than 500 m and the shapes of the geological structures look like blocks. During the glaciations the ice sheets were developed all over Iceland, Faeroes Islands and Scotland (Figs. 55 and 56). These ice sheets had to give a loading impulse for glacio-isostatic movements, and the earth core blocks under the ice sheets may have been submerged. On the paleotectonic scheme of the Cenozoic, made by M. Muratov* (1975) the North Atlantic barriers areas is shown like an alternation of young and old platforms and of continental and oceanic blocks. On the tectonic map of the Arctic basin made by V. Dibner et al. (1965 (72-73)) the regions represented by Greenland, Faeroes, and Scotland are separated by activated deep faults (Fig. 57). We can consider them as the transform faults, too, according to peate-tectonics. Another map by the same authors shows the thickness of the earth's core in this region (Fig. 58).

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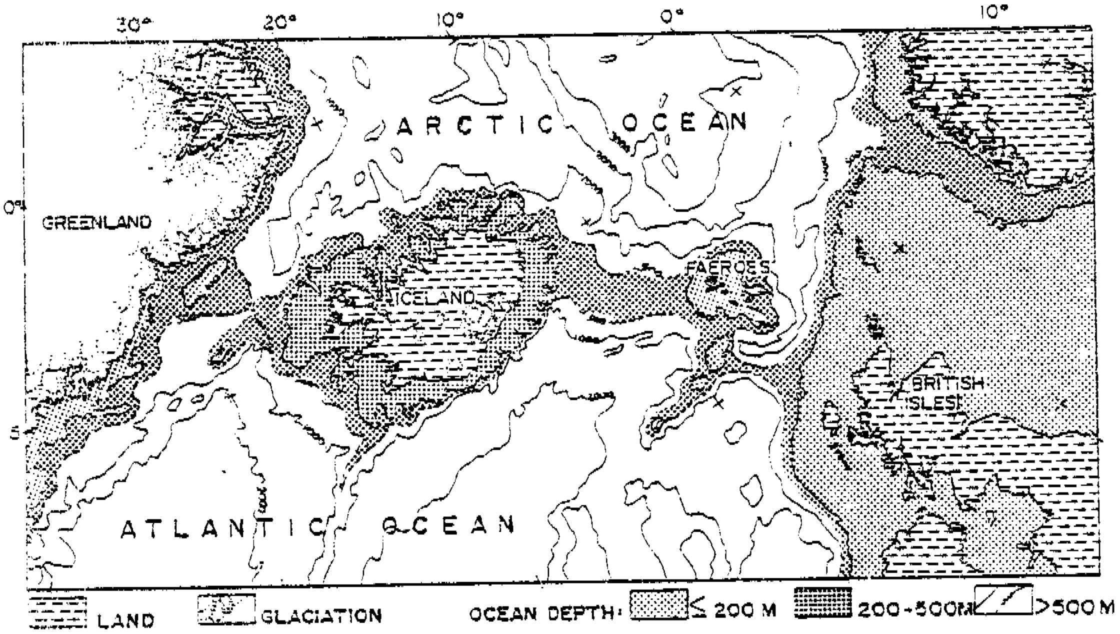
* M. Muratov (1975) Proishogdenie Materikov i Okeanicheskih vpadin, Moscova, Nauka.

Figure 54

NORTH ATLANTIC BARRIERS



SCHEMATIC PROFILE

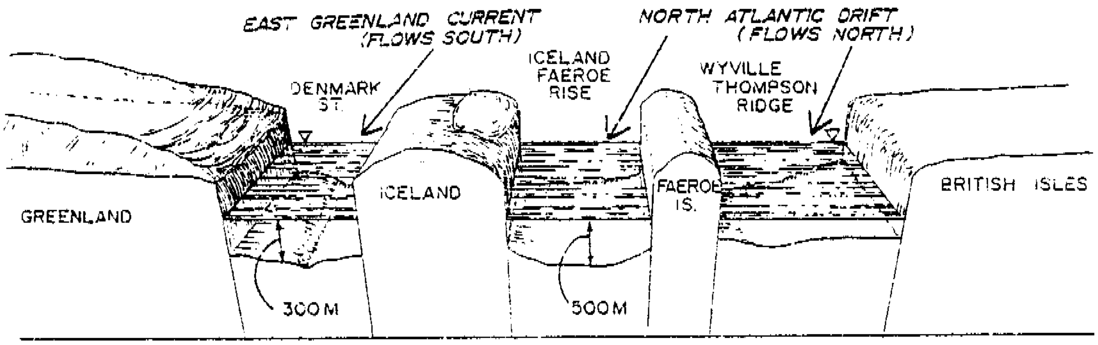
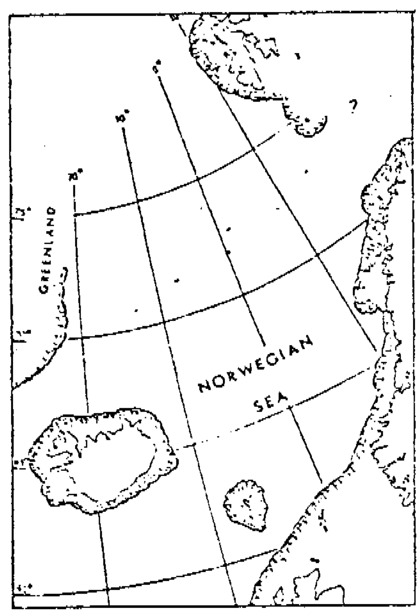


Figure 55

The probable extent of the northwestern European ice sheet according to Hoppe et al (1972).

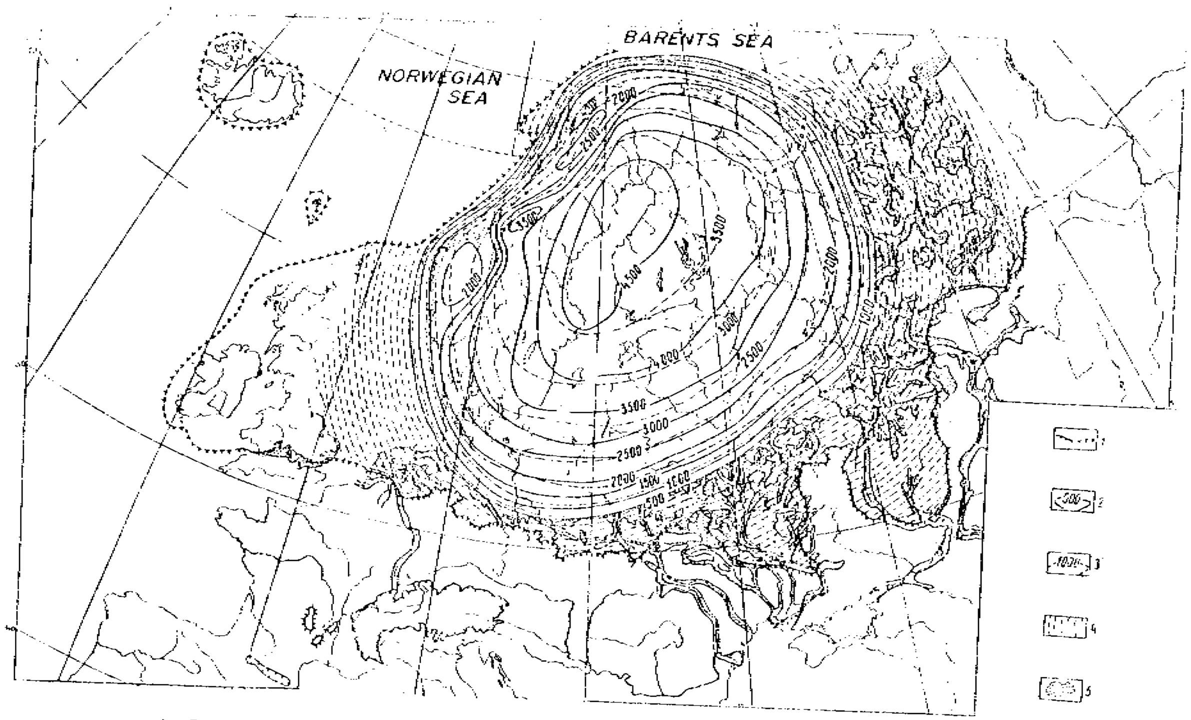


Recently the geomorphology of the floor of the Norwegian and Greenland Seas was described in detail by V. M. Litvin (1973) according to new results of the investigations carried out by Soviet and foreign expeditions during the last 15 years. The relief of the floor of the Norwegian and Greenland Seas has been fairly well studied. Very extensive data have been obtained through expeditions by the Polar Research Institute of Fishery and Oceanography abroad the ships Sevastopol, Akademik Knipovich, and others (Vinogradova et al., 1960; Litvin, 1964, 1968). During the IGY, investigations of the structure of the floor of the northern part of the seas were carried out through expeditions by the Arctic and Antarctic Institute aboard the Ob and the Lena (Voekov et al., 1968; Laktionov, 1960); in the central and southern parts, Norwegian expeditions operated aboard the Yogann, Yort, and the G. O. Sars (Eggvin, 1961). In recent years, American expeditions on icebreakers carried out geological and geophysical investigations of this region (Johnson et al., 1966-1969). It should be mentioned that detailed operations carried out in the earlier period by Norwegian scientists on the Norwegian Shelf yielded clues for an understanding of the structure and origin of glaciological shelves (Holtedahl, 1940, 1956). Finally, the latest investigations in the region of the Iceland and Jan Mayan islands were carried out in 1971 by an expedition of the Academy of Sciences of the USSR aboard the Akademik Kurchatov.

The present geomorphologic outline and the geomorphologic map (Fig. 59) constructed by V. Litvin (1973) are based on the data of Soviet and foreign investigators.

The Norwegian and Greenland Seas are bounded on the east and west by the continental boarders, including the shelf and the continental slope.

Figure 56 The reconstruction of the maximum (Middle Pleistocene) European ice sheet according to Aseev et al (1973).



1. The limit of spreading of the Middle-Pleistocene glaciation (established and tentative); 2. Contour lines of equal thickness of ice in the Scandinavian Ice Sheet, metres; 3. Contour lines of the surface of the Scandinavian Ice Sheet, metres a.s.l; 4. Periphery part of the ice sheet (altitude of the surface and ice thickness under 500 metres); 5. Outwash plaines of the beginning of ice degradation epoch; 6. Largest alluvial plaines mainly formed by melt water.

(The paleogeography of Europe during the late Pleistocene reconstructions and models, Institute of Geography of the USSR Academy of Sciences, Moscow, 1973)

Figure 57

Tectonic map of the Arctic Ocean according to Dibner et al (1965).

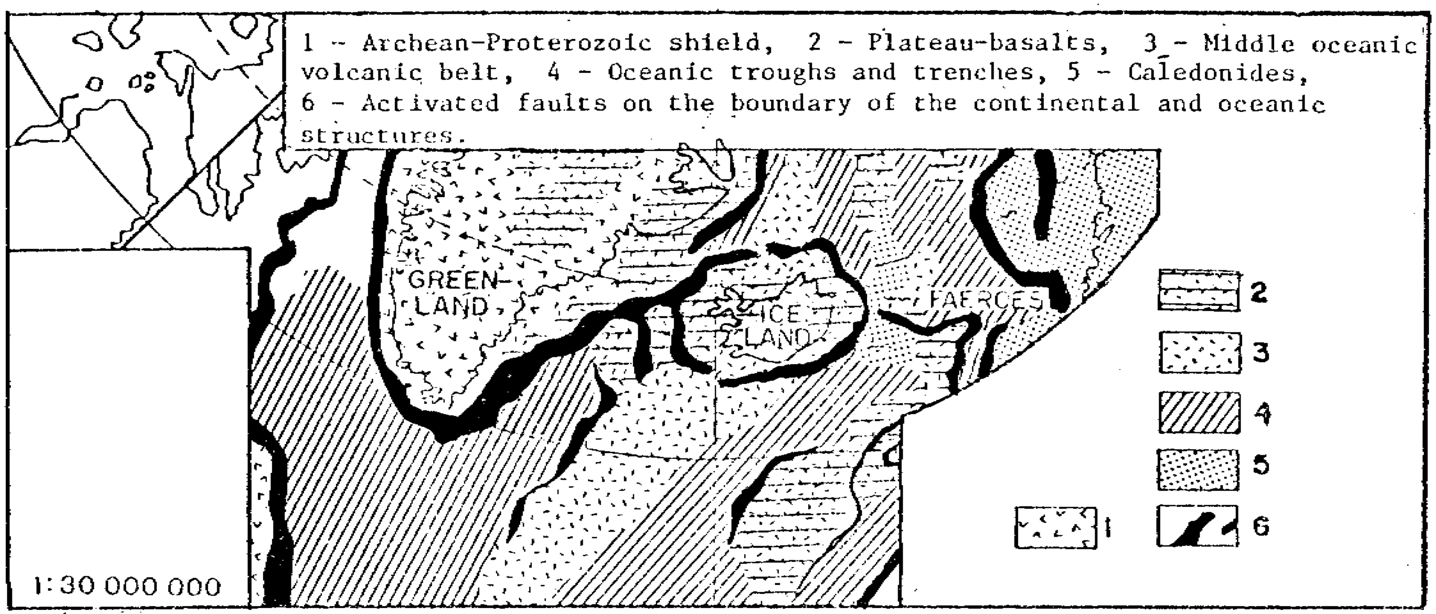
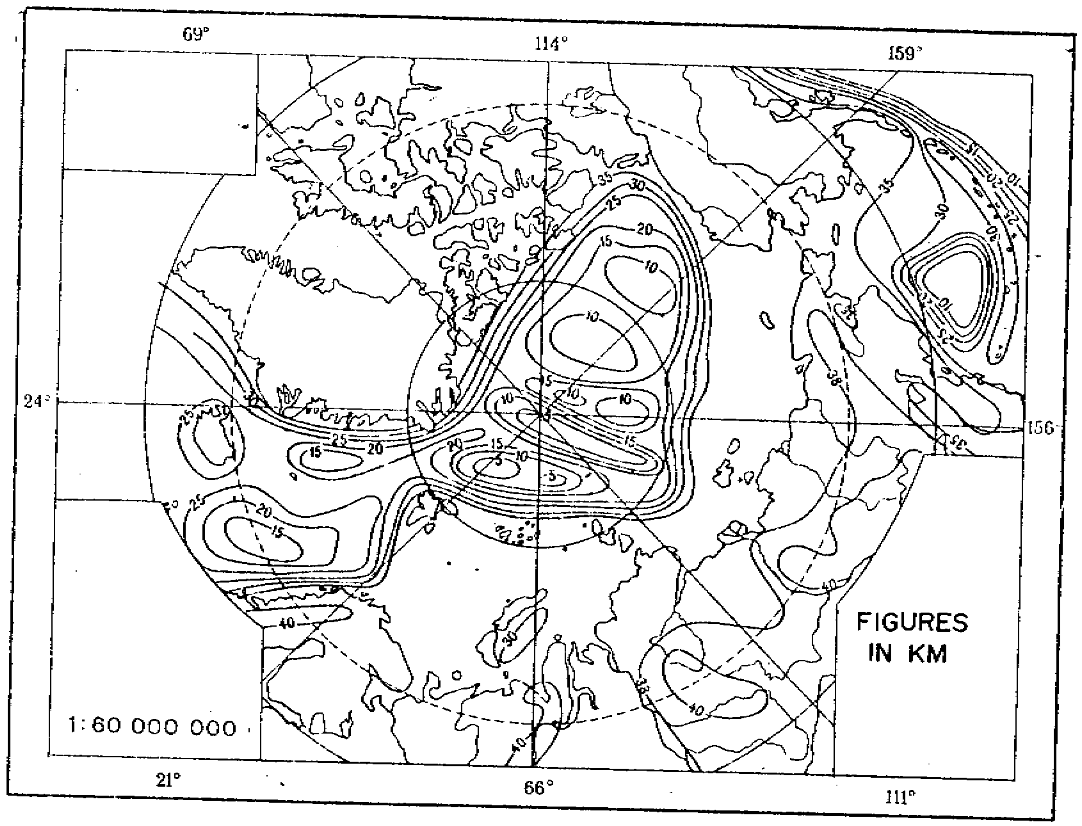


Figure 58 The thickness of the earth's core in the Arctic basin according to Dibner et al (1965).



In the south and outhwest, the seas are separated from the Atlantic Ocean by a chain of rises which include the islands of Iceland and the Faeroe Islands with their shelves and the underwater Wyville Thomson and Faeroe-Iceland Ridges, and the Iceland-Greenland Rise.

According to geophysical data, the lithosphere of the Norwegian and Greenland Seas within the limits of the shelf has a continental type structure (Demenitskaya et al., 1964; Ewing et al., 1959; Johnoson et al., 1969). The thickness of the crust here reaches 30 to 33 km. In the zone of the continental slope the crust, in general, becomes thicker and, at its foot, reaches 10 to 15 km. Here the "granite" layer tapers off. In the deep-water troughs the thickness of the crust is less than 10 km, and its section similar to the oceanic type. In the zone of the mid-oceanic ridge, the lithosphere becomes appreciably thicker reaching, in the regions of the Iceland and Jan Mayan Islands, a thickness of 25 to 28 km, due to the increased thickness of the "basalt" layer. The section of the crust here is almost identical to the section of the crust of the mid-Atlantic Ridge, which is evidence for the genetic link of these morphostructures.

The continental shelves extending along the coasts of eastern Greenland, western Spitsbergen, Norway, and the western borders of the Barents Sea, despite some differences, have many common features. Almost all of them are separated by a series of tectonically defined grooves into a number of raised banks. The longitudinal grooves are most clearly expressed along the coasts of Greenland and Norway and in the remaining regions are negligible. They are the morphologic expression of the edge fractures of the continental blocks embedded in the Tertiary period, and rejuvenated by glacio-isostatic movements in the Pleistocene epoch. The transverse grooves are developed nearly everywhere by concentrated, for the most part, opposite to the large fiords on land, which is indicative of their genetic link.

The coastal belt of the shelf up to a depth of nearly 50 m, in general, forms an underwater abrasive platform with uneven glacial exsertions, the platform being known as a strandflat (Holtedahl, 1956). It is cut across by narrow valleys which are underwater extensions of fiords. The surface of the banks of the shelf at depths less than 200 m are, for the most part, leveled by abrasive-accumulative processes during the postglacial rise of the ocean level. The floors of the grooves at depths up to 350 to 450 m are also leveled by the intense accumulations of deposits. The remaining territory of the shelves of the Norwegian and Greenland Seas has a shallow, undulating relief caused by extensive development of relict glacio-accumulative formations. The terminal moraine ranges in the transverse grooves, and along the external edge of the shelf, are particularly marked, and indicate the maximum extent of the glacial covers within the limits of the shelf. Terracing of the surface of the shelf of the Norwegian and Greenland Seas is also observed. The terraces at depths of 70 to 90, 150 and 180, and 240 to 270 m are most distinctly traced. Their development took place when the ocean level was lower. The last terrace is dated as pre-glaciations time in the northern hemisphere (Matuyama-Brunhes boundary) when the shelf, for the most part, was land.

The continental slope along both sides of the Norwegian and Greenland Seas has, on the whole, a fairly simple structure. Its dismemberment by underwater canyons, most numerous near the coast of Norway, is typical. The continental slope is less steep along the coast of Greenland and near the southwestern coast of Norway where it has a noticeable block-like dismemberment.

The formation of the continental slope is due to tectonic processes. It represents probably, an edge flexure which developed at the boundary of the continental and oceanic crusts, complicated in a number of places by systems of fractures and faults. The canyons of the slope lie along lines of tectonic disturbances and are shaped by underwater exogenic processes (for example, sludge flows). The edge plateaus represent blocks separated from the shelf and immersed, covered later by a train of deposits carried away from the land and the shelf. Accumulative trains pile up at the foot of the continental slope forming its characteristic concave profile and, on the inclined plains of the foot of the continent, extending into the sea beds. Portions of the very flat continental slope opposite mouths of shelf channels represent, evidently, huge debris cones of sedimentary material, which were carried over a long period from the shelf along these channels, particularly in the period of their subaerial development during the large fast regressions of the ocean (see Fig. 30).

The island shelves of Iceland and the Faeroe Islands are similar in many respects to the continental shelves of the seas. Traces of the action of Pleistocene glaciers in the form of glacio-erosional (valleys and channels) and glacio-accumulative (small hills and ridges) structures of underwater relief are most pronounced on the island shelves. The surface of the underwater Wyville Thomson and Faeroe-Iceland Ridges, as also of the adjoining flat-topped banks of the Rockall Rise, is distinguished by the relatively smooth, slightly undulating forms of relief. It is quite probable that they are composed of covers of Tertiary plateau-basalts known in Iceland, on the Faeroe Islands, in Greenland, and in Scotland (Gakkel et al., 1968; Muratov, 1961). On the other hand, judging by the geographical position, the morphology, and the finds, together with the basalts of the bedrocks of the sedimentary-metamorphic complex on the Faeroe-Iceland Ridge, this region should be considered probably a submerged part of the old Eria platform. Near the continental shelf the rise is crossed by the U-shaped Faeroe-Shetland trough. A similar trough crosses the Iceland-Greenland elevation. there is no doubt that these troughs are caused by tectonic processes and represent components of the system of disjunctive dislocations framing the continental borders.

The depth of the dismemberment on the Iceland Ridge ranges from 300 to 500 m. At a number of places, the rift zone is crossed with deep troughs which are the morphologic expression of transverse fractures along which the displacement of neighboring rift structures takes place. These troughs include the Lena trough on the boundary of the Arctic Basin, a system of two troughs in the region on Jan Mayan Island, and a less clearly expressed trough at 69° north. The present tectonic activity of the rift zone is indicated by the epicenters of numerous near-surface earthquakes concentrated exactly along the rift valleys and transverse troughs (Heezen et al., 1961; Sykes, 1965). Calculations of the stresses in the earthquake foci indicate the presence of tensil stresses directed transverse to the trend of the rift zone (Mucharina, 1967).

A large submarine volcanic massif is seen in the region of Jan Mayan Island, which has a wavy or somewhat undulating surface. South of this stretches the Jan Mayan Ridge, which has a block-shaped structure, a smooth apical surface, and steep side slopes. A similar plateau-like structure is found west of Jan Mayan Island, together with massive, flat-topped mountains. Probably all these forms of relief were caused by the development of covers of Tertiary plateau-basalts in much the way as the basalt plateaus were formed on both sides of the rift zone in Iceland (Muratov, 1961). Judging from its structure, the Iceland plateau is also composed of covers of basalts, through an older series (Johnson et al., 1967). It is highly probable that in the Tertiary period a hugh basalt plateau existed between Greenland, Jan Mayan, and Scotland, which was later fractured into a series of blocks, part of which submerged in the ocean. As the mid-oceanic ridge developed toward the end of the Tertiary and during the Quaternary periods, the Iceland-Jan Mayan region was drawn into its sphere, and the rift zone made its way across the plateau in the form of the Central Graben of Iceland and the Iceland Ridge.

On Figs. 59, 60, and 61 the recent seismic activity or active tectonic life of this area is shown. This history involves block--tectonic processes with displacement as an element of the plate movements. These secondary displacement processes under oceanic conditions produce the mosaic of plateau-basalt blocks as shown on Fig. 62, according to V. Dibner et al. (1965). The general correlation scheme of neotectonic and glacio-isostatic movements after N. Nikolaev (1967) (249) made on the materials from the Scandinavian ice sheet area is shown on Fig. 63.

The simple model (Fig. 64) shows the process stages and possible result of the glacio-isostatic movements in the briefly described special conditions to geological structure in the active barrier zone of the North Atlantic.

At present the maximal water depth in the North Atlantic barriers area is more than 500 m. Notice that the depth between Greenland (now glaciated) and Iceland is less--about 300 m. Using a simple formula (see below) we can calculate the magnitude of submergence of the blocks under ice and the compensated emergence of the blocks between them. One method of preliminary simplified computation is shown on Fig. 65. The isostatic uplift of the

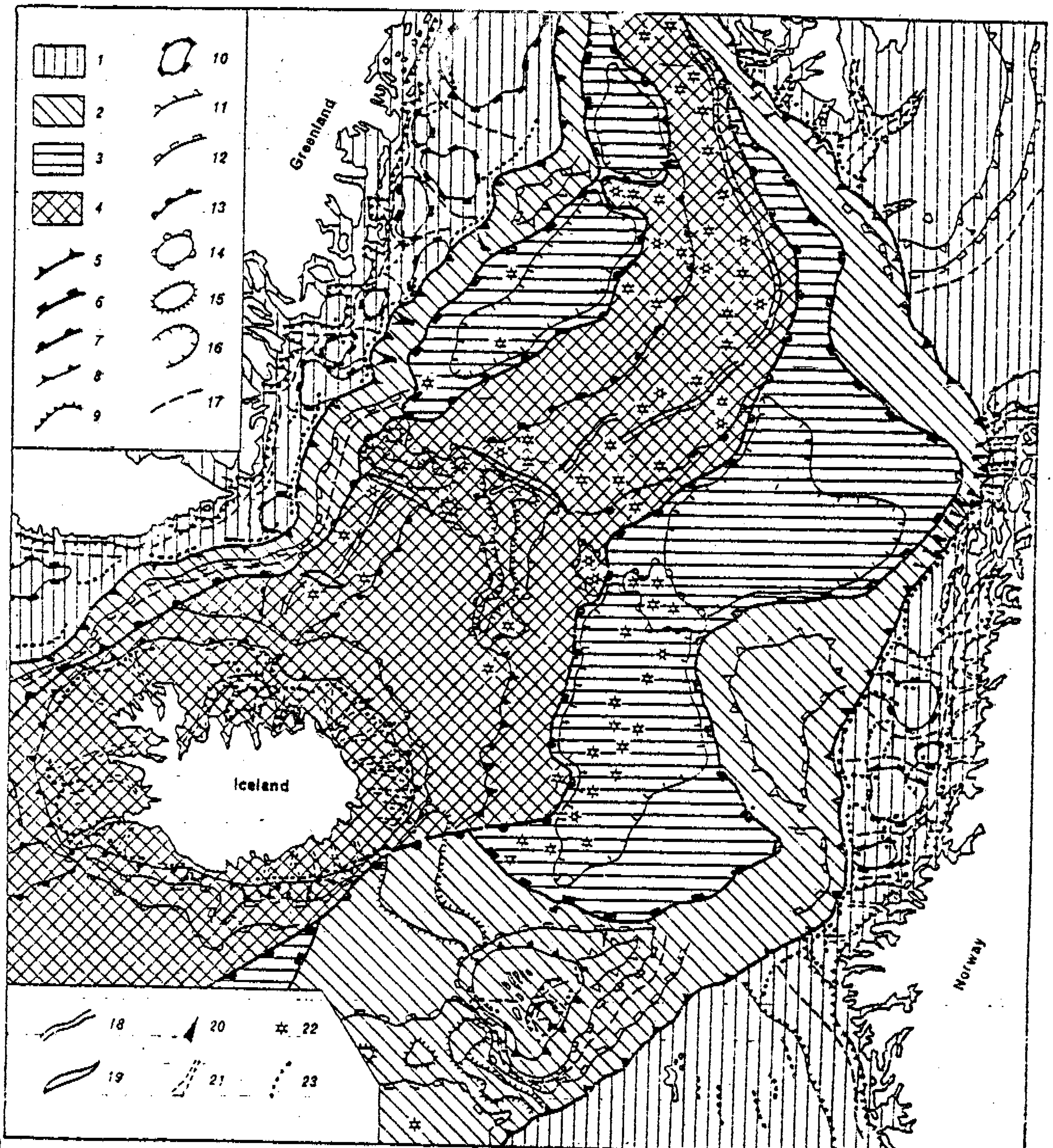


Figure 59 Geomorphologic diagram of the Norwegian-Greenland Basin.

1. continental shelf; 2. continental slope; 3. basin bed; 4. zone of mid-oceanic ridge; 5. edge of continental shelf; 6. foot of continental slope; 7. contour of mid-oceanic ridge; 8. edge of island shelf; 9. small tectonic scarps; 10. contour of rises (banks); 11. external edge of large steps; 12. foot of large scarps; 13. contour of fluted ridges; 14. contour of volcanic massifs; 15. external edge of surfaces of rises, block-shaped ridges, and flat-topped mountains; 16. bottom contour of deep-water troughs; 17. axes of tectonically defined grooves; 18. rift valleys; 19. transverse grooves (fractures); 20. underwater canyons; 21. glacial valleys; 22. volcanic underwater mountains; 23. terminal moraine ranges.

Figure 60 Representative seismisity map from Cutehberg and Riechter (1954).

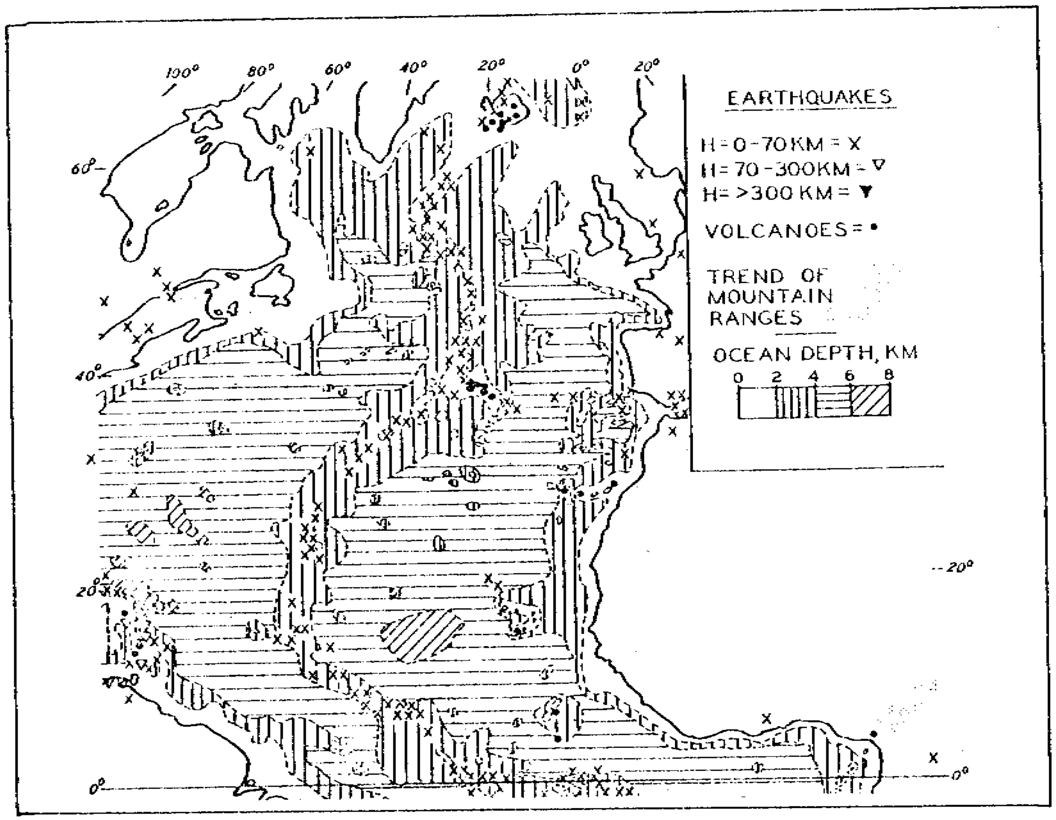


Figure 61 Postulated rotation of Nahsen ridge. Episenters marking plate boundaries. ESSA, CGS data, 1961-1969.

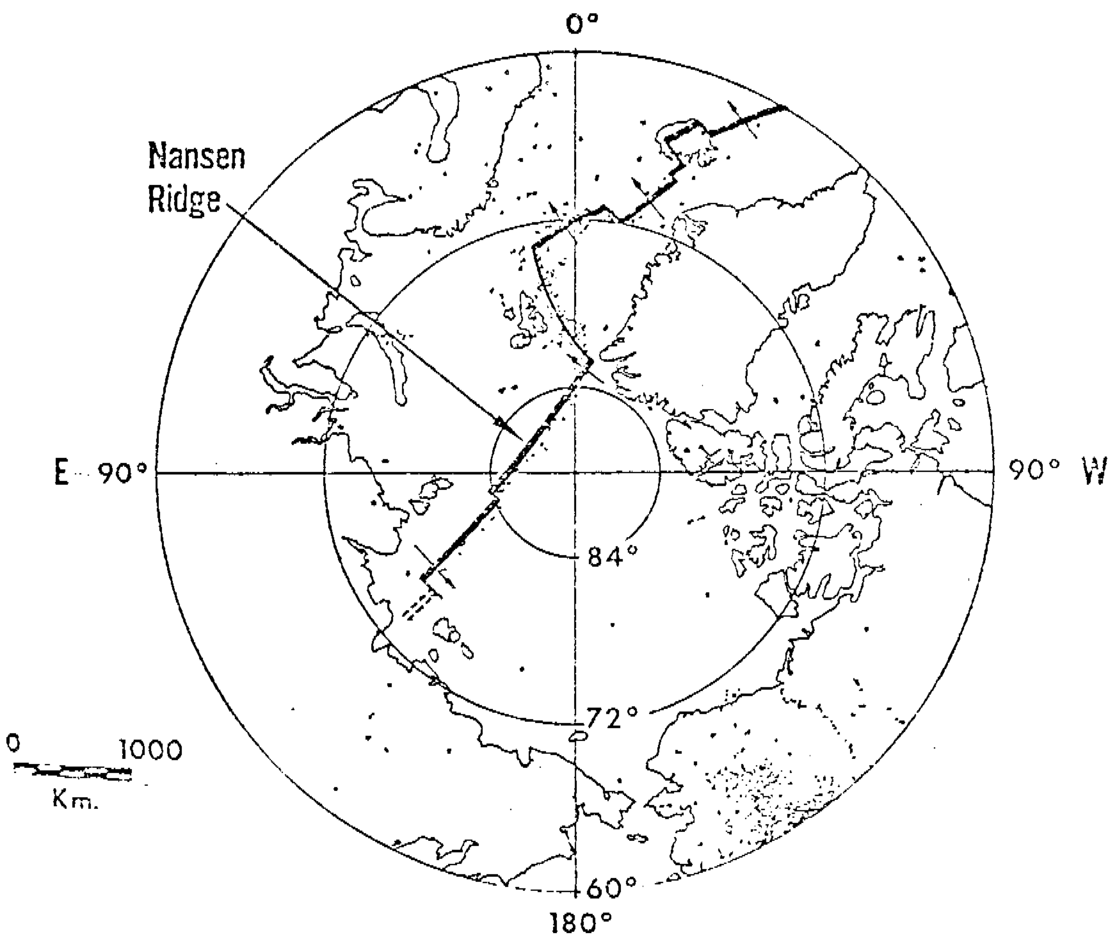


Figure 62 The block tectonics of the plateau basalts according to Dibner (1965).

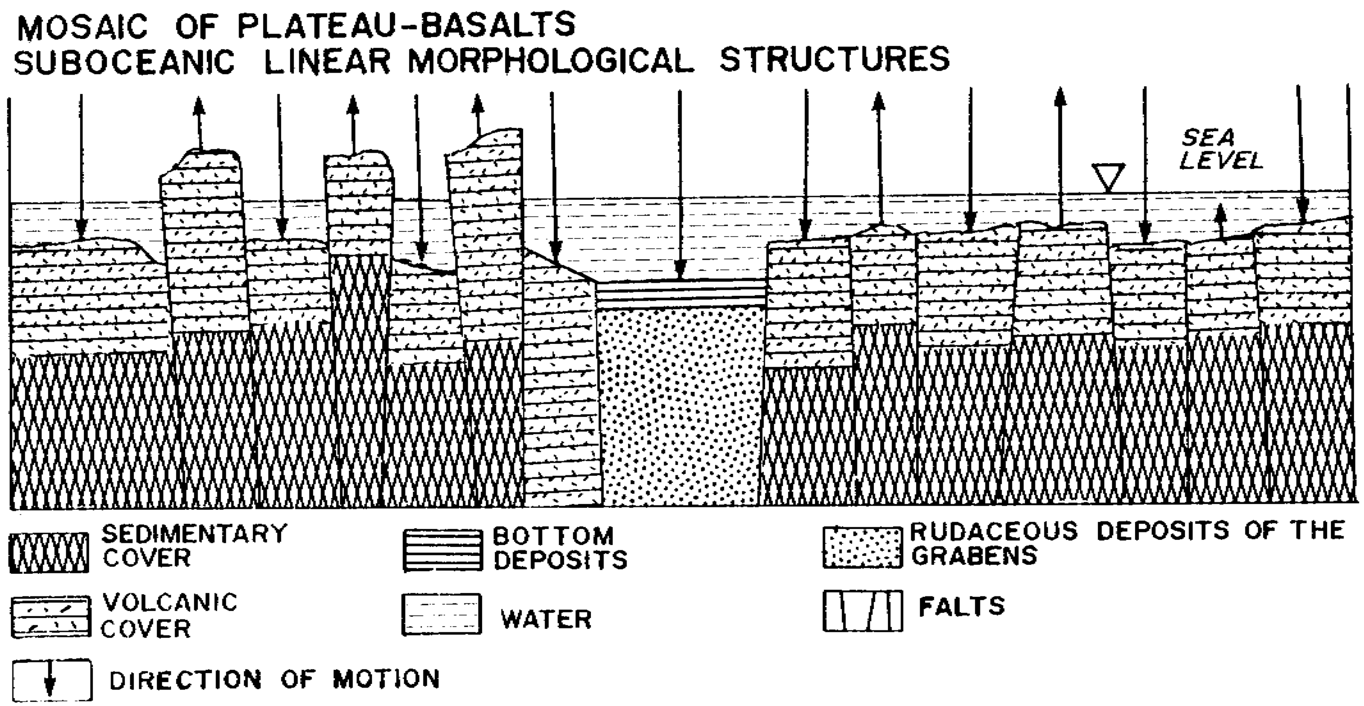
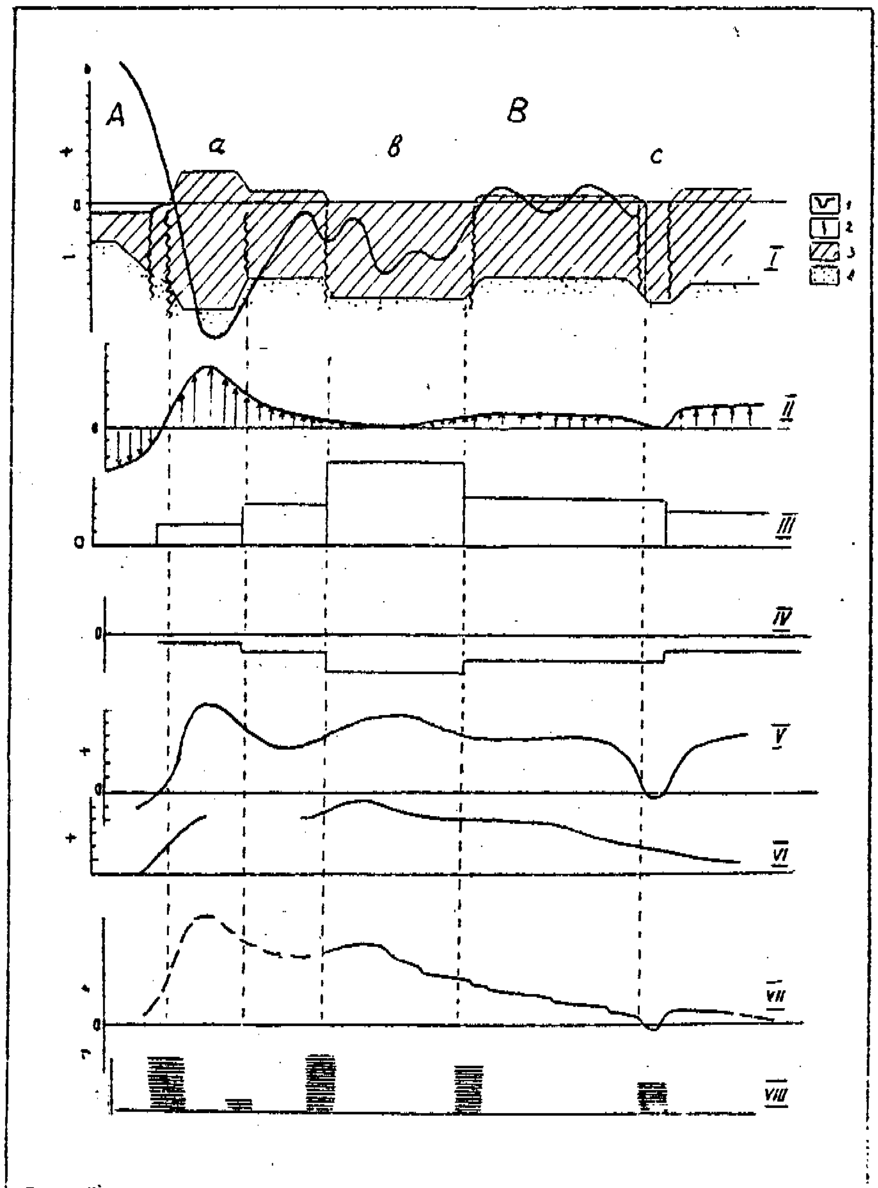
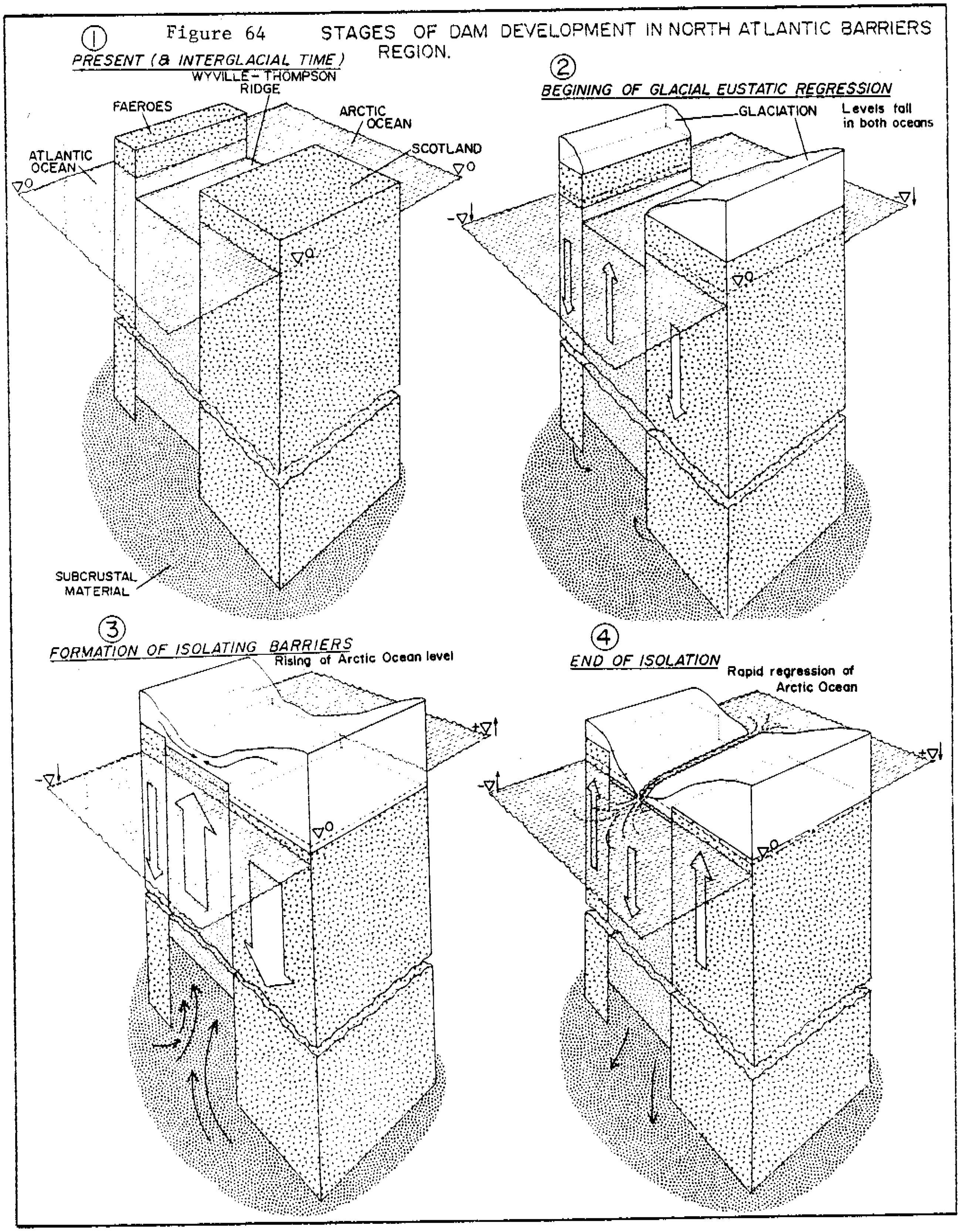


Figure 63 **The general correlation scheme of neotectonic and glacio-isostatic movements for the Scandinavian ice sheet area after Nikolaev (1967).**



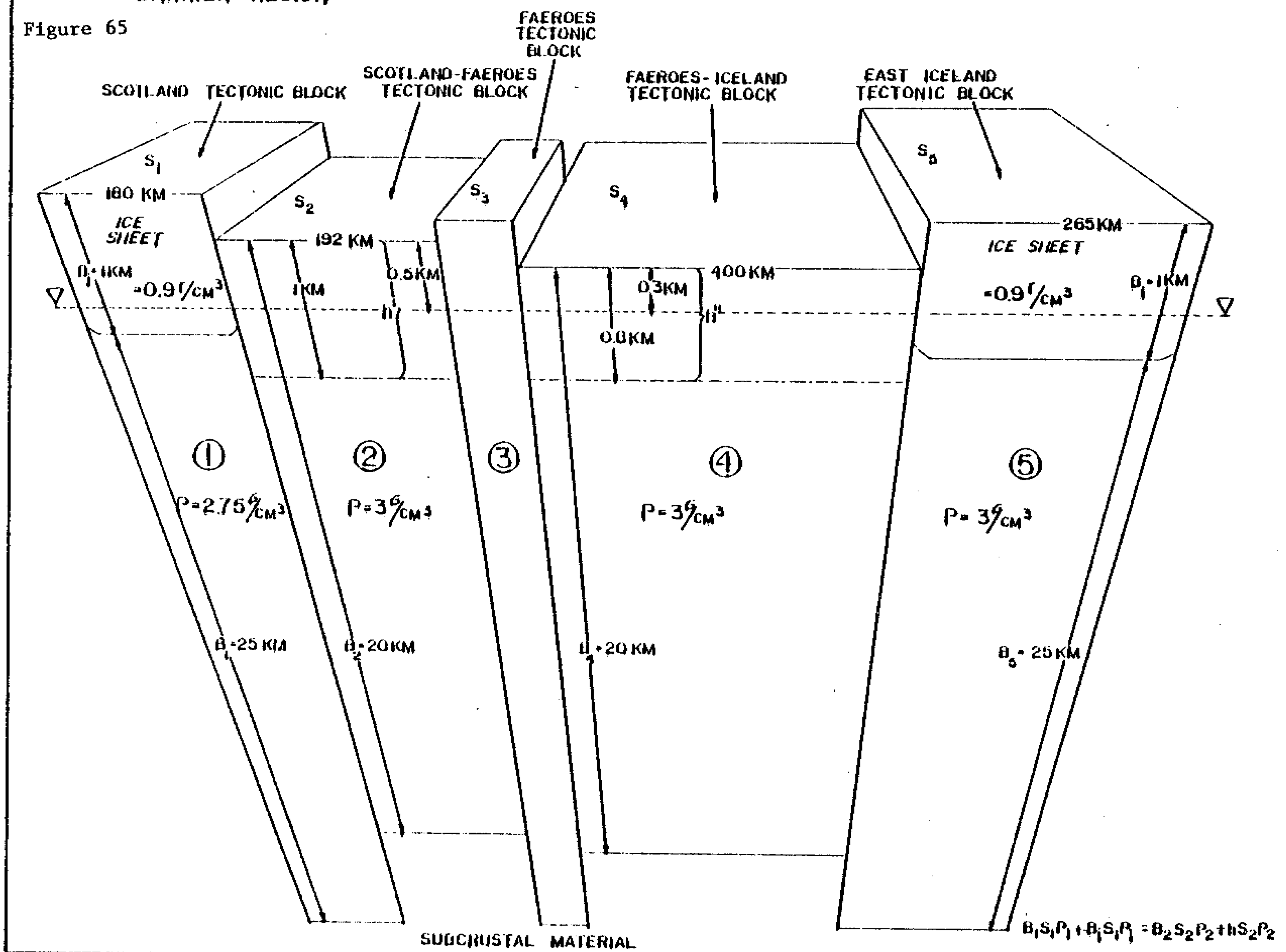
A — the Atlantic ocean; B — the Baltic Shield; a — the epiplatform Scandinavian Mountains; b — the Bothnia-Kandalakshan depression; c — graben; I — thickness of the Earth's core: 1 — gravity anomaly curve (in Bouguer reduction), 2 — main regional fault zones, 3 — the Earth's core, 4 — mantle; II — epure of summary neotectonic movements; III — epure of ice sheet loads; IV — epure of glacioisostatic movements; V — curve of Late- and Post-Glacial movements with interaction of neotectonic and glacio-isostatic components; VI — curve of Late- and Post-Glacial movements after A. Högbom; VII — curve of recent movements; VIII — epure of seismicity level

Figure 64 STAGES OF DAM DEVELOPMENT IN NORTH ATLANTIC BARRIERS REGION.



PRELIMINARY CALCULATION OF SOME BLOCK GLACIO-ISOSTATIC UPLIFT IN THE NORTH ATLANTIC BARRIER REGION

Figure 65



unglaciated block situated between ice loaded blocks can reach 250 m. Glacio-eustatic lowering of the World Ocean at that time might reach 150 m. In this case the water depth in the North Atlantic barriers area was only about 100 m, and in this condition the ice spread across the uplifted area. The result could be the following: the raised block plus the shelf glaciation created the dam and isolated the Arctic Ocean from the Artlantic.

The method of preliminary simplified calculation is based on data about the thickness of the continental and oceanic blocks of the earth's core in the North Atlantic region for each block: Scotland, Faeroes, Iceland and so on, involving density of the core (ρ), density of ice (ρ_i), and the sizes of blocks (thickness-B, areas-S). The preliminary equation looks like this:

$$B_1 S_1 \rho_1 + B_i S_1 \rho_i = B_2 S_2 \rho_2 + hS_2 \rho_2$$

$$h = \frac{B_1 S_1 \rho_1 + B_i S_1 \rho_i - B_2 S_2 \rho_2}{S_2 \rho_2}$$

Calculation shows that the uplift for the block between Scotland and Faeroes was about 0.5 km (h^1), for the block between Faeroes and Iceland was about 0.3 km; this is sufficient for possible dam creation. Of course all the calculations only show some way and point one of the ways for a possible model development.

We see that it is possible to consider the formation of the isolating barriers in the northern Atlantic (Greenland-Iceland-Faeroes Islands-Scotland) and Bering Strait areas as a cumulative result of the: (a) glacial-eustatic regression; (b) isostatic uplift of a peripheral bulge around the glacial shields (Daly, 1934; Fairbridge, Newman, 1968; Newman, Fairbridge, March, 1971); (c) glaciation of emerged and semi-emerged areas.

The transgression of the isolated Arctic Ocean could be about 150-180 m higher than the World Ocean. After the beginning of deglaciation further transgression occurred due to ice-melt, and complete isolation of the Arctic basin was ended in the course of deglaciation. The dams finally ceased to be effective and regression of the Arctic Ocean was rapid. Normal glacial-eustatic transgressions were resumed with warm waters spreading from the Atlantic to the Arctic.

The correlations between the dynamics of the glaciation and changes of levels of the World Ocean and Arctic Ocean are shown on Fig. 66. In the framework of this model, two regression-transgression sedimentation cycles in Arctic Ocean ocrrespond to one cycle in World Ocean, for the same time period (Vigdorchik, 1973 (372).

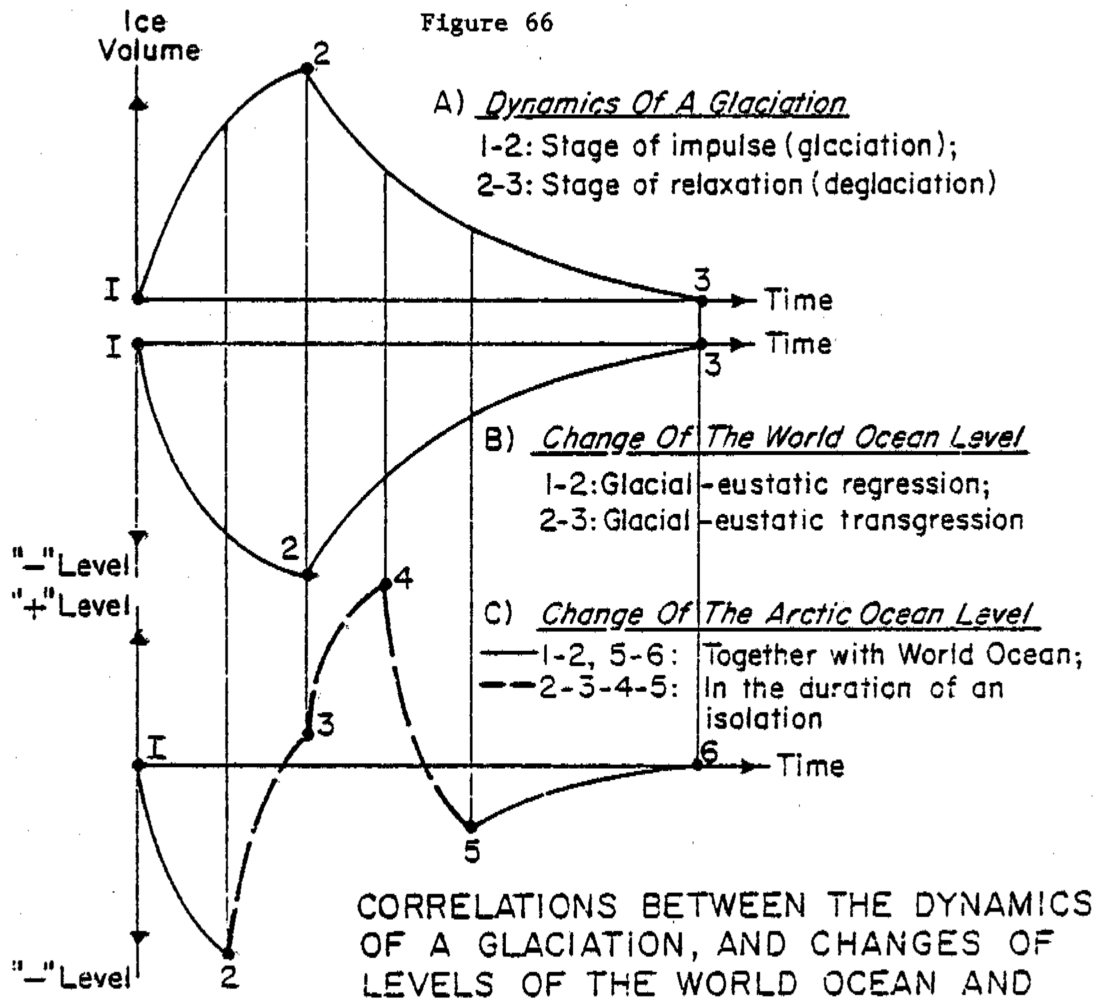
D.4. The Limits of the Arctic Ocean Level Rise.

The uprising of the Arctic Ocean level during maximal glaciation (Illinoian time) could be explained by the Arctic basin receiving river water inflow during several thousand years.

Let us see how the data about continental surface run-off into the Arctic Ocean could be helpful for our preliminary calculations of this ocean level rise during the glaciation. According to Antonov (1958 (9) , this modern run-off is 4380 km^3 per year. As Table 14 shows, the amount during glaciation was less than a third of this modern figure because of the ice sheets extension in a large part of the Arctic basin. So then at that time it was about 1000 km^3 per year.

We saw before that isolation had to take place only at the end of glaciation, occupying only about 3000-4000 years. The area of the Arctic Ocean is 13.1 million km^2. This means that rising of level $(H) = \frac{1000\ km^3 \times 3500\ years}{13.1\ mln\ km^2} = 270$ m. But this figure could not have been reached because of the "Turgai Strait", the big valley to the south of western Siberia, the "Strait" that connected the Siberian basin with the Aral and Caspian Sea basins. This "strait" transferred the surplus ocean water entering the Siberian plains to the Caspian pluvial sea. The terrace from

Figure 66



CORRELATIONS BETWEEN THE DYNAMICS OF A GLACIATION, AND CHANGES OF LEVELS OF THE WORLD OCEAN AND ISOLATED ARCTIC OCEAN

1: beginning of a glaciation, glacio -eustatic regression and glacio -isostatic movements;
1-2: glacio -eustatic regression together with World Ocean;
2: formation of isolating barriers (Greenland-Iceland-Faroes Islands-North Sea shelf; Bering Strait area) as a cumulative result of the a) regression; b) isostatic uplift of a periferal bulge; c) glaciation of emerged and semi-emerged areas;
2-3: transgression of isolated Arctic Ocean because of river waters inflow;
3: maximum of a glaciation, and the beginning of a deglaciation;
3-4: the more intensive transgression, with the addition of ice-melting waters;
4: the end of a complete isolation in course of a deglaciation; the barrier and Arctic Ocean levels are equal, and then are lowering together;
4-5: rapid regression of Arctic Ocean;
5: barriers finally ceased to be effective;
5-6: normal glacio -eustatic transgression up to full relaxation of a glaciation impulse.

Table 14 Continental run-off to the Arctic Ocean (rivers and glacial water) according to V. Antonov (1958).

Drainage Area	The Volume of the Annual Run-off in Km^3
Norwegia and northwest part of the USSR	153
Northern part of Europe	359
Northern part of Asia	2442
Alaska and Canada with islands	1053
Northern part of Greenland with islands	373
The average annual volume of water and ice received by the Arctic Ocean	4380

the maximal glacial age in this strait is about 180-190 m above sea level (Figs. 40 and 67). We could suppose that this figure is the controlling one for the Arctic Ocean level rise during the maximal glaciation. The transgression of the Caspian sea during that time, made possible by the Arctic water surplus inflow, was shown on Fig. 40 (see above). Thus in conclusion we see that the figure for the Arctic Ocean rise would be about 150-180 m.

Some geologists in the Soviet Union estimate that the levels of the cold marine transgressions reached 240 m during the maximal glaciation (Suzdalsky, 1971 (330); W. Zagorskaya, 1972 (398); and others). These scientists think that cold marine transgressions took place during each glaciation, including the last one (Valdai, Wisconsin). Let us emphasize, however, that in our opinion, the data concerning "cold marine transgressions" are persuasive only for the time of the maximal (Illinoian) glaciation, or about 250,000 years ago.

D.5. The Probable Influence of the Arctic Ocean Isolation on the Natural Environment in the Northern Hemisphere.

From the investigation of the composition and microfauna of the Arctic ocean bottom * sediments up to a depth of 4 m, Belov and·Lapina (1960)(49-51) (1973) were able to define a number of horizons formed during warming trends in the Arctic, and a number of other horizons formed during sudden cooling trends associated with the glacial periods. Horizons formed during the warming trends are characterized by the presence of microfauna of the North Atlantic type and by increased concentrations of calcium carbonate, iron, manganese, and organic matter. These sediments are also finer grained. The

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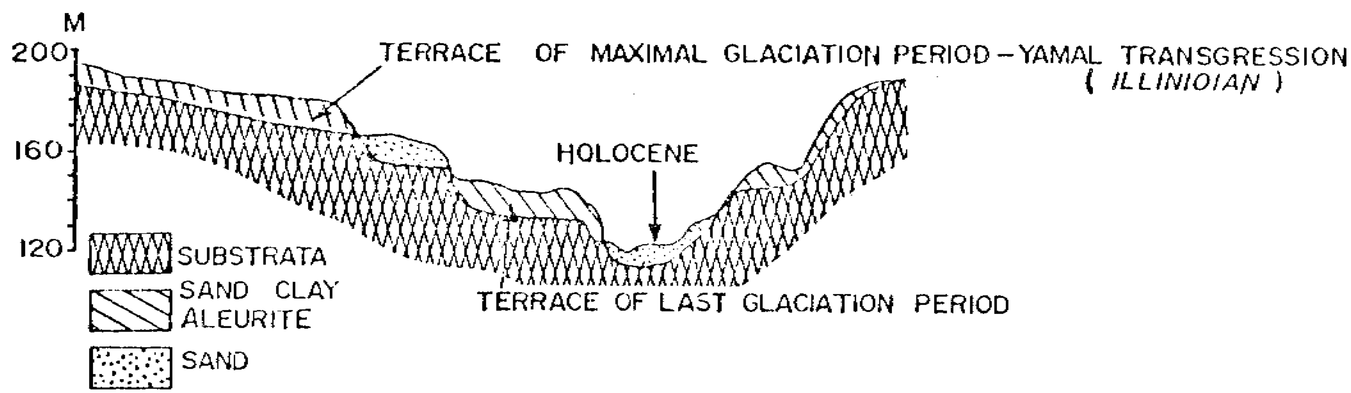
* Teplovaia melioratsia severnyeh Shirot, 1973, Moskva, Nauka.

Figure 67 Geological cross section through Turgai valley according to Bogenova (1975).

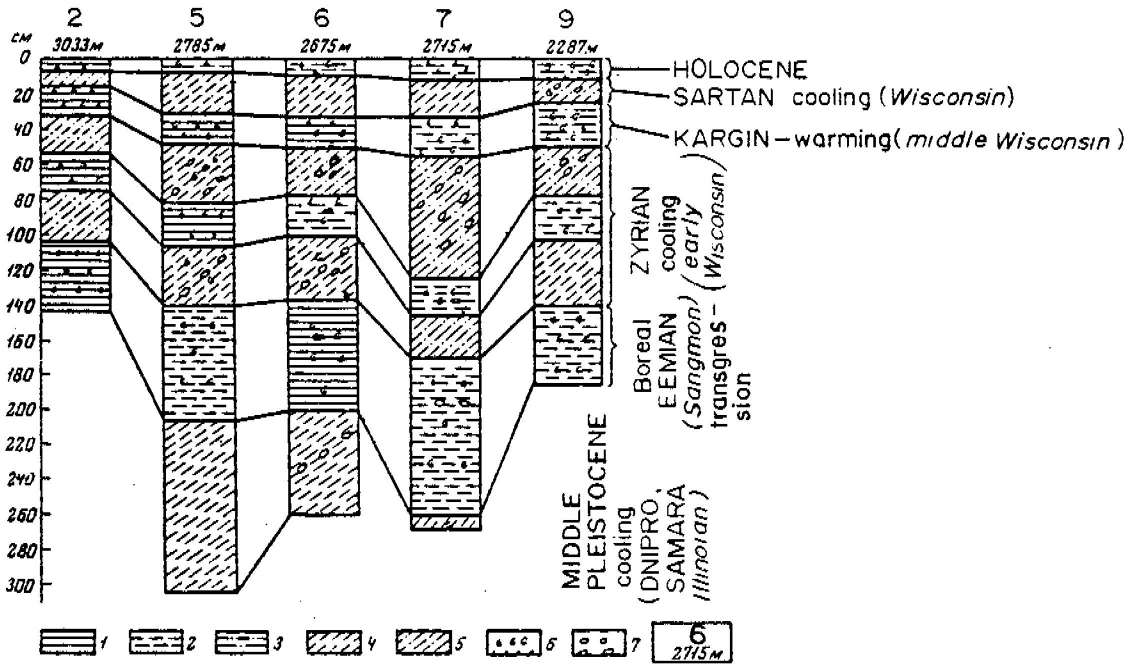


horizons formed during the cooling trends are characterized by the absence of microfauna of the North Atlantic type, and a lower percentage composition of all other components (Fe_2O_3, MnO, and $CaCO_3$). Thus, the analysis of the character of the longer bottom cores has shown that variations with depth are related to alternation of warming and cooling trends in the Northern Hemisphere. Not only climatic but also hydrological changes and sea level fluctuations are reflected in the sedimentary record.

Data have shown that during the cooling trend the total influx of warm Atlantic waters into the Arctic Basin deceased. The possibility that the connection between the Atlantic Ocean and the Arctic Basin was broken at various times is not excluded. During the warming trend the connection between the Atlantic Ocean and the Arctic Basin was re-established and the Atlantic waters flowed into the Arctic Basin over a wide front, just as they do at the present time.

From the structure of the sediments it was possible to calculate their rate of accumulation, their absolute age, and to reconstruct in a general way the geological history of the Arctic Ocean during that time. Briefly, the history of the Arctic Ocean may be recapitulated in the following manner. The longest bottom cores have uncovered the tops of mid-Quaternary deposits, which were formed at the close of the maximum glaciation in Siberia, and are represented by clayey silt with layers of sand and inclusions of gravel and pebbles (Fig. 68). The nature of the sediments of this period, which are characterized by a negligible amount of iron, manganese and calcium carbonate indicate that the climate was severe. The absence of micro-fauna of the North Atlantic type is an indication of the abrupt termination of the influx of warm Atlantic waters into the Arctic Basin. The total duration of the period was not determined by Belov and Lapina.

Fig. 68 Bottom deposits of the Makarov deep (Arctic) after Belov and Lapina (1973).



1-5 mud: 1 - dark-brown and brown layer, 2 - brown, 3 - brown and sandy, 4 - gray and yellow-gray, 5 - gray and yellow-grey sandy, 6 - foraminifer of the North Atlantic types, 7 - gravel, 8 - number of core and depth.

Relief of the floor of the Arctic Basin.

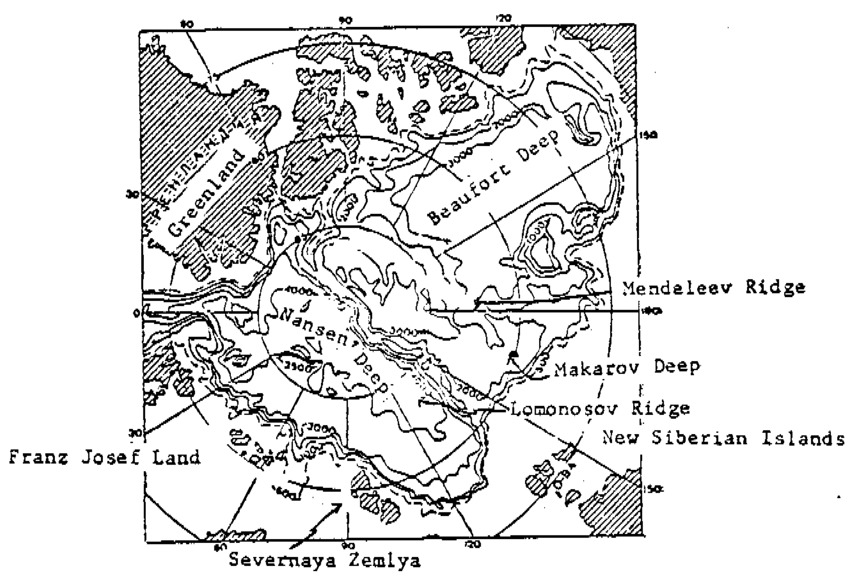


Fig. 69 Locations of cores taken in the Norwegian and Greenland Seas by R. V. Vema.

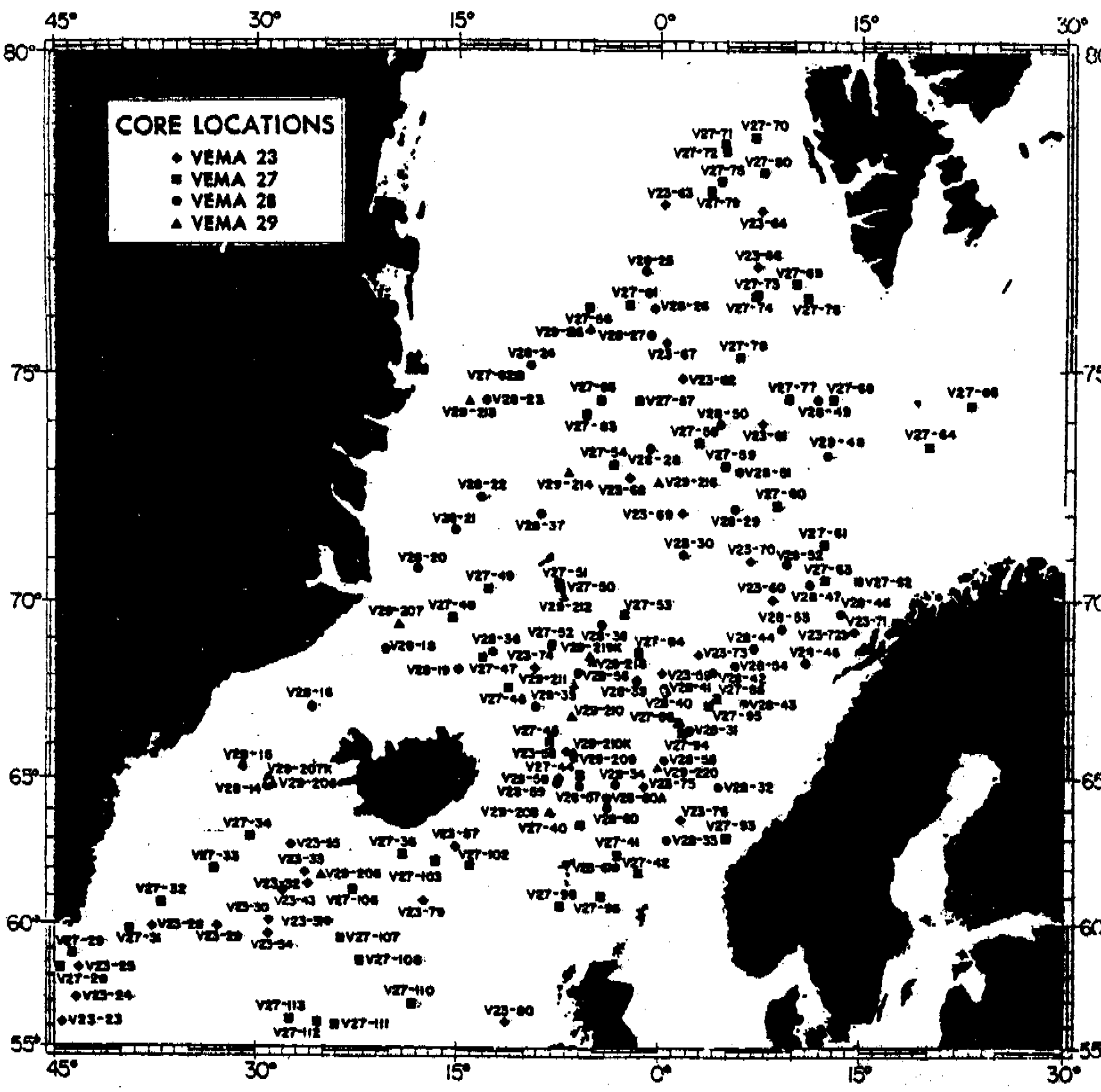


Fig. 70 Variations in the faunal and floral composition in the Norwegian Sea and northern North Atlantic. Climatic zones south of 62°N are based on coccoliths (McIntyre, et al., 1972). Note that subpolar faunas have been present in the Norwegian Sea only twice in the last 150,000 years: at present and about 120,000 years BP., corresponding to the Recent and Eemian (after Kellogg, 1973).

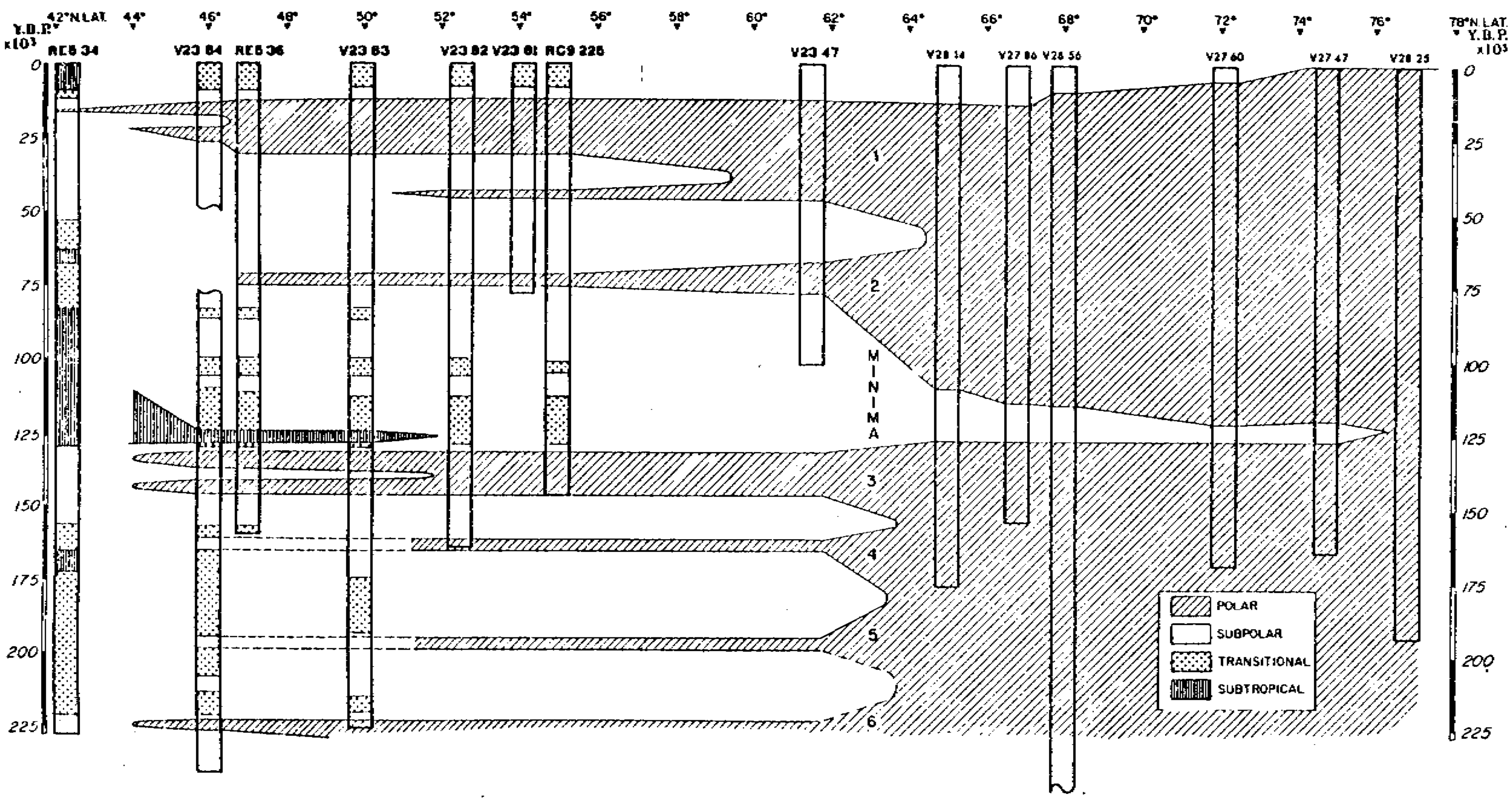


Table 15 Modern Thermal Balance of the Arctic Ocean (k cal/cm^2 year) According to P. Borisov (1970)

Heat Income		Heat Expenditure	
1. Sum of radiation . .	72,6	1. Reflected radiation	54,3
2. Heat from Atlantic water.	2,5	2. Effective radiation	16,8
3. Heat from Pacific water.	0,4	3. Heat exchange with atmosphere	5,0
4. Heat from river water.	0,2	4. Evaporation . .	5,0
5. Arctic heat conservation due to ice export	2,4		
6. Arctic heat conserva tion due to cool water export . . .	3,0		
	81,1		81,1

The Norwegian Sea and North Atlantic deep-sea sediments are relatively unstudied. A number of workers have dealt with the description of a fossil assemblage retrieved from one to several cores (Saito, et al., 1967; Stadum and Ling, 1969; Bjørklund and Kellogg, 1972). Other workers have studied limited numbers of cores covering only a small portion of the region (Böggild 1907; Holtedahl, 1959; Ericson, et al., 1964a; Olausson, 1972; Schreiber, 1967). The most comprehensive of these studies is the work of Ericson, et al., 1964a. In 26 cores from the Norwegian and Greenland Seas, they noted the predominance of "glacial-marine sediment" and suggested, on the basis of frequencies of foraminiferal species in six cores, that the last ice age ended 11,000 years ago in this region. Kellogg (1973) analyzed 34 surface-sediment samples and 6 cores spanning the past 150,000 years and made climatic interpretations based on frequences of foraminiferal species. The results seemed to correspond to the possibility of the periodic isolation of the Arctic (Figs. 69, 70).

The latest data on bottom deposits gathered during the XIth expedition of the ship "Professor Zubov" (Kulikov N. and Shkatov E. 1973 in "Geology of Sea", 3, Leningrad, U.S.S.R.) show a similar picture (Fig. 71). Note the relatively small amount of deposit on the slope of Faeroes Islands in Holocene (upper layer of the bottom deposits, core 22). This fact could possibly reflect the compensated uplift of the Faeroes block after the ice unloading. Likewise the relative thickness of the bottom deposits in the trench between Faeroes and Shetland Islands could be explained by compensated submergence of this block (cores 2 and 18).

The isolation of the Arctic would have had some influence on the important aspects of the natural environment development in the Arctic basin and the Northern Hemisphere (Fig. 72). The dam creation would have

Fig. 71 The bottom deposits cores of Norwegian-Greenland basin according to Kulikov and Shkatov, 1973.

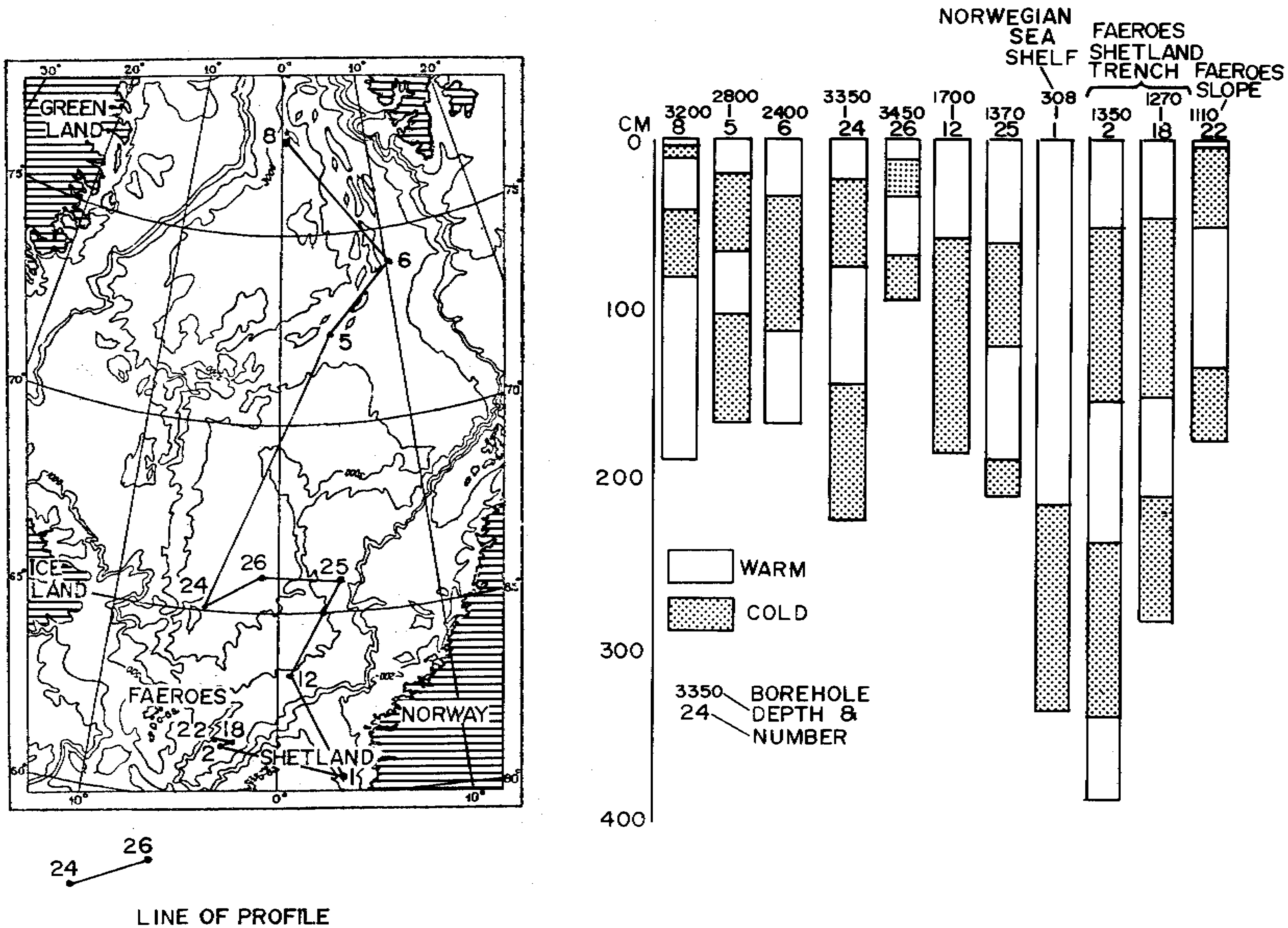
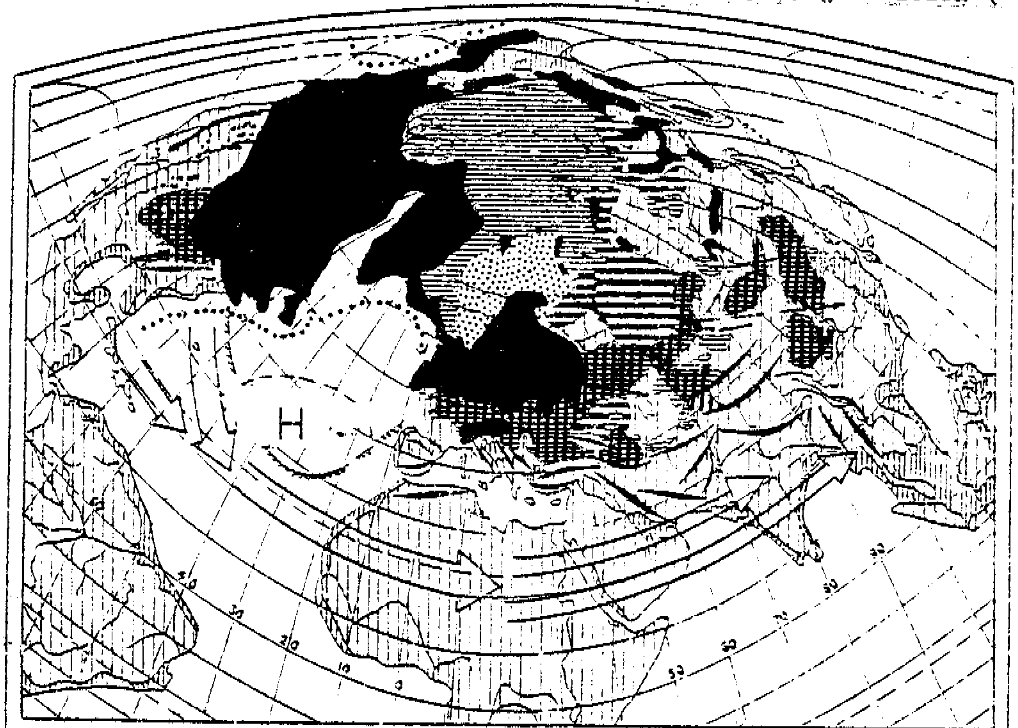
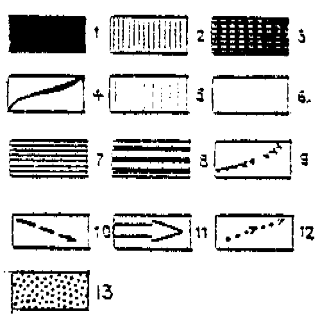


Figure 72 Paleogeographic situation in the Northern Hemisphere during maximal (Illinoian, Dnipro) glaciation (200-250,000 B.P.)





1. The areas of the glaciation extent.
2. The World Ocean shelf exposed because of glacio-eustatic regression.
3. The loess formation areas.
4. The mountain glaciations.
5. The pluvial regions.
6. World Ocean.
7. The isolated Arctic Ocean.
8. The territories innundated by the Arctic Ocean transgression
9. The boundary of the marine ice extent.
10. The main direction of the winds connected with the loess formation.
11. The main trajectory of the cyclones.
12. The "North Atlantic current" direction.
13 Area of possible shelf glaciation

contributed not to the cooling of the Atlantic Ocean during the glaciations, but on the contrary, the conservation of the ocean water heat. As a result the warm, wet air and water masses were directed to the coastal area of Africa and Asia. Let us consider this example from the modern thermal balance of the Arctic Ocean (Table 15). We may suppose that the heat of the Atlantic water (2.5 k cal/cm^2 year) would not be lost by the Atlantic in the case of isolation. We can also add that the currents such as Kebot, Labrador, and eastern Greenland would not bring the cool water (2.4 k cal/cm^2 year and ice (3 k cal/cm^2 year) to the Atlantic. This means that the Arctic loss of heat was about 2.5 + 2.4 + 3.0 = 7.9 (k cal/cm^2 year). On the contrary the figure shows the approximate surplus of heat for the Atlantic if the Arctic was isolated. But what was the figure of real cooling influence because of ice spreading in the North Atlantic and Bering barriers area? The consequences of this heat balance peculiarity are the points of interest for paleoclimatical and paleocenographical reconstructions, including the questions of temperature and salinity of the Arctic water and the permafrost development on the Arctic shelf. The further reconstruction of the atmospheric circulation and calculations of the thermal radiation and oceans water balances would give the picture of the natural conditions very different from the existing consensus. Of course, further investigation could help a great deal with the comprehension of a thermodynamic model of the natural processes that took place during glaciations on the Arctic shelf in connection with the permafrost development.

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In this Quarterly Report we tried to show the data and assumptions that characterize the development of the Arctic Ocean during the maximal (Dnipro, Samara, Illinoian) glaciation more than 200,000 Y.A. We saw the possibility of an ocean isolation at that time. If this was the case, it would have interrupted the exchange of the Pacific and Atlantic water with arctic water, changed the direction and vertical redistribution of the currents, temperatures and salinity of the arctic waters. Also it would have influenced the factors for submarine permafrost development. This data does not represent all available information on this subject, and we will therefore continue this analysis.

However in our next Quarterly Report we propose to also analyze the published Soviet data emphasizing the aspects of the exposure of the Arctic Ocean shelf during post Illinoian glaciation (Wisconsin) and its effects on the arctic water conditions and permafrost development on the shelf; here this exposure was caused by glacio-eustatic lowering of levels together with World Ocean levels (an unisolated condition).

To Be Continued

LIST OF FIGURES

LIST OF TABLES

ADDITIONAL BIBLIOGRAPHY FOR THE CHAPTER D

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FINANCIAL STATUS

Amount dispersed since beginning of work $34,220

Amount dispersed Third Quarter (July-September, 1977) $12,956

DATA MANAGEMENT

DATA MANAGEMENT

Quarterly Report

Contract #03-5-022-56
Research Unit #350
Task Order #2
Reporting Period 7/1 - 9/30/77
Number of Pages

ALASKAN OCS PROGRAM COORDINATION

Mr. Donald H. Rosenberg
Alaska Sea Grant Program
University of Alaska
Fairbanks, Alaska 99701

October 1, 1977

I. Task Objectives

This project provides for coordination of all NOAA/OCS Task Orders within the University of Alaska. It provides for a coordinator and related support services necessary for the accomplishment of the scientific programs. These services include Data Management, Fiscal Management, and Logistics Coordination.

II. Field and Laboratory Activities

Not applicable

III. Results

A. Data Management

1. Data Management Plans

Data management plans for recently approved task orders #33 and 34 need to be formulated. We request a meeting with the appropriate data manager to negotiate the content of these plans as soon as is convenient.

2. Data Submitted this Quarter

Task Order #1, primary productivity and phytoplankton data for '76 Surveyor cruises.

Task Order 27, a partial set of 1977 data has been submitted.

Task Order #12, STD data submitted for Acona cruise.

B. Logistics Coordination

The following cruises and field activities were undertaken within the OCS program and were coordinated through this office:

Field season	Bird Survey	T/O #27
Field Season	Bird Survey	T/O #28
Acona	STD	
Acona	Trace Metals	

C. Contract Monitoring

This office is currently involved in the preparation and submission of FY '78 proposals.

IV. Problems Encountered

Lateness in receiving letters of quidance for changes in renewal proposals has once again placed us in a funding crisis for FY '78.

Further, when letters were sent to the principal investigator, copies have, at times, not been sent to this office. This adds to delays in responding.

Due to, I assume, the work load caused by the finding negotiations for FY '78, we have as yet to meet the Data Managers to pursue revising D. M. P. for new and continuing task orders. Such a meeting is still requested.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 1 R.U. NUMBER: 159/164/427

PRINCIPAL INVESTIGATOR: Dr. Vera Alexander and Dr. Ted Cooney

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

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2	3	4
Discoverer Leg I #808	5/15/75	5/30/75	submitted	submitted	None	None
Discoverer Leg II #808	6/2/75	6/19/75	submitted	submitted	None	None
Discoverer Leg I #810	8/9/75	8/28/75	submitted	submitted	None	None
Miller Freeman #815	11/10/75	11/26/75	submitted	submitted	None	None
Surveyor Su/001/2	3/76	4/76	submitted	submitted	None	None
Surveyor 1	3/15/77	4/6/77	a			
Surveyor 2	4/14/77	5/3/77	a			
Discoverer	5/20/77	6/11/77	a			
UHIH	4/1/77	4/7/77	a			

Note: [1] Data Management Plan and data Formats have been approved and are considered contractual. An update of data management plan, reflecting FY '77 Work Statement must be negotiated.

a. A modified data management plan (see 1 above) is needed in order to schedule the data submission for these cruises.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 2

PRINCIPAL INVESTIGATOR: Mr. Donald H. Rosenberg

No environmental data are to be taken by this task order as indicated in the Data Management Plan.[1] A schedule of submission is therefore not applicable

NOTE: [1] Data Management Plan has been approved and made contractual.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 3 R.U. NUMBER: 291

PRINCIPAL INVESTIGATOR: Dr. C. M. Hoskin

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		
Discoverer Leg I #808	5/15/75	5/30/75	Submitted		
Discoverer Leg II #808	6/2/75	6/19/75	Submitted		
Miller Freeman	8/16/75	10/20/75	Submitted		

All data for FY '76 have been submitted.
FY '77 data (Received in coordination with R.U. #275 and #162) are in final stages of analysis.
Estimated submission date is June 1978.

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

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 5 R.U. NUMBER: 275/276/294

PRINCIPAL INVESTIGATOR: Dr. D. G. Shaw

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

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]		
	From	To	Batch 1	2	3
Silas Bent Leg I #811	8/31/75	9/14/75	None	submitted	submitted
Discoverer Leg III #810	9/12/75	10/3/75	None	None	submitted
Discoverer Leg IV #812	10/3/75	10/16/75	Submitted	None	submitted
Surveyor #814	10/28/75	11/17/75	None	submitted	None
North Pacific	4/25/75	8/7/75	submitted	None	None
Contract 03-5-022-34	Last	Year	submitted	submitted	submitted
Moana Wave MW 001	2/21/76	3/5/76	None	submitted	submitted
Miller Freeman	5/17/76	6/4/76	submitted	None	None
Glacier	8/18/76	9/3/76	None	submitted	None
Discoverer	9/10/76	9/24/76	None	submitted	submitted
Moana Wave	10/7/76	10/16/76	None	submitted	submitted
Acona	6/25/76	7/2/76	submitted	submitted	submitted
Discoverer	5/20/77	6/11/77	3/31/78	None	None
Acona	6/22/77	6/27/66	3/31/78		

Note: [1] Data Management plan has been approved and made contractual.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 6 R.U. NUMBER: 99

PRINCIPAL INVESTIGATOR: Dr. P. Jan Cannon

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable[1].

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

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 7 R.U. NUMBER: 178

PRINCIPAL INVESTIGATOR: Dr. Robert J. Barsdate

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable[1].

NOTE: [1] Data Management Plan has been approved and made contractural.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

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		submitted			
Kotzebue Sound	Summer 1976		submitted			
Alaska Peninsula	Summer 1977		3/31/78			
St. Lawrence Is.	Summer 1977		3/31/78			

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

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 12 R.U. NUMBER: 162/163/288/293/312

PRINCIPAL INVESTIGATOR: Dr. D. C. Burrell

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

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2	3	4
Discoverer Leg II #808	6/2/75	6/19/75	*	*	None	*
Silas Bent Leg I #811	8/31/75	9/14/75	None	None	None	None
Discoverer Leg IV #812	10/8/75	10/16/75	*	*	None	*
Miller Freeman	8/16/75	10/20/75	None	None	Unknown	None
Discoverer Leg III #810	9/12/75	10/3/75	None	None	None	*
North Pacific	4/25/75	8/7/75	None	None	Unknown	None
Intertidal Biota		1975	None	None	Unknown	None
Discoverer #816	11/12/75	12/2/75	*	*	None	*
Contract 03-5-022-34	Last	Year	*	None	None	None
USCGC Glacier	8/18/76	9/3/76	*	None	None	None
Discoverer	9/10/76	9/24/76	*	None	None	None

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

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 5	6	7	8
Discoverer Leg II 808	6/2/75	6/19/75	*	None	None	None
Silas Bent Leg I 811	8/31/75	9/14/75	None	None	None	None
Discoverer Leg IV 812	10/8/75	10/16/75	*	*	None	None
Miller Freeman	8/16/75	10/20/75	None	Lost	*	*
Discoverer Leg III 810	9/12/75	10/3/75	None	*	None	None
North Pacific	4/25/75	8/7/75	None	Lost	Lost	Lost
Intertidal Biota		1975	None	None	*	*
Discoverer 816	11/23/75	12/2/75	*	None	None	None
Contract 03-5-022-34	Last	year	*	None	*	*
Glacier	8/18/76	9/3/76	*	*	None	None
Acona	7/25/77	7/30/77	3/31/78	None	None	None

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 9	10		
Discoverer Leg II 808	6/2/75	6/19/75	*	*		
Silas Bent Leg I 811	8/31/75	9/14/75	*	*		
Discoverer Leg IV 812	10/8/75	10/16/75	*	*		
Miller Freeman	8/16/75	10/20/75	none	none		
Discoverer Leg III 810	9/12/75	10/3/75	none	none		
North Pacific	4/25/75	8/7/75	none	none		
Intertidal Biota		1975	none	none		
Discoverer 816	11/23/75	12/2/75	*	*		
Contract 03-5-022-34	Last	year	*	none		
Moana Wave	3/76	4/15/76	*	none		
Beaufort Sea Sediments	-	-	*	*		
Acona	4/6/77	4/14/77	9/30/77			
Acona	7/25/77	9/30/77	3/31/77	none		

* All data suitable for format entry have been punched. Computer processing is occurring.

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University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 13 R.U. NUMBER: 156/164

PRINCIPAL INVESTIGATOR: Dr. R. T. Cooney

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		
Discoverer Leg I #808	5/15/75	5/30/75	submitted		
Discoverer Leg II #808	6/2/75	6/19/75	submitted		
Discoverer Leg I #810	8/9/75	8/28/75	submitted		
Miller Freeman #815	11/10/75	11/26/75	submitted		
Contract #03-5-022-34	Last	Year	submitted		
Surveyor 001/2	3/76	4/76	submitted		
Discoverer 002	8/3/76	8/17/76	submitted		
Discoverer	6/28/77		(a)		

Notes: [1] Data Management Plan has been approved and made contractual. Format has been received and approved by all parties.

a. To be submitted in FY '78 as per guidence letter.

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University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 15 R.U. NUMBER: 5/303

PRINCIPAL INVESTIGATOR: Dr. H. M. Feder

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

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2		
Discoverer Leg I #808	5/15/75	5/30/75	submitted	None		
Discoverer Leg II #808	6/2/75	6/19/75	submitted	None		
Miller Freeman	8/16/75	10/20/75	submitted (a)	submitted		
Miller Freeman	3/76	6/76	(a)	(b)		

Note: [1] Data Management Plan and Data Format have been approved and are considered contractual.

(a) Only selected samples were processed

* That portion of cruise 808 grabs sorted, were submitted. The remainder are currently being sorted.

(b) Data has been keypunched and is currently being transferred to tape.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 19 R.U. NUMBER: 289

PRINCIPAL INVESTIGATOR: Dr. T. C. Royer

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

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]		
	From	To	Batch 1	2	3
Acona #193	7/1/74	7/9/74	submitted	None	None
Acona #200	10/8/74	10/14/74	submitted	None	None
Acona #202	11/18/74	11/20/74	submitted	None	None
Acona #205	2/12/75	2/14/75	submitted	None	None
Acona #207	3/21/75	3/27/75	submitted	None	None
Acona #212	6/3/75	6/13/75	submitted		
Oceangrapher #805	2/1/75	2/13/75	submitted	None	None
Silas Bent #811	8/31/75	9/28/75	Submitted		
Discoverer #812	10/3/75	10/16/75	(a)		
Surveyor #814	10/28/75	11/17/75	submitted		
Discoverer #816	11/23/75	12/2/75	(b)	None	None
Station 60	6/2/74	9/10/74	None	(c)	None
Station 64	4/28/75	5/20/75	None	(c)	None
Station 9	-	-	-	(c)	
Station 9	-	-	-	(c)	
Moana Wave MW 001	2/21/76	3/5/76	submitted		
Moana Wave MW 003/004	4/20/76	5/21/76	submitted		
Moana Wave MW005	7/22/76	8 /1/76	submitted		
Surveyor SU 003	9/7/76	9/17/76	submitted		

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2	3	
Surveyor	9/20/76	10/2/76	7/15/77			
Miller Freeman	11/1/76	11/19/76	submitted			
Moana Wave	10/7/76	11/16/76	submitted			
Miller Freeman	3/9/77	4/2/77	submitted			
Acona	8/11/77	8/14/77	12/15/77			

Note:

[1] Data Management Plan and Data Formats have been approved and are considered contractual.

(a) Parent tapes were coded in PODAS format, tapes were submitted to F. Cava as requested.

(b) Data useless due to malfunction of shipboard data logger.

(c) See following memo; copy enclosed, and problems section of Report.

INSTITUTE OF MARINE SCIENCE

MEMORANDUM

TO: Ray Hadley, Data Manager for Sea Grant

FROM: Dave Nebert, IMS Data Management DN DATE: 25 March 1977

SUBJECT: Forwarding Current Meter Data to NODC

Current meter data to be forwarded to NODC under contractual agreement are:

IMS Designation	Dates of Mooring	Translated by	Anticipated Completion Date
GASS 60	2 July-26 Aug 74	Aanderaa, Norway (PMEL)	2 May 77
GASS 64	28 Apr-11 Jun 75	PMEL	Unknown
GASS 9B	21 Apr-23 Jun 76	PMEL	Unknown
GASS 9C	23 Jun-4 Nov 76	Aanderaa, B.C.	2 May 77

We are presently developing current meter processing programs and IMS data files. Those data that have been translated by Aanderaa and subsequently processed by IMS should be delivered to you in NODC format by 2 May 1977. This will include documentation on processing. Lack of documentation from PMEL preclude forwarding data translated by that organization. We are able to forward GASS 60 data because original data tapes were returned to us after processing by PMEL. They were subsequently translated by Aanderaa, Norway and processed by IMS. We cannot forward data from GASS 64 or GASS 9B until we either receive adequate documentation from PMEL or they return the original data tapes for subsequent translation by Aanderaa.

DN/sr

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 20 R.U. NUMBER: 281

PRINCIPAL INVESTIGATOR: Dr. H. M. Feder

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

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]	
	From	To	Batch 1	2
Silas Bent Leg I #811	8/31/75	9/14/75	submitted	None
Discoverer Leg IV #812	10/8/75	10/16/75	submitted[a]	None
North Pacific	4/25/75	8/7/75	None	submitted
Discoverer #816	11/23/75	12/2/75	submitted	None
Contract #03-5-022-34	Last	Year	submitted	
Moana Wave	3/30/76	4/15/76	submitted	
Discoverer 001	3/17/76	3/27/76	(b)	
Miller Freeman			(b)	

Note: [1] Data Management Plan and Data Formats have been approved and are considered contractual.

(a) Only samples for Kodiak area were processed and submitted as requested.

(b) Selected samples will be processed to provide seasonal coverage as deemed necessary.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 21 R.U. NUMBER: 284

PRINCIPAL INVESTIGATOR: Dr. R. L. Smith

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			
Rex Sole			(a)			
Flathead Sole			(a)			
Pollock			(a)			
Arrowtooth Flounder			(a)			
Turbot			(b)			
Capelin			(b)			
Eelpout			(b)			
Rock Sole			(b)			
Dover Sole			(b)			

Note: [1] Data Management Plan has been approved and made contractual.

(a) Data submitted with errors, now being corrected for resubmission, expected date of corrected submission 11/1/77.

(b) Data in keypunching. Expected date of submission 11/1/77.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 23 R.U. NUMBER: 351

PRINCIPAL INVESTIGATOR: Ms. E. R. Dieter

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable[1].

NOTE: [1] Data Management Plan has been approved and made contractual.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 24 R.U. NUMBER:

PRINCIPAL INVESTIGATOR: Mr. David M. Hickok

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable[1].

NOTE: [1] Data Management Plan has been approved and made contractual.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 25 R.U. NUMBER: 347

PRINCIPAL INVESTIGATOR: Mr. James Wise

No environmental data are to be taken by this task order as indicated in the Data Management Plan. A schedule of submission is therefore not applicable[1].

NOTE: [1] Data Management Plan has been approved and made contractual.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 27 R. U. #441

PRINCIPAL INVESTIGATOR: Dr. P. G. Mickelson

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

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2	3	4
1976 Field Season	6/4/76	9/15/76	6/30/77*	6/30/77*	5/30/77*	9/30/77*
1977 Field Season	Current					

Cruise/Field Operation	Batch 5	6	7	8
1976 Field Season	5/30/77*	5/30/77*	4/30/77*	4/30/77*
1977 Field Season				

*Data submission delayed due to current field season.

1 Data management plan has been submitted and approved by F. Cava; we await contractual approval.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 28 R.U. NUMBER: 458

PRINCIPAL INVESTIGATOR: Dr, G. F. Shields and Mr. L. J. Peyton

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

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2	3	4
1976 Field Season	6/14/76	8/24/76	Submitted	None	12/31/77	Submitted
1977 Field Season	Current		Submitted in part			

	Batch 5			
1976 Field Season	12/31/77			
1977 Field Season				

1 Data management plan has been submitted and approved by F. Cava; we await contractual approval.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 29

PRINCIPAL INVESTIGATOR: Dr. H. M. Feder

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

Cruise/Field Operation	Collection Dates		Estimated Submission Dates[1]			
	From	To	Batch 1	2	3	4
Big Valley 001	6/17/76	6/23/76	(a)			
Big Valley 002	7/18/76	7/28/76	(a)			
Big Valley 003	8/19/76	8/29/76	(a)			
Big Valley 004	3/3/77	3/18/77	(a)			

NOTE: [1] Data Management Plan submitted August 16, 1976, we await formal approval by Contracting Officer.

(a) Data have been keypunched, conversion to tape is being accomplished.

OCS COORDINATION OFFICE

University of Alaska

ENVIRONMENTAL DATA SUBMISSION SCHEDULE

DATE: September 30, 1977

CONTRACT NUMBER: 03-5-022-56 T/O NUMBER: 30 R.U. NUMBER: 502

PRINCIPAL INVESTIGATOR: H. M. Feder
University of Alaska

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		
Miller Freeman	9/1/76	10/15/76	12/30/77[a]		

Note: [1] Data management plan was submitted on 8/30/76, approved by M. Pelto on 9/13/76; we await approval by the contracting officer.

[a] Raw field data was submitted at the end of the cruise. Verified and formated data will be submitted on above date.

QUARTERLY REPORT

Research Unit 362

Quarter Ending - 15 September 1977

Establish and Service a Project Marine Baseline Data Base for the Alaska MEA Program.

Submitted by: John J. Audet
Principal Investigator
National Oceanographic Data Center
Environmental Data Service
National Oceanic and Atmospheric Administration

October 1, 1977

DIGITAL DATA

A total of 42 data sets were received (excluding resubmissions) by NODC and NGSDC this quarter and a similar total of 42 data sets were 'final processed'. The totals to date are 712 data sets received and 344 final processed. Of this total, 573 data sets have been tentatively accepted by the Data Centers for further processing. There are 124 data sets being held for additional information or resubmissions.

The distribution and status of data sets by discipline is as follows:

	Received	Finaled	In Hold	In Processing
Biological	531	203	111	217
Physical	166	130	11	25
Chemical	11	9	0	2
Geological	4	2	2	0
	712	344	124	244

The data sets received for each file type during this quarter are shown in Table 1. The distribution of these data sets by lease area is included in this table.

TABLE 1. - Distribution of Data Sets Received between 6/16/77 and 9/15/77.

File Type-Format Name	Total	Lease Area Code								
		1	2	3	4	5	6	7	8	9
013-Fish Pathology	1	-	-	1	-	-	-	-	-	-
015-Current Meters	2	-	-	-	2	-	2	-	-	-
022-STD Data	5	5	1	3	-	-	-	-	-	-
023-Fish Resource	4	4	-	4	-	-	-	-	-	-
024-Zooplankton	3	1	2	1	-	-	-	-	-	-
030-Intertidal	4	4	-	4	-	-	-	-	-	-
033-Marine Bird Sighting	4	-	-	-	-	-	-	4	-	4
034-Marine Bird-Land Census	1	-	-	-	-	-	-	1	-	1
035-Marine Bird Colony	4	-	-	-	-	-	-	4	-	4
056-Lagrangian Meas.	8	-	-	-	-	8	-	-	-	-
063-Marine Invertebrate Path.	1	-	-	-	-	-	-	1	-	1
101-Wind Data	5	3	-	-	-	1	-	1	-	-
	42									

Lease Area Code
1 - NEGOA
2 - Lower Cook Inlet
3 - Kodiak
4 - St. George
5 - Beaufort
6 - Bristol
7 - Norton
8 - Aleutians
9 - Chukchi

DATA REPORTS

A total of 39 data reports were received from the Project Offices this quarter. As with previous data reports entered in the data tracking system, many of these reports are RU. quarterly and annual reports that include tabular data which identifies specific dates and lease areas. The distribution of reports by discipline and lease are for this quarter is shown in Table 2.

Table 2. Distribution of Data Reports received between June 16, 1977 and September 15, 1977.

Discipline	Total	Lease Areas									General
		1	2	3	4	5	6	7	8	9	
Mammals	3	1	-	-	2	-	2	1	-	2	-
Birds	3	1	-	-	1	-	2	1	-	-	-
Fish/Plankton/Intertidal	6	1	1	2	-	3	1	2	-	2	-
Chemistry/Microbiology	3	-	1	-	-	-	-	1	-	-	1
Phy. Oceanography/Meteor.	2	1	-	-	1	2	1	1	-	1	-
Geology/Geophysics	6	3	1	-	3	1	2	1	-	-	-
Sea Ice/Permafrost	12	-	-	-	1	12	1	-	-	5	-
Maps/Charts and General Reports	4	-	-	-	-	1	-	-	-	1	2
	39										

ROSCOPs

A total of 38 ROSCOPs were received this quarter. A total of 304 have been received to date for OCSEAP surveys and cruises. ROSCOPs for this quarter were received by ADF&G, Univ. Alaska, Univ. Washington, Univ. California, USFWS, USGS, NMFS and PMEL.

DATA REQUESTS

Requests for OCSEAP data continue to increase each quarter. The following is a list of requests received during this quarter.

Date Received	Date Completed	Requestor/Description
7/7	7/12	Cava (JPO) - Data report on Otolithic keys to Project Office.
7/11	8/30	Pelto (JPO) - Selected plots of temp., salinity and density vs. depth for file ID DI 76B3 (90 plots).
7/28	8/8	Cava (JPO) - Tape copy of STD data (file ID 814IMS) to Feely (PMEL).
8/1	8/2	Wilson (SAI) - Tape copy of Carey 032 data - File ID OCS-3.
8/2	Partial	Wilson (SAI) - tape copy of selected OCSEAP data files - all 029, 032 and 073 finalized data forwarded - other files to follow.
8/12	8/16	Cava (JPO) - Data report on Otolithic keys to Peter Craig (RU 467).
8/12	8/17	Cava (JPO) - Tape copy of STD data (file ID IMS810) to Hadley (IMS).
8/14	8/19	Cava (JPO) - Tape copy of STD data (file ID IMS 812) to Feely (PMEL).
8/15	9/21	Crane (NODC) - Copy of NODC taxonomic codes on diskettes.
8/15	8/30	Dale (NODC) - Tape copy of Lagrangian data - (file IDs 770523-30) to Stateman (AIDJEX).
8/21	9/2 and 9/7	Fischer (Program Office) - request by BLM (Nancy Maynard) for coral data from file types 023 and 032. Listing's and annotated plots forwarded to Anchorage office.
8/30	-	Johnson (Arctic Project) - STD formatted output and annotated station plots for bottom temperatures - File IDs W00025 and W00027. (File ID W00027 just received at NODC on 9/28/77)

Data Received	Date Completed	Requestor/Description
9/6	9/14	Crane (NODC) - Listing and plots of ichthyoplankton/meroplankton species within 200 miles of Alaskan coast - for Eugene Buck AEIDC .
9/8	9/9	Fischer (Program Office) - request for updated data tracking info. for all chemistry investigations.

NGSDC has serviced several for the Alaskan area which included digital earthquake data and analog seismic profiles from OCSEAP studies.

FORMAT DEVELOPMENT

A copy of all current OCSEAP format codes was distributed to each OCSEAP office during this quarter. A format 'fact' sheet was distributed to all OCSEAP data management personnel on August 23 and included modifications to 6 formats and 16 codes. A copy of all OCSEAP formats and their codes was forwarded to the Program Office (Overstreet) on September 15 for the RPC review of 'core data' and digital data requirements.

The task for digitizing all format codes is underway. Personnel in NODC's Application Design Branch developed a format for the codes that will be system-compatable. Mike Crane's office will process the initial version of the codes on diskettes and forward them to NODC for further work.

The status of all OCSEAP formats undergoing any action during this quarter is indicated in Table 3.

File Type	Format Name	Forwarded to JPO	Approved by JPO	Distributed to OCSEAP
033	Marine Bird Sighting (mod.)	2/28/77	5/23/77	6/28/77
035	Marine Bird Colony (mod.)	2/28/77	5/23/77	9/23/77
061	Trace Elements (new)	3/14/77	5/24/77	6/23/77
024	Zooplankton (mod.)	4/21/77	5/17/77	6/23/77
025	Mammal Specimen (mod.)	5/4/77	6/20/77	(9/23/77)
027	Mammal Sighting I (mod.)	5/4/77	6/20/77	(9/23/77)
063	Marine Invertebrate Pathology (new)	9/14/77	-	-
038	Migratory Bird Seawatch (mod.)	9/15/77	-	-
057	Herring Spawning (mod.)	9/15/77	-	-

DATA PROCESSING

Steps to assist the Project Offices in evaluating data sets prior to final processing are being established.

- Checking program results for all data sets will be forwarded to the Project Offices along with parameter inventories and taxonomic code summaries (with codes translated).

- Range checks, more complete parameter inventories and format code translations are being developed. Range checking for physical and chemical data formats will be tested this month. Biological data range checking awaits information supplied by the investigators to the Project Offices. Range and relational checks for the grain size analysis (File Type 073) have been completed by NGSDC.

- Technical corrections to the data will be completed as much as possible between the Data Centers and the investigators prior to the check program results being sent to the Project Offices. This will provide as complete a description of parameters and taxonomic code inventories as possible.

- A memo describing each step in data processing at the Data Centers is being prepared for distribution to OCSEAP data management and investigators. A separate memo describing the use of sequence numbers for each file type also is being prepared.

Mammal sighting data from John Hall (USFWS) was converted to the 027 format by NODC and forwarded to Mike Crane to discuss and review with the investigator.

DATA PRODUCT DEVELOPMENT

NODC and NGSDC are continuing to develop products in response to the OCSEAP Data Compendium and BLM requirements. Time-series data displays, three-dimensional plots and other special products will be included. A response to the Program Office was completed on August 2 in terms of current data and data products available for the Product Compendium, potential developmental products and those products only available from other than EDS or from non-digital sources.

All possible products appropriate to the Lower Cook Inlet lease area available from the OCSEAP data base are being assembled by NODC and NGSDC for review by November 15 for the L.C.I. synthesis meeting in December.

Gary Falk is assembling samples of each product developed with OCSEAP data as part of a'product brochure'. A copy of this brochure will be forwarded to each OCSEAP office when a suitable number of examples are available.

DATA TRACKING SYSTEM

The quarterly report version of the tracking system and accompanying file type summaries was delivered to the Juneau Project Office on September 20. Copies also were forwarded to the Program Office and Mike Crane. The remaining distribution to BLM, OCSEAP, and EDS will be completed the first week of October.

No major modifications have been made in the tracking system during this quarter. Approximately 400 new records and 2500 updates were entered in the system during the quarter. An indicator for the source of where data is actually received by OCSEAP (Juneau, Arctic Project Office, Crane, Petersen, etc.) will be added for the next version of the tracking system

DATA CATALOG

Inquiries for parts II, III and IV of the OCSEAP Data Catalog have been received from BLM and others. Plans are being completed for producing Part II in the next few month. This will most likely require an update to Part I.

TAXONOMIC CODE

Translations of codes to species names within the data base are now available. Requests for copies of the NODC codes, additional codes, and clarifications of the present codes continue to be received at NODC; replies to each of these requests have been answered by Dr. Collins working with Dr. Mueller of IMS as a consultant. Comparisons of other agency taxonomic codes with the NODC code is currently underway.

MEETINGS

A number of meetings involving NODC and NGSDC personnel were held in the latter part of this quarter including the following:

8/30-9/2 - Meeting in Boulder with Program and Juneau Project personnel (Crane and Audet).

9/15/9/16 - OCSEAP Chemistry discipline meeting in Seattle (Dean Dale).

9/14 and 9/28 - Briefed BLM personnel (Anchorage and Washington, D.C.) at NODC concerning the operation and status of the OCSEAP data base (Audet, Law and others).

9/20 - Meeting in Juneau to discuss data checking, data processing and other items with Contract Supervisors (Audet and Noe).

9/21-9/22 - Meetings in Anchorage with BLM to discuss data products and requirements for the data base (Audet and Crane). Also met with Ray Hadley to discuss data processing.

9/23 - Presentations were given in Anchorage at the 28th Alaska Science Conference discussing the OCSEAP data base and the ENDEX system for describing digital and other data bases available to Alaskan investigators. (Audet and Noe).

9/27-9/28 - Meetings were held at NODC with J. Hameedi and D. Irving of SAI, Wayne Fischer and NODC personnel Hamilton, Falk and Audet to discuss biostatistics packages to be made available to NODC for OCSEAP products.

ADMINISTRATIVE

A new employee, Sid Stillwaugh, has been hired to assist Dean Dale in Seattle with OCSEAP tasks.

PROBLEMS

Lack of telecommunications between the Project Offices and Mike Crane's office with the OCSEAP data base inventories and tracking system continue to exist. Recent discussions with EDS and GSA personnel indicate that this situation may be improved in the near future.

A recent BLM request for annotated charts highlighted a problem in answering special requests. To answer this request in a timely manner and to provide the necessary information on the plot; it was necessary to hand-annotate some of the data which is a time-consuming task, Further clarifications are required of what computer products can be made available directly from the data base vs. what specific products are required of the users of the data base.

The forwarding of relevant inventory and data checking summaries to the Project Offices has been a problem when technical problems such as keypunch errors occur in the data set. With the agreement in Boulder that the Data Centers contact the investigators or data processors directly when necessary to correct such technical problems, more timely and reliable inventories and summaries can be provided to the Project Offices for their scientific evaluation.

Quarterly Report

Contract No: N/A
Research Unit No: 496
Reporting Period: July 1977
through September 1977
Number of Pages: 2

"Maintenance of Alaskan OCSEAP Surface Marine and Coastal Station Data File"

Principal Investigator:

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National Climatic Center
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Asheville, NC 28801
Comm: (704) 258-2850, x266
FTS : 672-0266

September 26, 1977

I. Task Objectives

This task serves to maintain the data file compiled for use in the production of the "Climatic Atlas of the OCS Waters and Coastal Regions of Alaska" (RU #347) and to provide meteorological data products and services for the Alaskan area to OCSEAP's Principal Investigators.

II. Field and Laboratory Activities

NA

III. Results

- A digital data inventory of hourly surface weather observations for stations in Alaska has been completed (see inventory map). This is a supplement to the "Index of Original Surface Weather Records for Stations in Alaska" (135 pp.), which was completed under RU #496 in June 1977. The combined set serves to define those stations having data through 1976 held at the National Climatic Center in digital and manuscript forms.

- The surface marine digital data set, which was compiled in 1975 under RU #347 for production of "Climatic Atlas of the OCS Waters and Coastal Regions of Alaska" (in print), has been updated through early 1977. This update increases the atlas file from 600,000 observations through 1974 to 750,000 through April 1977 for the marine area within 50°-80°N, 130°-180°W. An inventory by 10° square-year-month for the total data set and a statistical summary for the Valdez marine area are scheduled for production during the next quarter.

- Surface weather data have been keyed to tape for two Alaskan coastal stations. The stations and periods keyed are: Valdez, 7/67-6/73; and Cape Hinchinbrook, 7/64-6/74. The Valdez data are to be combined with existing 7/73-6/77 digital data and, during next quarter, statistical summaries are to be produced based on these 10 years of record for each station.

- There have been several requests by OCSEAP PI's for data products and services.

IV. Preliminary Interpretation of Results

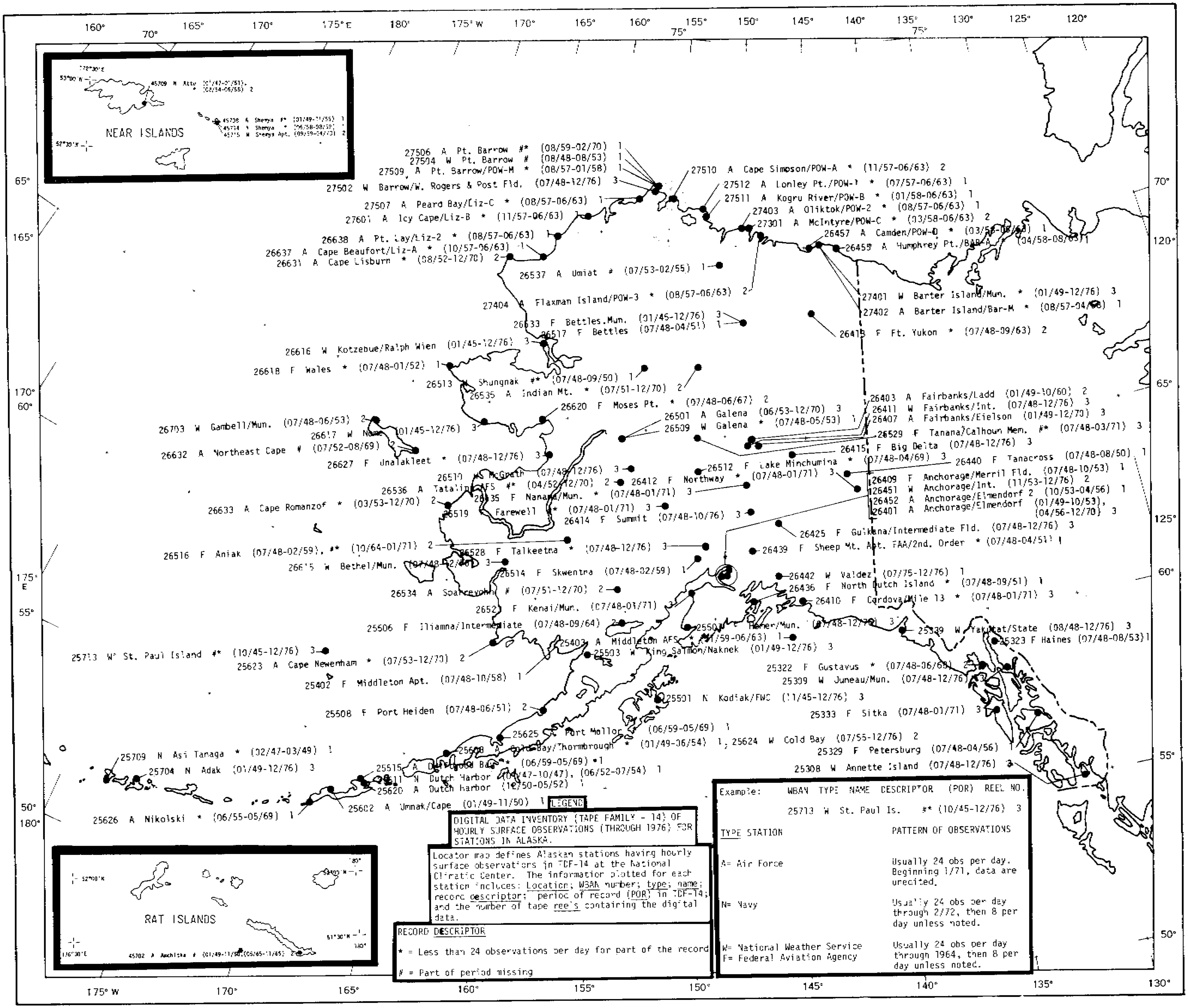
Items 1 and 2 under Results fulfills the task defined for this FY to update and maintain the Alaskan atlas data file. Under RU #496, NCC continues to provide meteorological data products and services for the Alaskan area to OCSEAP's Principal Investigators.

V. Problems Encountered

None

VI. Estimate of Funds Expended

As of 9/15/77, the $25K funded for FY-77 have been expended. Some $7K were used to provide free services and products to OCSEAP PI's; the remainder was applied toward the maintenance of the atlas file and production of data inventories.


NEAR ISLANDS
45709 N Attu (01/42-01/51) * (02/54-06/56) 2
45708 A Shemya #* (01/49-11/55) 1
45714 W Shemya * (06/58-08/62) 1
45715 W Shemya Apt. (09/59-04/73) 2
27506 A Pt. Barrow #* (08/59-02/70) 1
27504 W Pt. Barrow # (08/48-08/53) 1
27509 A Pt. Barrow/POW-M * (08/57-01/58) 1
27502 W Barrow/W. Rogers & Post Fld. (07/48-12/76) 3
27510 A Cape Simpson/POW-A * (11/57-06/63) 2
27512 A Lonley Pt./POW-1 * (07/57-06/63) 1
27511 A Kogru River/POW-B * (01/58-06/63) 1
27403 A Oliktok/POW-2 * (08/57-06/63) 1
27301 A McIntyre/POW-C * (03/58-06/63) 2
26457 A Camden/POW-D * (03/58-06/63) 1
26458 A Humphrey Pt./BAR-A (04/58-08/63) 1
27507 A Peard Bay/Liz-C * (08/57-06/63) 1
27601 A Icy Cape/Liz-B * (11/57-06/63) 1
26638 A Pt. Lay/Liz-2 * (08/57-06/63) 1
26637 A Cape Beaufort/Liz-A * (10/57-06/63) 1
26631 A Cape Lisburn * (08/52-12/70) 2
26537 A Umiat # (07/53-02/55) 1
27404 A Flaxman Island/POW-3 * (08/57-06/63) 2
27401 W Barter Island/Mun. * (01/49-12/76) 3
27402 A Barter Island/Bar-M * (08/57-04/63) 1
26533 F Bettles.Mun. (01/45-12/76) 3
26517 F Bettles (07/48-04/51) 1
26413 F Ft. Yukon * (07/48-09/63) 2
26616 W Kotzebue/Ralph Wien (01/45-12/76) 3
26618 F Wales * (07/48-01/52) 1
26513 A Shungnak #* (07/48-09/50) 1
26535 A Indian Mt. * (07/51-12/70) 2
26620 F Moses Pt. * (07/48-06/67) 2
26501 A Galena (06/53-12/70) 3
26509 W Galena * (07/48-05/53) 1
26403 A Fairbanks/Ladd (01/49-10/60) 2
26411 W Fairbanks/Int. (07/48-12/76) 3
26407 A Fairbanks/Eielson (01/49-12/70) 3
26529 F Tanana/Calhoun Mem. #* (07/48-03/71) 3
26415 F Big Delta (07/48-12/76) 3
26703 W Gambell/Mun. (07/48-06/53) 2
26617 W Nome (01/45-12/76) 3
26632 A Northeast Cape # (07/52-08/69) 1
26627 F Unalakleet * (07/48-12/76) 3
26510 W McGrath (07/48-12/76) 3
26512 F Lake Minchumina * (07/48-04/69) 3
26440 F Tanacross (07/48-08/50) 1
26412 F Northway * (07/48-01/71) 3
26409 F Anchorage/Merrill Fld. (07/48-10/53) 1
26451 W Anchorage/Int. (11/53-12/76) 2
26452 A Anchorage/Elmendorf 2 (10/53-04/56) 1
26401 A Anchorage/Elmendorf (01/49-10/53), (04/56-12/70) 3
26536 A Tatalina AFS #* (04/52-12/70) 2
26635 F Nanana/Mun. * (07/48-01/71) 3
26633 A Cape Romanzof * (03/53-12/70) 2
26519 Farewell * (07/48-01/71) 3
26414 F Summit (07/48-10/76) 3
26425 F Gulkana/Intermediate Fld. (07/48-12/76) 3
26439 F Sheep Mt. Apt. FAA/2nd. Order * (07/48-04/51) 1
26516 F Aniak (07/48-02/59), #* (10/64-01/71) 2
26528 F Talkeetna * (07/48-12/76) 3
26615 W Bethel/Mun. (07/48-12/76) 3
26514 F Skwentna (07/48-02/59) 1
26442 W Valdez (07/75-12/76) 1
26436 F North Dutch Island * (07/48-09/51) 1
26534 A Sca * (07/51-12/70) 2
26410 F Cordova/Mile 13 * (07/48-01/71) 3
26523 F Kenai/Mun. (07/48-01/71) 3
25506 F Iliamna/Intermediate (07/48-09/64) 2
25507 F Homer/Mun. (07/48-12/76) 3
25713 W St. Paul Island #* (10/45-12/76) 3
25623 A Cape Newenham * (07/53-12/70) 2
25402 F Middleton Apt. (07/48-10/58) 1
25401 A Middleton AFS * (07/59-06/63) 1
25503 W King Salmon/Naknek (01/49-12/76) 3
25339 W Yakutat/State (08/48-12/76) 3
25323 F Haines (07/48-08/53) 1
25322 F Gustavus * (07/48-06/68) 2
25309 W Juneau/Mun. (07/48-12/76) 3
25501 N Kodiak/FWC (11/45-12/76) 3
25508 F Port Heiden (07/48-06/51) 2
25333 F Sitka (07/48-01/71) 3
25625 F Port Moller (06/59-05/69) 1
25624 W Cold Bay (07/55-12/76) 2
25329 F Petersburg (07/48-04/56) 1
25308 W Annette Island (07/48-12/76) 3
Thornbrough * (01/49-06/54) 1
25709 N Asi Tanaga * (02/47-03/49) 1
25704 N Adak (01/49-12/76) 3
25515 A D * (06/59-05/69) 1
25611 N Dutch Harbor (01/47-10/47), (06/52-07/54) 1
25620 A Dutch Harbor (10/50-05/52) 1
25602 A Umnak/Cape (01/49-11/50) 1
25626 A Nikolski * (06/55-05/69) 1
LEGEND
DIGITAL DATA INVENTORY (TAPE FAMILY - 14) OF HOURLY SURFACE OBSERVATIONS (THROUGH 1976) FOR STATIONS IN ALASKA.
Locator map defines Alaskan stations having hourly surface observations in TDF-14 at the National Climatic Center. The information plotted for each station includes: Location; WBAN number; type; name; record descriptor; period of record (POR) in TDF-14; and the number of tape reels containing the digital data.
RECORD DESCRIPTOR
* = Less than 24 observations per day for part of the record
# = Part of period missing
Example: WBAN TYPE NAME DESCRIPTOR (POR) REEL NO.
25713 W St. Paul Is. #* (10/45-12/76) 3
TYPE STATION
PATTERN OF OBSERVATIONS
A= Air Force
Usually 24 obs per day. Beginning 1/71, data are unedited.
N= Navy
Usually 24 obs per day through 2/72, then 8 per day unless noted.
W= National Weather Service
F= Federal Aviation Agency
Usually 24 obs per day through 1964, then 8 per day unless noted.
RAT ISLANDS
45702 A Amchitka # (01/49-11/50),(05/65-11/65) 2

INDEX OF ORIGINAL

SURFACE WEATHER RECORDS

(HOURLY, SYNOPTIC AND AUTOGRAPHIC)

FOR STATIONS IN

ALASKA

ON FILE AT
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA 28801

This Index of Original Surface Weather Records for Stations in Alaska was produced as a part of the Environmental Data Index (ENDEX) Program. It is the first for the U.S. states to be revised and printed; and, although, work has been initiated on an index for each of the remaining 49 states, completion is dependent upon future funding.

Completion of the Alaskan Index was made possible through support by the Department of the Interior's Bureau of Land Management Alaskan Outer Continental Shelf Environmental Assessment Program under the direction of the National Oceanic and Atmospheric Administration. It was prepared as a part of Research Unit No. 496, Maintenance of Alaskan OCSEAP Surface Marine and Coastal Station Data File, which serves to maintain the data file compiled for use in the production of the "Climatic Atlas of the OCS Waters and Coastal Regions of Alaska" (RU #347) and to provide meteorological data products and services for the Alaskan area to OCSEAP's Principal Investigators.

For sale by National Climatic Center, Asheville, NC 28801
ATTN: Publications. PRICE: $.50 per copy

Hourly, Synoptic, and Autographic Original Records

CONTENTS

1. Introduction

This index has been prepared as a part of ENDEX, the Environmental Data Index Experiment. Its purpose is to automate the indexes of environmental data to efficiently serve the needs of atmospheric and earth scientists.

All the hourly aviation, synoptic, supplementary airways, and similar observations available in manuscript form at the National Climatic Center are listed in this state index. In deciding about the inclusion of unusual records, those which would help in plotting detailed synoptic weather maps were included; those similar to cooperative climatological daily observations were not. Indexes of the latter will be digitized as another project.

Autographic charts and traces have been included in this index, since values of temperature, pressure, wind, humidity and so forth, could be extracted for the kinds of studies this index has been designed to aid.

One of the most valuable parts of this index is the station history information contained in the latitude-longitude and station elevation columns. Many of the earlier station indexes are incomplete in this regard. Extensive research went into the effort to pinpoint the locations of the stations. Users who find inconsistencies in the station history information are asked to call them to the attention of the Chief, Archival Services Branch, NCC.

The records covered by this series of indexes form the major file of meteorological data within the United States. Begun by the Army Signal Corps in the late 19th century, some of the records have been preserved and passed on by the government agencies that have followed. The records that are filed by the National Archives are not indexed here. Nearly all of those are for the years before 1900.

Copies of the records can be provided at the requester's expense in a number of forms including paper copy, microfilm, microfiche, punched cards and magnetic tape. For costs or information, write

Director
National Climatic Center
Federal Building
Asheville, North Carolina 28801

2. Description of Indexes

Alphabetic
The alphabetic listing utilizes the names of the weather station preparing the observations. This is often the name of the city or community; occasionally, it is the name of a military installation, an airport, or a geographical feature. Cross-referencing has been inserted to help the user. For a given station, the records are listed in time order. When one becomes familiar with the index, this arrangement gives a quick, and almost pictorial, presentation of the weather station activity of each location. Station moves stand out.

By Year
The records are listed from the oldest to the newest to readily show which are available for studies based on many years of data. This arrangement also expedites the selection of records when studying particular storms of the past. By referring to a specific year, all available records can be seen. An interesting feature of this index is the way in which it shows the expansion of the national meteorological network. From few entries per year in the early times, there is a marked increase with the advent of commercial aviation in the 1930's. The many stations shown during World War II and the post-War era are followed in most states by a shrinkage due to retrenchment in the more recent times.

By Elevation
This index will aid those looking for observations characteristic of certain altitudes above sea level.

By Latitude
This index is abbreviated to give names and station history data for locating weather observing points on a geographical basis. This supplements the map.

3. Explanation of Entries

Station Name
Long names were abbreviated. Commonly used abbreviations are:

AP, APT - Airport	Lk - Lake
Cty - City	LS - Light Ship/Station
Fld - Field	Mt - Mount, Mountain
Ft - Fort	Nk - Neck
Hb - Harbor	Rck - Rock
Is - Island	Rvr - River
LB Sta - Light Boat Station	

Type
The type of weather station. This is sometimes best described by naming the service which operated the station. Codes used are:

Code	Type of Station	Code	Type of Station
Weather Bureau		Military	
A	Aviation Reports & Coop-A Stations	AAB	Army Air Base
AC	Cooperative Aviation Reports	AAF	Army Air Field
S	Synoptic Reports	AAFB	Auxiliary Air Force Base
SA	Synoptic and Aviation Reports	AB	Air Base (Air Force)
SAC	Cooperative Synoptic and Aviation Reports	AF	Air Force
SC	Cooperative Synoptic Reports	AFB	Air Force Base
WBAS	Weather Bureau Airport Station	AFS	Air Force Station
WBFO	Weather Bureau Forecast Office	ANG	Air National Guard
WBMO	Weather Bureau Meteorological Observatory	ASC	Army
WBO	Weather Bureau Office	MCAF	Marine Corps Air Facility
WBUA	Weather Bureau Upper Air Unit	MCAS	Marine Corps Air Station
WSFO	Weather Service Forecast Office	NAAF	Naval Auxiliary Air Facility
WSMO	Weather Service Meteorological Observatory	NAAS	Naval Auxiliary Air Station
WSO	Weather Service Office	NAF	Naval Air Facility
		NAS	Naval Air Station
Others		NF	Naval Facility
AMOS	Automatic Weather Station	NS	Naval Station
CAA	Civil Aeronautics Adm. Facility		
CG	Coast Guard		
COOP	Cooperative		
FAA	Federal Aviation Agency		
FSS	Flight Service Station (FAA)		
LAWR	Limited Airport Weather Reporting Station (Tower)		
MARS	Marine Reporting Station		
SAWR	Supplementary Airways Weather Reporting Station		
SPL	Special Purpose Office (Fire weather, temporary observing sites)		

Latitude, Longitude
The coordinates given for the station in the most authoritative documents available to the workers. Given in degrees and minutes.

Elevation
In feet. The height above sea level of the barometer was used if known. The reported station elevations and ground heights at the stations were used as first- and second-alternatives when necessary.

"Hourly" Records by Month
These are the records usually made for aviation purposes and are the most detailed observations made. Because of their importance, they have been indexed in greater detail than the other records. A number entry means that records are on file for that month. The value of the number is a code which tells the number of observations recorded per day.

Code for Observations per Day used in the "Hourly" Records Columns

Blank - No Records
1 - 24 per day
2 - (Not used)
3 - 3 or less obs per day
4 - 4
5 - 5 to 11
6 - 12 to 18
7 - 19 to 23
0 - Records on microfilm only. See the film for number of obs per day.

A valuable source of information about data appearing on these forms through the years is:

History of Weather Bureau Climatological Record Forms for Surface Synoptic and Airway Observations. (Key to Meteorological Records Documentation No. 2.211) Washington, DC 1964. For sale by the Superintendent of Documents, Washington, DC 20402. Price 40 cents.

Number of Months in Year with:
The records in these categories are so voluminous that it was felt an abbreviated index would suffice for nearly all purposes. In these columns, a 12 means that records are on file for every month. A blank means that no records are on file. 08 followed by a group of 12's will nearly always mean that records began in May of the first year and were continuous thereafter. Numbers higher than 50 mean that the records exist only on microfilm. In such cases, 50 has been added to the number of months available for that year.

Synoptic Form
Form 1083. This usually gives 4 observations per day in the special code used for reporting weather internationally. Examples of the forms are given in the publication listed previously under the explanation for "Hourly" records. Intermediate 3-hourly observations are sometimes included on the form; from July 1939 to December 1948 the 3-hourly observations may appear on a companion form (Form 1082). Some stations omitted the nighttime observations. Laymen find these forms difficult to use because of its special coding and the fact that times are often in GMT. "Hourly" records, if available, are usually preferable.

Meteorological Summary
Form 1001, and/or 1002, and/or 1014. These are the comprehensive station records kept by first-order Weather Bureau stations from 1892 to 1948. A few stations have continued a modified form. Examples of the forms are given in the publication listed previously under the explanation for "Hourly" records. A similar military record, Form 1, is also indexed under this category.

Barograms
A continuous record of pressure in which the oscillations have been traced by a pen on a moving sheet of paper. In the older records, a 1-inch change of pressure was shown as a 1-inch change on the chart. Beginning in 1936, the older instruments were replaced by microbarographs which magnified the change 2 1/2 times. At Weather Bureau stations each chart formerly contained 4 days record. The exact times of pressure changes with squall lines, thunderstorms and other phenomena were hard to read, so the chart commonly in use today is accelerated to rotate once each 12-hours. Two traces appear on each chart since they are changed daily.

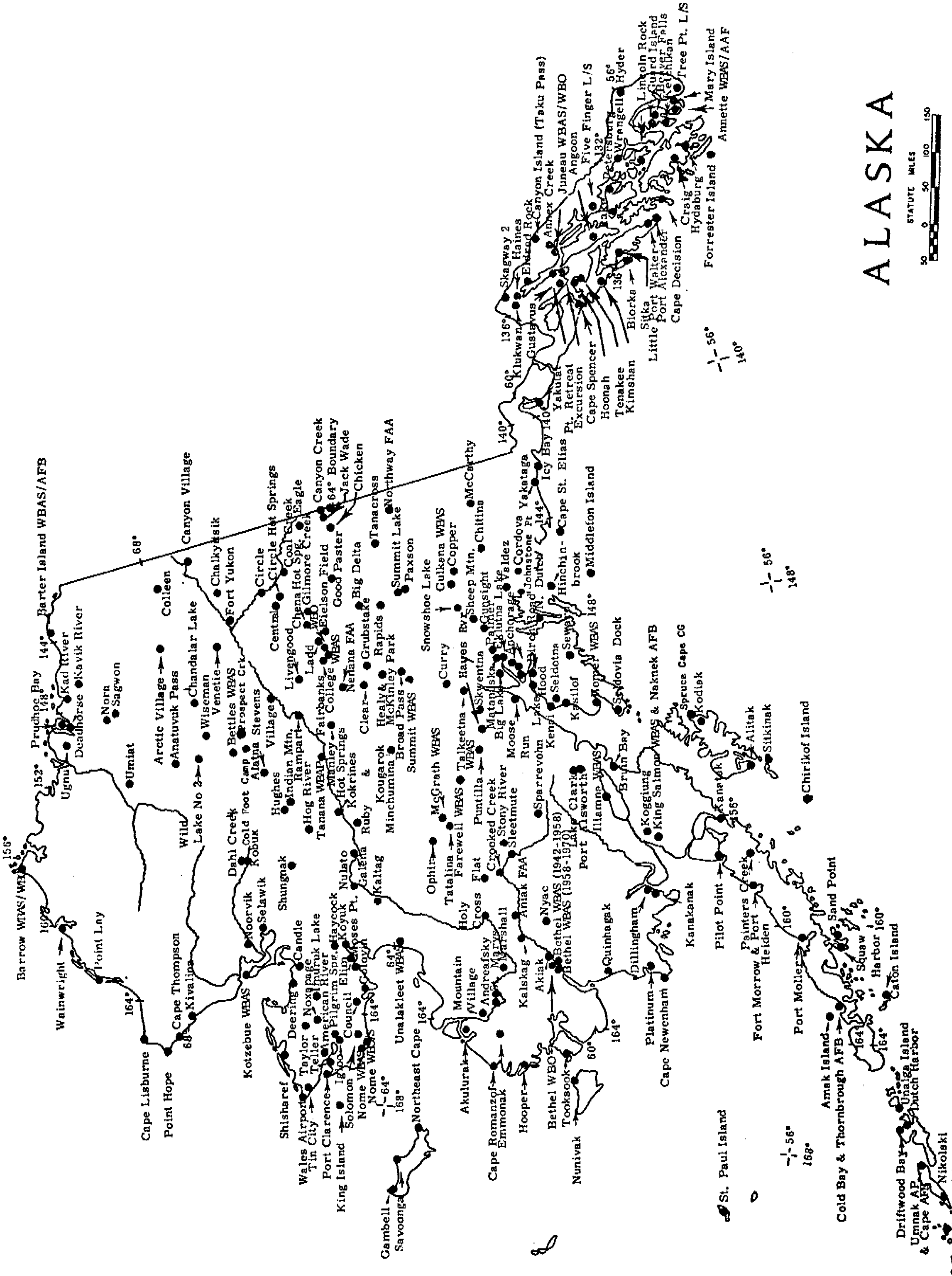
Thermograms
A continous record of temperature. A variety of charts has been used through the years. First-order stations are no longer required to operate thermographs. During the years in which thermograms were considered an official record, they were carefully annotated and the periods are nearly complete. In recent years, some instruments appear to be out of calibration and there are gaps in the series of forms. Most being received now are from cooperative stations that have volunteered their records.

Triple Register
Most of the records indexed under this column are the daily sheets from the station meteorographs, sometimes known also as a quadruple register since they recorded wind direction, wind speed, sunshine and rainfall. The oldest records are from single registers which recorded speed only; from two-magnet registers which recorded wind speed, rainfall and sunshine; and from double registers (anemographs) which recorded wind direction and speed. The most recent records of this type are in the form of long strips torn from continuous rolls in daily increments.

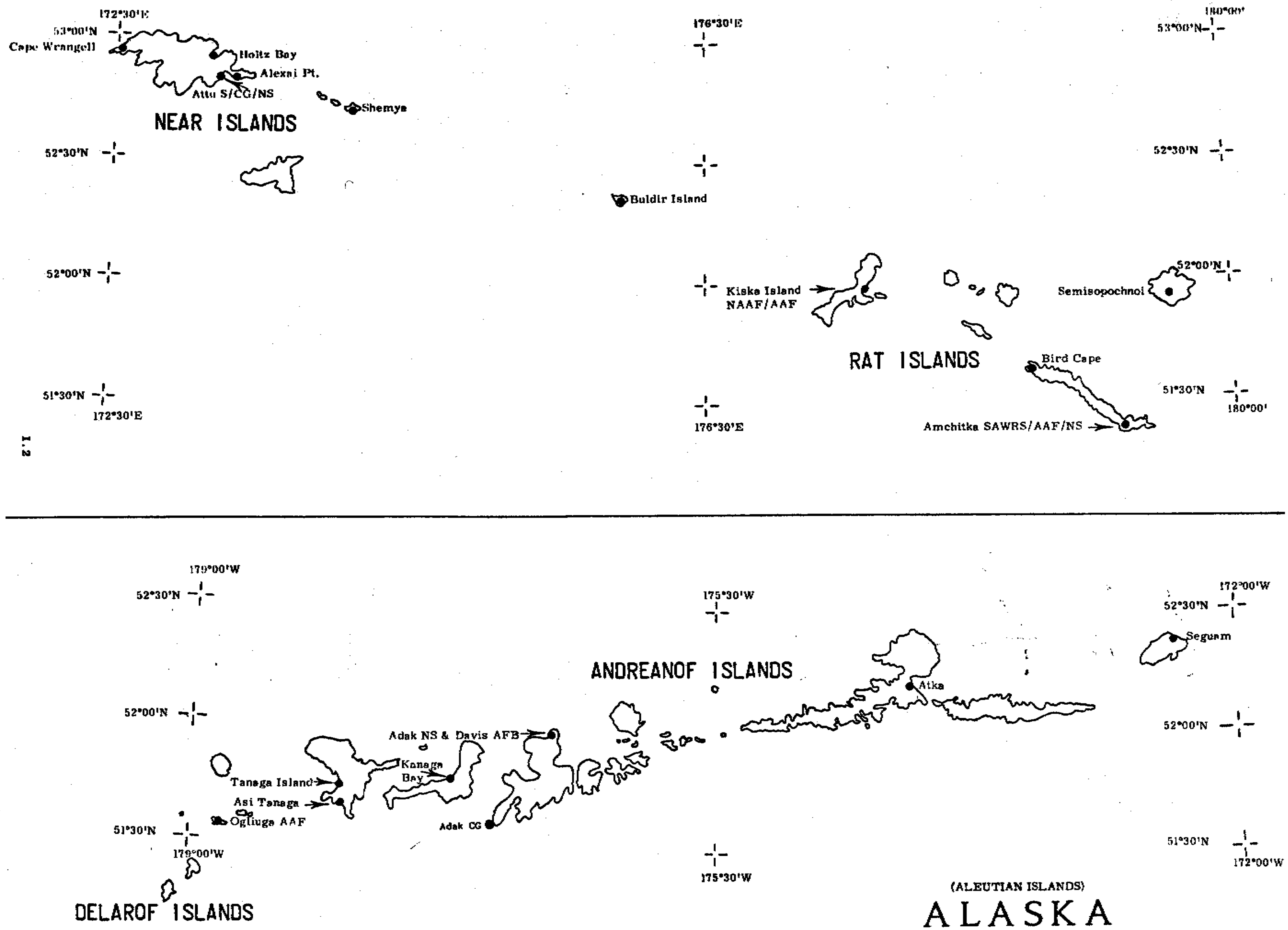
Wind Recorder
These show a continuous trace of wind speed as opposed to the triple register type of equipment which is based on an electrical contact opening and closing with the passage of each mile of wind. These records have not been quality controlled and there have been problems of calibration, lack of annotation and improper time registration. Many of the records do not contain direction traces. For some stations, direction and speed are on different rolls.

Humidity Recorder
These are instrument charts which give a measurement of relative humidity or dew point. Those of the hygrothermograph type usually contain an adjoining record of temperature.

Radar Logs
These records give the radar operator's interpretation of the echoes seen on his scope. Location, size, shape, movement, intensity and change of intensity are given in code.


ALASKA
STATUTE MILES
50 0 50 100 150
Barrow WBAS/WBO
Wainwright
Point Lay
Cape Lisburne
Point Hope
Cape Thompson
Kivalina
Kotzebue WBAS
Noorvik
Selawik
Shungnak
Kobuk
Dahl Creek
Cold Foot Camp
Wild Lake No 2
Umiat
Ugnu
Prudhoe Bay
Deadhorse
Kavik River
Kad River
Barter Island WBAS/AFB
Norn
Sagwon
Arctic Village
Anatuvuk Pass
Chandalar Lake
Wiseman
Venetie
Bettles WBAS
Prospect Crk
Alatna
Stevens Village
Chalkyitsik
Fort Yukon
Colleen
Canyon Village
Circle
Circle Hot Springs
Central
Coal Creek
Eagle
Canyon Creek
64° Boundary
Jack Wade
Chicken
Northway FAA
Tanacross
Big Delta
Good Paster
Gilmore Creek
Eielson Field
Chena Hot Spg.
Livengood
Ladd
Fairbanks
College
Nenana FAA
Grubstake
Rapids
Park
McKinley
Healy &
Clear
Broad Pass
Summit WBAS
Summit Lake
Paxson
Gulkena WBAS
Copper
Snowshoe Lake
McCarthy
Chitina
Sheep Mtn.
Gunsight
Valdez
Cordova
Yakataga
Cape St. Elias
Middleton Island
Icy Bay
Yakutat
Hinchinbrook
Anchorage
Palmer
Talkeetna
Skwentna
Matanuska
Big Lake
Moose Run
Kenai
Seldovia
Homer WBAS
Kasilof
Seward
Kodiak
Spruce Cape CG
Naknek AFB
King Salmon WBAS &
Alitak
Sitkinak
Chirikof Island
Kanatak
Bruin Bay
Iliamna WBAS
Koggiung
Port Alsworth
Lake Clark
Sparrevohn
Sleetmute
Stony River
Crooked Creek
Flat
Puntilla
Farewell WBAS
McGrath WBAS
Tatalina
Ophir
Holy Cross
Aniak FAA
Nyac
Bethel WBAS (1942-1958)
Bethel WBAS (1958-1970)
Bethel WBO
Kalskag
Akiak
Tooksook
Nunivak
Hooper
Cape Romanzof
Emmonak
Akulurak
Mountain Village
Andreafsky
Marshall
St. Marys
Quinhagak
Dillingham
Platinum
Cape Newenham
Kanakanak
Pilot Point
Painters Creek
Fort Morrow & Port Heiden
Port Moller
Sand Point
Squaw Harbor
Caton Island
Amak Island
Cold Bay & Thornbrough AFB
Unalga Island
Dutch Harbor
Driftwood Bay
Umnak AP & Cape AFB
Nikolski
Chuginadak
St. Paul Island
Northeast Cape
Gambell
Savoonga
Unalakleet WBAS
Kaltag
Galena
Nulato
Ruby
Kokrines
Tanana WBAS
Hot Springs
Manley
Rampart
Indian Mtn.
Hog River
Hughes
Kougarok
Minchumina
Moses Pt.
Koyuk
Haycock
Elim
Council
Golovin
Candle
Deering
Noxapage
Inmachuk Lake
American River
Pilgrim Spg.
Taylor
Teller
Igloo
Solomon
Nome WBAS
Shishmaref
Wales Airport
Tin City
Port Clarence
King Island
Skagway 2
Haines
Eldred Rock
Klukwan
Gustavus
Canyon Island (Taku Pass)
Annex Creek
Juneau WBAS/WBO
Angoon
Five Finger L/S
Petersburg
Wrangell
Hyder
Lincoln Rock
Guard Island
Ketchikan
Tree Pt. L/S
Mary Island
Annette WBAS/AAF
Craig
Hydaburg
Forrester Island
Cape Decision
Port Alexander
Little Port Walter
Sitka
Biorka
Kimshan
Tenakee
Hoonah
Cape Spencer
Excursion
Pt. Retreat

I.1



ALASKA
(ALEUTIAN ISLANDS)
NEAR ISLANDS
Cape Wrangell
Holtz Bay
Alexai Pt.
Attu S/CG/NS
Shemya
Buldir Island
RAT ISLANDS
Kiska Island
NAAF/AAF
Semisopochnoi
Bird Cape
Amchitka SAWRS/AAF/NS
ANDREANOF ISLANDS
Atka
Seguam
Adak NS & Davis AFB
Kanaga Bay
Adak CG
Tanaga Island
Asi Tanaga
Ogliuga AAF
DELAROF ISLANDS
172°30'E
53°00'N
52°30'N
52°00'N
51°30'N
176°30'E
180°00'
179°00'W
175°30'W
172°00'W
I.2

Sample Page

RECORDS INDEX ALPHABETIC BY STATION NAME

ALASKA

NUMBER OF MONTHS IN YEAR WITH

HOURLY RECORDS BY MONTH

1 = 24 OBS PER DAY

NAME	TYPE	YEAR	LAT.	LONG.	ELEV.	J	F	M	A	M	J	J	A	S	O	N	D	SYNOPTIC FORM	METL SUMMARY	BAROGRAMS	THERMOGRAMS	TRIPLE REGISTER	WIND RECORDER	HUMIDITY RECORDER	RADAR LOGS	WBAN NUMBER
ADAK	SEE	DAVIS	AFB																							25701
ADAK	AAF	1944	51 53N	176 39W	14		1	1	1	1	1	1	1	1	1	1	1									25707
ADAK	NS	1942	51 52N	176 39W	15										1	1	1									25704
	NS	1943	51 52N	176 39W	15	1	1																			25704
ADAK	NS	1943	51 53N	176 38W	15			1	1	1	1	1	1	1	1	1	1									25704
	NS	1944	51 53N	176 38W	15	1	1	1	1	1																25704
ADAK	NS	1944	51 57N	176 36W	104						1	1	1	1	1	1	1									25704
	NS	1945	51 57N	176 36W	104	1	1	1	1	1	1	1	1	1												25704
ADAK	NS	1950	51 53N	176 39W	15							1	1	1	1	1	1									25704
	NS	1951	51 53N	176 39W	15	1	1	1	1	1	1	1	1	1	1	1	1									25704
	NS	1952	51 53N	176 39W	14	1	1	1	1	1	1	1	1	1	1	1	1			12			12	11		25704
	NS	1953	51 53N	176 39W	14	1	1	1	1	1	1	1	1	1	1	1	1			12			12	12		25704
	NS	1954	51 53N	176 39W	14	1	1	1	1	1	1	1	1	1	1	1	1			12			12	12		25704
	NS	1955	51 53N	176 39W	14	1	1	1	1	1	1	1	1	1	1	1	1			12			11	12		25704
	NS	1956	51 53N	176 39W	14	1	1	1	1	1	1	1	1	1	1	1	1			12			12	12		25704
	NS	1957	51 53N	176 39W	14	1	1	1	1	1	1	1	1	1	1	1	1			12			12	12		25704
	NS	1958	51 53N	176 39W	14	1	1	1	1	1	1	1	1	1	1	1	1			12			12	12		25704
	NS	1959	51 53N	176 39W	14	1	1	1	1	1	1	1	1	1	1	1	1			12			12	12		25704
	NS	1960	51 53N	176 39W	14	1	1	1	1	1	1	1	1	1	1	1	1			12	05		12	12		25704
	NS	1961	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12	10		25704
	NS	1962	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12	01		25704
	NS	1963	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12			25704
	NS	1964	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12			25704
	NS	1965	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12			25704
	NS	1966	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12			25704
	NS	1967	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	05		12			25704
	NS	1968	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	09		12			25704
	NS	1969	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			11	12		12			25704
	NS	1970	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	08		12			25704
	NS	1971	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12			25704
	NS	1972	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12			25704
	NS	1973	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12			25704
	NS	1974	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12			25704
	NS	1975	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12			25704
	NS	1976	51 53N	176 39W	16	1	1	1	1	1	1	1	1	1	1	1	1			12	12		12			25704
ADAK	CG	1972	51 35N	177 00W											5	5	5									
	CG	1973	51 35N	177 00W		5	5	5	5	5	5	5	5		5	5	5									
	CG	1974	51 35N	177 00W		5	5	5	5	5	5	5	5	5	5	5	5									
	CG	1975	51 35N	177 00W		5	5	5	5	5	5			5	5	5	5									
	CG	1976	51 35N	177 00W		5	5	5	5	5	5		5	5	5	5	5									
AKIAK	COOP	1919	60 52N	161 23W	21														01	02						
	COOP	1920	60 52N	161 23W	21														09	09						
	COOP	1921	60 52N	161 23W	21														12	12						
	COOP	1922	60 52N	161 23W	21														07	07						
	COOP	1923	60 52N	161 23W	35														09	08						
AKULURAK	A	1941	62 30N	164 25W	33													09	08	07						
	A	1942	62 30N	164 25W	33													12	12	11						
	A	1943	62 30N	164 25W	33													06		05						
AKULURAK	AAF	1944	62 30N	164 25W	31				1	1	1	1	1							57						26610
ALATNA	A	1936	66 34N	152 44W	600												3									
	A	1937	66 34N	152 44W	600	3	3	3	3	3	3	3	3	3	3	3	3									
	A	1938	66 34N	152 44W	600	3	3	3	3	3	3	3	3	3	3	3	3									
	A	1939	66 34N	152 44W	600	3	3	3	3	3	3	3	3	3	3	3	3									
	A	1940	66 34N	152 44W	600	3	3	3	3	3	3	3	3	3	3	3	3									
	A	1941	66 34N	152 44W	600	3	3	3	3	3	3	5	5	5	5	5	5									
	A	1942	66 34N	152 44W	600	5	5	5	5	5	5	5	5	5	5	5	5									
	A	1943	66 34N	152 44W	600	5	5	5	5	5	5	5	5	5	5	5	5									
	A	1944	66 34N	152 44W	600	5	5	5	5	5																
ALEXAI PT	AFS	1943	52 50N	173 19E	27						1	1	1	1	1	1	1			57	52					45701
	AFS	1944	52 50N	173 19E	27	1	1	1	1	1	1	1	1	1	1	1	1			62	62		01			45701
	AFS	1945	52 50N	173 19E	27	1	1	1	1	1	1	1	1	1						59	59					45701
ALITAK	A	1942	56 57N	154 10W	24			3	3	3	3	3	3	3	3	3		09	06	09						25512
ALITAK	NF	1942	56 55N	154 15W	30												6	01	01	01						25512
	NF	1943	56 55N	154 15W	30	6	6	6	6	6	6	6	6	6	6	6	6		06							25512
	NF	1944	56 55N	154 15W	30	6	6	6	6																	25512
ALITAK	NS	1945	56 55N	154 15W	30		7	7	7	7	7	7	7					03								25502
AMAK ISLAND	AF	1943	55 24N	163 08W	15		5	5			5	5	5	5	5											25609
	AF	1944	55 24N	163 08W	15				1	1	1	1	1	1												25609
AMCHITKA IS	SAWR	1967	51 23N	179 15E	237							6	6	6	6	6	6									
	SAWR	1968	51 23N	179 15E	237	6	6	6	6	6	6	6	6	6	6	6	6									
	SAWR	1969	51 23N	179 15E	237	6	6	6	6	6	6	6	6	6	6	6	6									
	SAWR	1970	51 23N	179 15E	237	6	6	6	5	6	6	6	6	6	6	6	6									
	SAWR	1971	51 23N	179 15E	237	6	6	6	6	6	6	6	6	6	6	6	6									
	SAWR	1972	51 23N	179 15E	237	3	3	3	3	3	3	3	3		3	3	3									
	SAWR	1973	51 23N	179 15E	237	0	0	0	0	0	0	0	0													

Sample Page

RECORDS INDEX ARRANGED BY YEAR

ALASKA

NUMBER OF MONTHS IN YEAR WITH

HOURLY RECORDS BY MONTH

1 = 24 OBS PER DAY

YEAR	NAME	TYPE	LAT.	LONG.	ELEV.	J	F	M	A	M	J	J	A	S	O	N	D	SYNOPTIC FORM	METL SUMMARY	BAROGRAMS	THERMOGRAMS	TRIPLE REGISTER	WIND RECORDER	HUMIDITY RECORDER	RADAR LOGS	WBAN NUMBER
1898	SITKA	SPL	57 03N	135 20W	63														07	05	07					25334
1899	EAGLE	WBO	64 46N	141 12W	821														05	05		12				26422
	SITKA	SPL	57 03N	135 20W	63														02	03	02					25334
1900	EAGLE	WBO	64 46N	141 12W	821														12	12		12				26422
1901	EAGLE	WBO	64 46N	141 12W	821														12	09		12				26422
1908	NOME	SPL	64 30N	165 24W	22														12							26617
	SITKA	SPL	57 03N	135 20W	63														06							25334
1909	EAGLE	WBO	64 46N	141 12W	834														05							26422
	NOME	SPL	64 30N	165 24W	22														12							26617
	SITKA	SPL	57 03N	135 20W	63														12							25334
	TANANA	S	65 10N	152 06W	220														04							26529
	VALDEZ	S	61 07N	146 16W	27														04							26442
1910	EAGLE	WBO	64 46N	141 12W	834														12							26422
	NOME	SPL	64 30N	165 24W	22														12							26617
	SITKA	SPL	57 03N	135 20W	63														12							25334
	TANANA	S	65 10N	152 06W	220														12							26529
	VALDEZ	S	61 07N	146 16W	27														12							26442
1911	EAGLE	WBO	64 46N	141 12W	834														12							26422
	NOME	SPL	64 30N	165 24W	22														12							26617
	SITKA	SPL	57 03N	135 20W	63														12							25334
	ST PAUL IS	SPL	57 07N	170 16W	20														04							25713
	TANANA	S	65 10N	152 06W	220														12							26529
	VALDEZ	S	61 07N	146 16W	27														12							26442
1912	EAGLE	WBO	64 46N	141 12W	834														12							26422
	NOME	SPL	64 30N	165 24W	22														12			08				26617
	SITKA	SPL	57 03N	135 20W	63														12							25334
	ST PAUL IS	SPL	57 07N	170 16W	20														08							25713
	TANANA	S	65 10N	152 06W	220														12							26529
	VALDEZ	S	61 07N	146 16W	27														12							26442
1913	EAGLE	WBO	64 46N	141 12W	834														12							26422
	NOME	SPL	64 30N	165 24W	22														12			12				26617
	SITKA	SPL	57 03N	135 20W	63														12							25334
	TANANA	S	65 10N	152 06W	220														12							26529
	VALDEZ	S	61 07N	146 16W	27														12							26442
1914	EAGLE	WBO	64 46N	141 12W	834														12							26422
	NOME	SPL	64 30N	165 24W	22														12			12				26617
	SITKA	SPL	57 03N	135 20W	63														12							25334
	TANANA	S	65 10N	152 06W	220														12							26529
	VALDEZ	S	61 07N	146 16W	27														12							26442
1915	DUTCH HARBOR	NF	53 53N	166 32W	47														08	01						25616
	EAGLE	WBO	64 46N	141 12W	834														12							26422
	KODIAK	NF	57 46N	152 22W	12														03							25509
	NOME	SPL	64 30N	165 24W	22														12			12				26617
	SITKA	SPL	57 03N	135 20W	63														12							25334
	ST PAUL IS	S	57 07N	170 16W	20														05							25713
	TANANA	S	65 10N	152 06W	220														12							26529
	VALDEZ	S	61 07N	146 16W	27														12							26442
1916	ANCHORAGE	COOP	61 14N	149 52W	40																	12				
	DUTCH HARBOR	NF	53 53N	166 32W	47														12	12						25616
	EAGLE	WBO	64 46N	141 12W	834														12							26422
	KODIAK	NF	57 46N	152 22W	12														12							25509
	NOME	S	64 29N	165 24W	10														06			06				26617
	NOME	SPL	64 30N	165 24W	22														06			06				26617
	SITKA	SPL	57 03N	135 20W	63														12							25334
	ST PAUL IS	S	57 07N	170 16W	20														10							25713
	TANANA	S	65 10N	152 06W	220														12	01						26529
	VALDEZ	S	61 07N	146 16W	27														12	03						26442
1917	ANCHORAGE	COOP	61 14N	149 52W	40																	12				
	DUTCH HARBOR	NF	53 53N	166 32W	47														12	12						25616
	EAGLE	WBO	64 46N	141 12W	834														12	05						26422
	JUNEAU	WBO	58 18N	134 24W	80														12	12	11	11				25324
	KODIAK	NF	57 46N	152 22W	12														12	08						25509
	NOME	S	64 29N	165 24W	10														12	06		12				26617
	SITKA	SPL	57 03N	135 20W	63														12							25334
	ST PAUL IS	S	57 07N	170 16W	20														12							25713
	TANANA	S	65 10N	152 06W	220														12	12						26529
	VALDEZ	S	61 07N	146 16W	27														12	12	08					26442
1918	ANCHORAGE	COOP	61 14N	149 52W	40																	12				
	DUTCH HARBOR	NF	53 53N	166 32W	47														12	12						25616
	EAGLE	WBO	64 46N	141 12W	834														12	12						26422
	JUNEAU	WBO	58 18N	134 24W	80														12	12	12	12				25324
	KODIAK	NF	57 46N	152 22W	12														12	11						25509
	NOME	S	64 29N	165 24W	10														12	12		12				26617
	SITKA	SPL	57 03N	135 20W	63														12							25334
	ST PAUL IS	S	57 07N	170 16W	20														12	06						25713
	TANANA	S	65 10N	152 06W	220														12	12						26529
	VALDEZ	S	61 07N	146 16W	34														12	12	12					26442

III.1

Sample Page

BY ELEVATION

ALASKA

ELEV.	NAME	TYPE	LAT.	LONG.	WBAN NUMBER
0	KETCHIKAN	SAWR	55 20N	131 34W	25325
4	IGLOO	A	65 09N	165 04W	
5	FUNTER BAY	A	58 15N	134 54W	
8	EMMONAK	SAWR	62 46N	164 30W	
8	POINT BARROW	AFS	71 18N	156 47W	27506
9	HYDER	A	55 54N	130 01W	
10	CANDLE	A	65 56N	161 55W	26619
10	COFFMAN COVE	A	56 00N	132 50W	
10	DUTCH HARBOR	NS	53 54N	166 32W	25611
10	ICY BAY	SAWR	59 59N	141 48W	
10	KIVALINA	A	67 45N	164 42W	
10	KOYUK	A	64 57N	161 08W	
10	NOME	S	64 29N	165 24W	26617
10	PRUDHOE BAY	SAWR	70 19N	148 33W	
10	PT SPENCER	AAF	65 15N	166 21W	26612
10	QUINHAGAK	SAWR	59 45N	161 54W	
10	TELLER	A	65 16N	166 21W	26626
10	TELLER	AAF	65 18N	166 55W	26607
11	ATKA	A	52 12N	174 20W	25715
11	KOTZEBUE	SA	66 52N	162 38W	26616
11	POINT BARROW	CAA	71 20N	156 39W	27504
11	SKAGWAY	A	59 27N	135 19W	25335
12	ATTU	S	52 50N	173 11E	45712
12	GOLO'IN	A	64 33N	163 01W	26628
12	KODIAK	NF	57 46N	152 22W	25509
12	KOTZEBUE	SA	66 52N	162 38W	26616
12	NOME	S	64 29N	165 24W	26617
12	NOME	WBO	64 29N	165 24W	26617
12	POINT LAY	SA	69 45N	163 03W	26624
12	PORT ALTHORP	A	58 09N	136 22W	
12	VALDEZ	A	61 07N	146 16W	26442
13	CRAIG	A	55 29N	133 09W	25317
13	DUTCH HARBOR	A	53 53N	166 32W	25614
13	DUTCH HARBOR	SAWR	53 53N	166 32W	25614
13	KIMSHAN	A	57 41N	136 06W	
13	POINT BARROW	NS	71 20N	156 24W	27501
13	VALDEZ	A	61 07N	146 16W	26442
14	ADAK	AAF	51 53N	176 39W	25707
14	ADAK	NS	51 53N	176 39W	25704
14	ANGOON	A	57 30N	134 35W	25310
14	DAVIS	AAF	51 53N	176 39W	25701
14	LITTLE PORT	A	56 23N	134 39W	25327
14	PLEASANT IS	A	58 10N	135 30W	25340
14	POINT BARROW	AFS	71 21N	156 39W	27505
14	POINT HOPE	A	68 20N	166 48W	26623
15	ADAK	NS	51 53N	176 38W	25704
15	AMAK ISLAND	AF	55 24N	163 08W	25609
15	BETHEL	WBAS	60 47N	161 43W	26615
15	DAVIS	AAF	51 53N	176 39W	25701
15	DAVIS	AFB	51 53N	176 39W	25701
15	DEERING	A	66 04N	162 45W	
15	DUTCH HARBOR	NS	53 54N	166 32W	25611
15	EGAVIK	A	64 02N	160 55W	
15	HAINES	A	59 14N	135 27W	25323
15	KETCHIKAN	SA	55 21N	131 39W	25325
15	KETCHIKAN	WBO	55 21N	131 39W	25325
15	NOME	WBAS	64 30N	165 26W	26617
15	PLATINUM	A	59 01N	161 47W	25613
15	RADIOVILLE	A	57 36N	136 09W	25332
15	SOLOMON	A	64 35N	164 24W	26629
15	TOKSOOK	SAWR	60 32N	165 07W	
15	VALDEZ	A	61 07N	146 16W	26442
16	ADAK	NS	51 53N	176 39W	25704
16	KETCHIKAN	SA	55 20N	131 39W	25325
16	MOSES POINT	CAA	64 42N	162 03W	26620
16	SHISHAREF	SA	66 14N	166 07W	26625
16	VALDEZ	A	61 07N	146 16W	26442
16	WALES	CAA	65 37N	168 03W	26618
16	WALES	WBAS	65 37N	168 03W	26618
17	SEWARD	SAWR	60 08N	149 25W	
17	VALDEZ	A	61 07N	146 16W	26442
17	WALES	AAF	65 37N	168 03W	26609
18	NOME	WBAS	64 30N	165 26W	26617
18	NOME	WSO	64 30N	165 26W	26817
18	POINT LAY	SA	69 45N	163 03W	26624
18	PORT ALEXAND	A	56 15N	134 39W	25348
18	PORT CLARENC	CG	65 15N	166 52W	
18	SKAGWAY	A	59 27N	135 19W	25335
18	VALDEZ	A	61 07N	146 16W	26442
18	WALES	SA	65 37N	168 03W	26618
18	WALES	SAWR	65 37N	168 03W	26618
18	WALES	WBAS	65 37N	168 03W	26618
18	WRANGELL	A	56 28N	132 23W	25338
19	GUSTAVUS	SAWR	58 25N	135 44W	25322
19	POINT BARROW	AFS	71 20N	156 39W	27506
19	POINT HOPE	AAF	68 21N	166 47W	26601
19	SELDOVIA	SAWR	59 26N	151 42W	
19	ST PAUL IS	NS	57 07N	170 16W	25712
19	ST PAUL IS	SA	57 07N	170 16W	25713
19	TENAKEE	A	57 47N	135 12W	25336
20	BARTER IS	AFB	70 08N	143 36W	27401
20	ELFIN COVE	A	58 12N	136 40W	
20	GOLOVIN	A	64 33N	163 01W	26628
20	GUARD ISLAND	CG	55 27N	131 53W	25320
20	GUSTAVUS	A	58 25N	135 42W	25322
20	JUNEAU	WBAS	58 22N	134 35W	25309
20	JUNEAU	WSO	58 22N	134 35W	25309
20	KOTZEBUE	WBAS	66 52N	162 38W	26616
20	KOTZEBUE	WSO	66 52N	162 39W	26616
20	PLATINUM	A	59 01N	161 47W	25613
20	PT RETREAT	CG	58 25N	134 57W	25330
20	SELAWIK	A	66 34N	160 01W	
20	ST PAUL IS	S	57 07N	170 16W	25713
20	ST PAUL IS	SPL	57 07N	170 16W	25713
20	UNALAKLEET	A	63 53N	160 48W	26627
20	WIDE BAY	SAWR	57 22N	156 25W	
21	AKIAK	COOP	60 52N	161 23W	
21	BARTER IS	AFB	70 08N	143 36W	27401
21	MOSES POINT	AAF	64 43N	162 05W	26603
21	MOSES POINT	AC	64 42N	162 03W	26620
21	MOSES POINT	CAA	64 42N	162 03W	26620
21	MOSES POINT	FAA	64 42N	162 03W	26620
21	PLATINUM	AAF	59 01N	161 47W	25604
21	SKAGWAY	AAF	59 27N	135 19W	25303
21	UNALAKLEET	CAA	63 53N	160 48W	26627
21	UNALAKLEET	FAA	63 53N	160 48W	26627
21	UNALAKLEET	WBAS	63 53N	160 49W	26827
21	UNALAKLEET	WSO	63 53N	160 48W	26627
22	BETHEL	WBO	60 48N	161 45W	26615
22	DUTCH HARBOR	SA	53 53N	166 32W	25614
22	JUNEAU	WBAS	58 22N	134 35W	25309
22	NOME	SPL	64 30N	165 24W	26817
22	UNALAKLEET	AAF	63 54N	160 47W	26608
23	DUTCH HARBOR	AFS	53 54N	166 32W	25620
23	KANATAK	A	57 34N	156 02W	
23	VALDEZ	S	61 07N	146 16W	26442
24	ALITAK	A	56 57N	154 10W	25512
24	ANNEX CREEK	A	58 19N	134 06W	25311
24	BARROW	WBO	71 18N	156 47W	27502
24	CANDLE	A	65 56N	161 55W	26619
24	DAVIS	AAF	51 53N	176 39W	25701
24	JOHNSTONE PT	A	60 29N	146 36W	
24	NIKOLSKI	A	52 57N	168 52W	
25	BARROW	WBO	71 18N	156 46W	27502
25	CHIRIKOF IS	SAWR	55 54N	155 34W	25511
25	CORDOVA	S	60 31N	145 36W	26410
25	EXCURSION IN	A	58 25N	135 26W	
25	GAMBELL	SAWR	63 46N	171 45W	
25	HYDABURG	A	55 12N	132 49W	
25	LINCOLN ROCK	CG	56 03N	132 48W	25326
25	SITKA	A	57 03N	135 20W	25333
25	WOSNESSENSKI	A	55 13N	161 21W	
26	ATKA	NS	52 14N	174 13W	25710
26	DUTCH HARBOR	NS	53 53N	166 32W	25611
27	ALEXAI PT	AFS	52 50N	173 19E	45701
27	VALDEZ	S	61 07N	146 16W	26442
28	POINT LAY	SA	69 45N	163 03W	26624
28	ST PAUL IS	WBAS	57 09N	170 13W	25713
28	ST PAUL IS	WSO	57 09N	170 13W	25713
29	BARROW	WBAS	71 18N	156 47W	27502

Sample Page

BY LATITUDE

ALASKA

LAT.	NAME	TYPE	LONG.	WBAN NUMBER
52 55N	HOLTZ BAY	AAF	173 10E	45704
52 53N	CAPE WRANGEL	NF	172 31E	45713
52 50N	ALEXAI PT	AFS	173 19E	45701
52 50N	ATTU	CG	173 11E	45712
52 50N	ATTU	NS	173 11E	45709
52 50N	ATTU	S	173 11E	45712
52 48N	ATTU	NS	173 10E	45709
52 43N	SHEMYA	AAF	174 06E	45708
52 43N	SHEMYA	AFB	174 06E	45708
52 43N	SHEMYA	NS	174 06E	45714
52 43N	SHEMYA	SAWR	174 06E	45715
52 43N	SHEMYA	WBAS	174 06E	45715
52 43N	SHEMYA	WSO	174 06E	45715
52 22N	BULDIR IS	AAF	175 58E	45706
51 59N	KISKA ISLAND	AAF	177 34E	45703
51 59N	KISKA ISLAND	NAAF	177 33E	45710
51 58N	KISKA ISLAND	NAAF	177 32E	45710
51 55N	SEMISOPOCHNO	AAF	179 35E	45707
51 39N	BIRD CAPE	AAF	178 40E	45705
51 24N	AMCHITKA IS	AAF	179 16E	45702
51 24N	AMCHITKA IS	AFB	179 18E	45702
51 24N	AMCHITKA IS	NS	179 16E	45711
51 23N	AMCHITKA IS	AAF	179 15E	45702
51 23N	AMCHITKA IS	AFB	179 15E	45702
51 23N	AMCHITKA IS	SAWR	179 15E	
71 21N	POINT BARROW	AFS	156 39W	27505
71 20N	POINT BARROW	AFS	156 39W	27506
71 20N	POINT BARROW	CAA	156 39W	27504
71 20N	POINT BARROW	NS	156 24W	27501
71 18N	BARROW	WBAS	156 47W	27502.
71 18N	BARROW	WBO	156 47W	27502
71 18N	BARROW	WBO	156 46W	27502
71 18N	BARROW	WSO	156 47W	27502
71 18N	POINT BARROW	AFS	156 47W	27506
70 37N	WAINWRIGHT	A	160 04W	27503
70 37N	WAINWRIGHT	SA	160 04W	27503
70 23N	UGNU	SAWR	149 50W	
70 20N	WEST KUPARUK	SAWR	149 16W	
70 19N	PRUDHOE BAY	SAWR	148 33W	
70 15N	HULL	SAWR	148 57W	
70 15N	PRUDHOE BAY	SAWR	148 20W	
70 12N	DEADHORSE	FSS	148 28W	
70 12N	DEADHORSE	FSS	148 27W	
70 12N	DEADHORSE	SAWR	148 27W	
70 08N	BARTER IS	AAF	143 36W	27401
70 08N	BARTER IS	AFB	143 36W	27401
70 08N	BARTER IS	WBAS	143 38W	27401
70 08N	BARTER IS	WSO	143 38W	27401
70 04N	KAD RIVER	SAWR	147 43W	
70 03N	WEST KAVIK	SAWR	147 42W	
70 02N	PINGO	SAWR	147 43W	
69 45N	POINT LAY	SA	163 03W	26624
69 43N	FRANKLIN BLK	SAWR	148 41W	
69 41N	KAVIK	SAWR	146 56W	
69 41N	KAVIK RIVER	SAWR	146 56W	
69 34N	NORA FEDERAL	SAWR	148 45W	
69 31N	SUSIE 1	SAWR	148 53W	
69 22N	SAGWON	SAWR	148 42W	
69 22N	UMIAT	AFS	152 08W	26537
69 22N	UMIAT	CAA	152 08W	265rd
69 22N	UMIAT	NS	152 08W	26506
69 22N	UMIAT	SAWR	152 08W	28508
69 22N	UMIAT	SAWR	152 03W	26508
69 22N	UMIAT	WBAS	152 08W	26508
69 10N	HAPPY VALLEY	SAWR	148 50W	
69 09N	AUFEIS	SAWR	149 35W	
68 53N	CAPE LISBURN	AFS	166 08W	26631
68 52N	CAPE LISBURN	AFS	166 08W	26631
68 38N	MURPHY LAKE	SAWR	149 34W	
68 29N	GALBRAITHE	SAWR	149 29W	
68 21N	POINT HOPE	AAF	166 47W	26601
68 20N	POINT HOPE	A	166 48W	26623
68 11N	ATIGUN	SAWR	149 25W	
68 10N	ANAKTUVUK	A	151 46W	
68 10N	ANAKTUVUK	COOP	151 48W	

LAT.	NAME	TYPE	LONG.	WBAN NUMBER
68 08N	ARCTIC VILAG	COOP	145 32W	
68 06N	CAPE THOMPSO	SPL	165 46W	26636
67 45N	KIVALINA	A	164 42W	
67 44N	COLLEEN	COOP	142 28W	
67 41N	DIETRICH	SAWR	149 44W	
67 33N	WILD LAKE 2	COOP	151 33W	
67 33N	WILK LAKE 2	COOP	151 33W	
67 30N	CHANDALAR	A	148 30W	
67 30N	LAKE CHANDAL	A	148 30W	
67 30N	LAKE CHANDAL	COOP	148 30W	
67 27N	OLD MAN	SAWR	150 35W	
67 26N	WISEMAN	A	150 13W	26511
67 09N	CANYON VILAG	COOP	141 45W	
67 03N	COLD FT CAMP	SAWR	149 34W	
67 00N	VENETIE	COOP	146 34W	
66 56N	DAHL CREEK	A	156 52W	
66 55N	BETTLES	CAA	151 31W	26533
66 55N	BETTLES	FAA	151 31W	26533
66 55N	BETTLES	WBAS	151 31W	26533
66 55N	BETTLES	WSO	151 31W	26533
66 54N	BETTLES	CAA	151 43W	26517
66 54N	KOBUK	A	156 52W	
66 54N	SHUNGNAK	CAA	157 02W	26513
66 54N	SHUNGNAK	SA	157 07W	26513
66 52N	KOTZEBUE	SA	162 38W	26616
66 52N	KOTZEBUE	WBAS	162 38W	26616
66 52N	KOTZEBUE	WSO	162 38W	26616
66 50N	NOORVIK	COOP	161 00W	
66 48N	PROSPECT CRK	SAWR	150 38W	
66 38N	CHALKYITSIK	COOP	143 43W	
66 35N	FORT YUKON	A	145 18W	26413
66 35N	FORT YUKON	CAA	145 18W	26413
66 35N	FORT YUKON	FAA	145 18W	26413
66 35N	FORT YUKON	SAWR	145 18W	26413
66 34N	ALATNA	A	152 44W	
66 34N	FORT YUKON	A	145 16W	
66 34N	SELAWIK	A	160 01W	
66 33N	FORT YUKON	AC	145 12W	26413
66 14N	SHISHAREF	SA	166 07W	26625
66 05N	FIVE MILE CP	SAWR	150 00W	
66 04N	DEERING	A	162 45W	
66 04N	HUGHES	A	154 14W	26522
66 03N	INDIAN MTN	AFS	153 45W	26535
66 01N	STEVENS VILA	A	149 05W	26449
66 00N	INDIAN MTN	AFS	153 42W	26535
65 56N	CANDLE	A	161 55W	26619
65 48N	CIRCLE	A	144 04W	26446
65 45N	HOG RIVER	A	155 50W	
65 40N	TAYLOR	A	164 47W	
65 37N	WALES	A	168 03W	26618
65 37N	WALES	AAF	168 03W	26609
65 37N	WALES	CAA	168 03W	26618
65 37N	WALES	SA	168 03W	26618
65 37N	WALES	SAWR	168 03W	26618
65 37N	WALES	WBAS	168 03W	26618
65 35N	CENTRAL	A	144 48W	26418
65 35N	CENTRAL	A	144 47W	26418
65 35N	IMURUK LAKE	AAF	163 50W	26613
65 35N	LIVENGOOD	A	148 29W	26428
65 35N	LIVENGOOD	SAWR	148 29W	
65 34N	TIN CITY	A	167 55W	
65 34N	TIN CITY	AFS	167 55W	26634
65 33N	CENTRAL	COOP	144 49W	
65 32N	LIVENGOOD	COOP	148 31W	
65 32N	NOXAPAGE	AAF	164 12W	26606
65 30N	RAMPART	COOP	150 08W	
65 28N	CIRCLE HOT S	A	144 36W	26419
65 28N	CIRCLE HOT S	SAWR	144 36W	26419
65 28N	WEST FORK	COOP	148 40W	
65 27N	AMERICAN RVR	AAF	165 46W	26611
65 18N	TELLER	AAF	166 55W	26607
65 16N	COAL CREEK	A	143 16W	
65 16N	TELLER	A	166 21W	26626
65 15N	PORT CLARENC	CG	166 52W	
65 15N	PT SPENCER	AAF	166 21W	26612

V.1

QUARTERLY REPORT

Research Unit 497

Reporting Period 1 July 1977
through 30 September 1977

ALASKAN DATA PROCESSING FACILITY

Edgar F. Law

3 October 1977

SUMMARY

Travel

Fairbanks	22 July
Juneau	9 and 10 August
Denver	27 August through 2 September

CODING FORMS STATUS

Total Froms Received to Date	266
Total Forms Processed to Date	263
Total Forms Received this Period	7
Total Forms Processed this Period	4
Total Forms to be Completed	3

DATA SET STATUS

Total Data Received to Date	382
Total Data Controlled to Date	293
Total Data Received this Period	126
Total Data Controlled this Period	36
Total Data to be Controlled	90

1. Ship or Laboratory Activities

A. Travel Schedule

The field activities are limited to meetings with investigators or OCSEAP management personnel. Many meetings were held in Anchorage as investigators were traveling to field operations. The balance of the meetings in Anchorage included local investigators. The travel itineraries are listed below.

TRAVEL RU's - 497/370

Dates	
1. 22 July 1977	Fairbanks
2. 9-10 August 1977	Juneau
3. 27 August-2 September 1977	Boulder, Colorado

2. Scientific Party

Staff for the data processing facility and the NODC representative support is listed below.

Michael L. Crane	EDS	Physical Scientist
Joanne Grant	U of A	Data Transcriber
Wandalyn McClure	U of A	Data Transcriber
Virginia Holsapple	U of A	Secretary

3. Methods

The Anchorage data processing facility has an advantage in data checking from the experience gained in keyentry, consultation with Principal Investigators and coordination with the OCSEAP Data Base. The methods of checking will be improved by adding code valid tests and relational checks. Existing software will be used to provide standard data checking. Agreements for computer services have been negotiated with federal agencies and commercial firms. The emphasis will remain an "in-house' operation using intelligent entry equipment which is diskette based.

The following section highlights the activities this quarter for keyentry and Principal Investigator support.

083 Hunt

Keyentry of 033 Data	(UCI501, UCI601, 2 file idents)
Keyentry of 035 Data	25 file idents completed
Coded 033 Data	UCI602

Status - all data have been keyentered, all source documents and data media returned to investigator and copies of DDF's sent to investigator.

337 Lensink

Keyentry of 033 Data	71 Data sets

Status-data have been keyentered, all source documents and data returned to investigator and all support listings returned to investigator.

Keyentry of 035, 038 Data 26 Data sets completed

229, 243 Pitcher, Calkins

Keyentry of 025 Data 47 Data sets completed

Status - all 1975, 1976 data have been completed, source documents returned to investigator. All 1977 data have been keyentered, listed and the listings returned to the investigator.

196 Divoky

Keyentry of 033 data 83 data sets completed

Status - all 1975, 1976 data have been keyentered but the data have not been checked. Sorts and "selected" listings have been made and these paper outputs will be reviewed. These data will be the test data sets for the data checking activity for the Anchorage facility. The ice record has coding errors and must be corrected.

To assist the BLM/OCS office, RU 497 provides direct support in framing data requests. This task will continue and expand during FY78. Direct access to the interactive files will help assess the data coverage for potential data requests. A commercial or FTS phone line with data grade or data acceptable capacity will be necessary to connect terminals with the data inventories.

4. Sample Localities/Ship or Aircraft Tracklines

N/A

5. Data Collected or Analyzed

N/A

MILESTONES

The major milestones this quarter are noted in the attached tables for data processing activity for each research unit. The transition from data entry to data checking has few visible attributes. The housekeeping activity which completes the handling of data sets was a principal activity for the month of September. A library of diskettes was established, some keyentry equipment was returned to the vendor, data processing procedures were expanded and classes in FORTRAN were begun. All of these activities require time and effort but have few visible milestones. Production is not straight forward in data checking (which is a passive, abstract function); in contrast, production in data entry is identified as data sets received, completed and forwarded.

The milestones are divided into data sets received this quarter, data sets forwarded to the contract data manager and data sets not completed. The three tables identify the type of data by file type, the particular data set by file ident, the investigator by last name, the research unit, number, the media of the data and the date by the last two digits of the year, two digits of the month and two digits of the day (in that order of year, month and day).

PROBLEMS

The problems described in the last quarterly report remain. To emphasize the importance of these problems, they are repeated this quarter.

The increased effort in certifying data as it is received will require powerful software and the volume of material will require greater capacity equipment. Because the data managers in the OCSEA Program require more direct support in data handling, expanded telecommunications is needed to facilitate this support. Access to powerful software through telecommunication equipment would be both necessary and sufficient to accomplish the tasks of checking, inventorying and delivering summary reports.

Another problem is the software used to check the OCSEAP digital data. This research unit will require delivery of software or access to expanded software. NODC is currently developing the necessary check programs. Depending on the completion time, implementation of software checking will require NODC assistance.

Additional problems have surfaced during the transition from data entry to data checking.

Working in a vacuum to check the data submission is extremely inefficient. To make the data checking a more effective and efficient process, it is recommended that the coding forms (or sample coding forms) be forwarded with the data and the DDF's. The strategy for data checking can be greatly enhanced if the fields could be defined by the OCSEA Program before the data are received.

ESTIMATE OF FUNDS EXPENDED

RU 497	Salaries	30k
	Indirect	10k
	Travel	12k

Detailed Budget available under RU 362

RU 370 Submitted under separate University report.

Table Number I

STATUS OF CODING FORMS

RU	NAME	FILE TYPE	FILE IDENT	DATE RECEIVED YY MM DD	DATE COMPLETE YY MM DD	FORMS RETURNED YY MM DD	LIST RETURNED YY MM DD
196	DIVOKY	033	1DI577	77-07-18	- -	77-07-21	- -
196	DIVOKY	033	1DI577	77-07-18	- -	77-07-21	- -
196	DIVOKY	033	1DI577	77-07-18	- -	77-07-21	- -
337	LENSINK	033	FW6093	77-07-25	77-08-04	77-08-08	77-08-08
341	LENSINK	038	FW6023	77-08-26	77-09-15	77-09-19	77-09-19
341	LENSINK	038	FW6061	77-08-26	77-08-31	77-09-19	77-09-19
341	LENSINK	038	FW6099	77-08-26	77-08-31	77-09-19	77-09-19

Table Number II

DATA SENT TO JUNEAU

RU	NAME	FILE TYPE	FILE IDENT	MEDIA	DATE RECEIVED YY MM DD	DATE RETURNED YY MM DD	DATE MAILED YY MM DD
083	HUNT	035	PAUSP6	LST	77-05-02	- -	77-08-09
083	HUNT	035	RLKSP6	LST	77-05-02	- -	77-08-09
083	HUNT	035	UCISP6	LST	77-05-02	- -	77-08-09
083	HUNT	035	RLKSG5	LST	77-05-02	- -	77-08-09
083	HUNT	035	BKLSP6	LST	77-05-02	- -	77-08-09
083	HUNT	035	BLKSP6	LST	77-05-02	- -	77-08-09
083	HUNT	035	RFCSP6	LST	77-05-02	- -	77-08-09
083	HUNT	035	BLKSG6	LST	77-05-02	- -	77-08-09
083	HUNT	035	TBMSG6	LST	77-05-02	- -	77-08-09
083	HUNT	035	CMUSG6	LST	77-05-02	- -	77-08-09
083	HUNT	035	RFCSG6	LST	77-05-02	- -	77-08-09
083	HUNT	035	HPUSP6	LST	77-05-02	- -	77-08-09
083	HUNT	035	BLKSP5	LST	77-05-20	- -	77-08-09
083	HUNT	035	TBMSP5	LST	77-05-20	- -	77-08-09
083	HUNT	035	RLKSG6	LST	77-05-20	- -	77-08-09
083	HUNT	035	TBMSP6	LST	77-05-20	- -	77-08-09
083	HUNT	035	NFUSP6	LST	77-05-20	- -	77-08-09
083	HUNT	035	CMUSP6	LST	77-05-20	- -	77-08-09
083	HUNT	035	UCISP5	LST	77-05-23	- -	77-08-09
083	HUNT	035	RLKSP5	LST	77-05-23	- -	77-08-09
083	HUNT	035	RFCSP5	LST	77-05-23	- -	77-08-09
083	HUNT	035	HPUSP5	LST	77-05-23	- -	77-08-09
083	HUNT	035	BKTSP6	LST	77-05-23	- -	77-08-09
083	HUNT	035	RKTSP6	LST	77-05-31	- -	77-08-09
083	HUNT	035	TBTSP6	LST	77-05-31	- -	77-08-09
083	HUNT	035	UCISG6	LST	77-05-31	- -	77-08-09
337	LENSINK	033	FW6082	LST	77-06-29	- -	77-07-14
337	LENSINK	033	FW6025	LST	77-06-29	- -	77-07-14
337	LENSINK	033	FW6013	LST	77-06-29	- -	77-07-14
337	LENSINK	033	FW5038	LST	77-06-29	- -	77-07-14
237	DRURY	033	WD6WFS	LST	77-07-01	- -	77-07-18
237	DRURY	033	WD5WFS	LST	77-07-01	- -	77-07-18
237	DRURY	033	WD6OSI	LST	77-07-01	- -	77-07-18
237	DRURY	033	WD6SUI	LST	77-07-01	- -	77-07-18
237	DRURY	035	WD5BLF	LST	77-07-01	- -	77-07-18
237	DRURY	035	WD6KGI	LST	77-07-01	- -	77-07-18
237	DRURY	035	WD5SLG	LST	77-07-01	- -	77-07-18
237	DRURY	035	WD6SLG	LST	77-07-01	- -	77-07-18
237	DRURY	035	WD6BLF	LST	77-07-01	- -	77-09-15
458	SHEILDS	034	GTGOWL	MT9	77-07-12	- -	77-08-01
005	FEDER	032	000808	MT9	77-07-12	- -	77-08-01
005	FEDER	032	000818	MT9	77-07-12	- -	77-08-01
337	LENSINK	033	FW5003	LST	77-07-15	- -	77-07-26
337	LENSINK	033	FW5006	LST	77-07-18	- -	77-07-26
337	LENSINK	033	FW6014	LST	77-07-19	- -	77-07-26
337	LENSINK	033	FW6006	LST	77-07-21	- -	77-07-26
337	LENSINK	033	FW5010	LST	77-07-22	- -	77-07-26
337	LENSINK	033	FW5016	LST	77-05-04	- -	77-06-15

Table Number III

DATA TO BE CONTROLLED

RU	NAME	FILE TYPE	FILE IDENT	MEDIA	DATE RECEIVED YY MM DD
237	DRURY	035	WD6BLF	LST	77-07-01
196	DIVOKY	033	2PD976	LST	77-07-07
196	DIVOKY	033	3C0676	LST	77-07-07
196	DIVOKY	033	2CL676	LST	77-07-07
196	DIVOKY	033	3C0676	LST	77-07-07
196	DIVOKY	033	2GL976	LST	77-07-07
196	DIVOKY	033	2GLA76	LST	77-07-07
196	DIVOKY	033	2BI776	LST	77-07-07
196	DIVOKY	033	2BW076	LST	77-07-07
196	DIVOKY	033	2KL676	LST	77-07-07
196	DIVOKY	033	2KL676	LST	77-07-07
196	DIVOKY	033	2KL776	LST	77-07-07
196	DIVOKY	033	2BW776	LST	77-07-07
196	DIVOKY	033	3PP776	LST	77-07-07
196	DIVOKY	033	2WR676	LST	77-07-07
196	DIVOKY	033	2IC676	LST	77-07-07
196	DIVOKY	033	2WR976	LST	77-07-07
196	DIVOKY	033	2UP776	LST	77-07-07
196	DIVOKY	033	2CB776	LST	77-07-07
196	DIVOKY	033	2CL976	LST	77-07-07
196	DIVOKY	033	2IC976	LST	77-07-07
196	DIVOKY	033	2IC876	LST	77-07-07
196	DIVOKY	033	2PD776	LST	77-07-07
196	DIVOKY	033	3A1976	LST	77-07-07
196	DIVOKY	033	3A2976	LST	77-07-07
196	DIVOKY	033	3A3976	LST	77-07-07
196	DIVOKY	033	3A1A76	LST	77-07-07
196	DIVOKY	033	3A2A76	LST	77-07-07
196	DIVOKY	033	2A3976	LST	77-07-07
196	DIVOKY	033	2A4976	LST	77-07-07
196	DIVOKY	033	2A1A76	LST	77-07-07
196	DIVOKY	033	2A1B76	LST	77-07-07
196	DIVOKY	033	3A1676	LST	77-07-07
196	DIVOKY	033	3A2676	LST	77-07-07
196	DIVOKY	033	3A3676	LST	77-07-07
196	DIVOKY	033	3A2776	LST	77-07-07
196	DIVOKY	033	3A3776	LST	77-07-07
196	DIVOKY	033	3A4776	LST	77-07-07
196	DIVOKY	033	3A5776	LST	77-07-07
196	DIVOKY	033	3A6776	LST	77-07-07
196	DIVOKY	033	3A1876	LST	77-07-07
196	DIVOKY	033	3A2876	LST	77-07-07
196	DIVOKY	033	3AL876	LST	77-07-07
196	DIVOKY	033	2BW576	LST	77-07-07
196	DIVOKY	033	3OK676	LST	77-07-07
196	DIVOKY	033	3PB876	LST	77-07-07
196	DIVOKY	033	3BR776	LST	77-07-07

DATA TO BE CONTROLLED

RU	NAME	FILE TYPE	FILE IDENT	MEDIA	DATE RECEIVED YY MM DD
196	DIVOKY	033	3PI776	LST	77-07-07
196	DIVOKY	033	3BB776	LST	77-07-07
196	DIVOKY	033	3PF876	LST	77-07-07
196	DIVOKY	033	3OK976	LST	77-07-07
196	DIVOKY	033	2GL876	LST	77-07-07
196	DIVOKY	033	2GL876	LST	77-07-07
196	DIVOKY	033	2CL876	LST	77-07-07
196	DIVOKY	033	2WR776	LST	77-07-07
196	DIVOKY	033	3CO876	LST	77-07-07
196	DIVOKY	033	3CO776	LST	77-07-07
196	DIVOKY	033	3CO776	LST	77-07-07
196	DIVOKY	033	3OK776	LST	77-07-07
196	DIVOKY	033	3CO776	LST	77-07-07
196	DIVOKY	033	3BL676	LST	77-07-07
196	DIVOKY	033	2PD676	LST	77-07-07
196	DIVOKY	033	2A7676	LST	77-07-07
196	DIVOKY	033	2A1776	LST	77-07-07
196	DIVOKY	033	2A2776	LST	77-07-07
196	DIVOKY	033	2A3776	LST	77-07-07
196	DIVOKY	033	2A4776	LST	77-07-07
196	DIVOKY	033	2A1876	LST	77-07-07
196	DIVOKY	033	2A2876	LST	77-07-07
196	DIVOKY	033	2A1976	LST	77-07-07
196	DIVOKY	033	2A2976	LST	77-07-07
196	DIVOKY	033	2A1576	LST	77-07-07
196	DIVOKY	033	2A2576	LST	77-07-07
196	DIVOKY	033	2A1676	LST	77-07-07
196	DIVOKY	033	2A2676	LST	77-07-07
196	DIVOKY	033	2A3676	LST	77-07-07
196	DIVOKY	033	2A5676	LST	77-07-07
196	DIVOKY	033	2A6676	LST	77-07-07
196	DIVOKY	033	3CR776	LST	77-07-07
196	DIVOKY	033	2DI976	LST	77-07-07
196	DIVOKY	033	2GL875	LST	77-07-07
196	DIVOKY	033	2GL875	LST	77-07-07
196	DIVOKY	033	2DI976	LST	77-07-07
196	DIVOKY	033	2GL875	LST	77-07-07
337	LENSINK	033	FW6093	LST	77-09-06
243	CALKINS	025	277LIO	LST	77-09-07
243	CALKINS	025	377LIO	LST	77-09-07
243	CALKINS	025	477LIO	LST	77-09-07
243	CALKINS	025	577LIO	LST	77-09-07
229	PITCHER	025	377KEN	LST	77-09-07
229	PITCHER	025	477KOD	LST	77-09-07
229	PITCHER	025	577KOD	LST	77-09-07
337	LENSINK	033	FW7035	DIS	77-09-19

QUARTERLY REPORT

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OCSEAP Data Processing Services

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Background and Objectives

The OCSEA Program encompasses a multitude of investigations covering a wide spectrum of environmental parameters. As part of program requirements, data resulting from these investigations are to be quality controlled and formatted into several multi-card type file formats, then forwarded to archiving centers through the project offices.

Much of the data flow is monitored by the Juneau Project Office (JPO). In some cases, two of the many steps required in the successful execution of this task require the use of data processing services. These include data validation and data product generation, and are addressed by this work.

In order to carry out these procedures, use is made of a data base management system, known as the MARMAP Information System (MIS), along with other programs specific to the needs of this work.

Procedures

In order to provide data validation for a multi-card type file format, four areas must be addressed. These include card type validation, data code validation, data range and relational parameter checking, and format, code, or unit conversion. Typically, the following concerns apply, and require that these steps be carried out. First, in a multi-card format, the card designation code must be verified (an incorrect value would lead to the improper interpretation of remaining fields on the card). Second, codes used in each code field (ex.-a two digit weather code) must be compared against all valid codes for that field for verification. Also, part of this second step is the verification of proper occurrence and sequencing of all card types. Next, range checks must be carried out on all appropriate fields (ex.-sea surface temperature should be between certain upper and lower limits), and relational checks madc on inter-related fields (ex.-wet bulb temperature readings should be less than or equal to corresponding dry bulb temperature readings). Lastly, if the data are not coded in format, units, and codes acceptable to OCSEAP, the necessary conversion(s) must be carried out.

Typically, data are received by this RU on tapes, each of which contains the results of several field operations. A back-up copy of the original tape is first made, then a disk data set is created for each field operation. Card type designations and valid code field contents are then checked using a program called CODEPULL. The card type designation causes selection of appropriate code tables to be used in code field validations, hence an incorrectly designated card type causes selection of inappropriate code tables, which in turn causes virtually all codes on that card to appear incorrect. The problem is in the card type designation, of course, and corrections are made to the file with a program called URUNCTF. When CODEPULL is rerun, the appropriate code tables are then called, and each code of each code field is compared with the appropriate table containing all valid codes for that field. Exceptions are listed as part of the program output. Also checked in this program is the proper sequencing and occurrence of all card types. Extra cards and locations of missing cards are also part of program output. A sample output is given in Figure 1. While card type designation corrections can be deciphered by inspection of other data on the cards, code and card exception resolution must be made by the data originator. Hence, CODEPULL output is returned to the originator's site for resolution, then returned to this RU for actual data corrections on the file. Such corrections are carried out using an interactive program EDITLOG.

The next step in the data validation process is concerned with data coded as raw numbers, rather than in code fields, and utilizes a program called LOGLIST. In this case, two types of checks are made, range checking, and relational checking. In the former, the contents of data fields are compared with upper and lower limits appropriate to each field. In the latter case, the value of the contents of one field may be dependent on the value of the contents of another field. When data fail either of these types of checks, appropriate error messages are output. An example is shown in Figure 2. As with CODEPULL output, LOGLIST output is returned to the originator for resolution, with actual data corrections carried out by this RU through use of EDITLOG.

At this point, runs of CODEPULL and LOGLIST on corrected files are sent to the originator for final verification. If no further corrections are necessary, and the data format, units, and codes used are all in conformance with program requirements, the data is sent to JPO for submission.

However, data are often not coded in accordance with program protocol, and in such cases conversions must be made. These conversions are accomplished with a program called CONVPROG, and this step is quite detailed, since many different operations are carried out. For example, data fields must be moved from one place to another on a given card, and even to a different card; units must be converted and rounded, truncated, or converted to codes; and codes must be converted from those peculiar to one investigator to those equivalent codes acceptable to program protocols. An example of one of the more complicated operations is conversion from data recorded as direction with respect to an observation platform, recorded in units of clock position, to a value based on compass readings, based on a 0-36 range, with correction for platform orientation in degrees on a compass! After conversions of this type are carried out, data are ready for submission to JPO.

A last step, not required for data validation per se, but needed for data product generation, is conversion of data files into a data base. Again, CONVPROG is used for this step, and the data are converted into an MIS data base in preparation for product generation. Once in the form of a data base, other programs which form a part of the MIS can be used to prepare data reports, maps, input data into statistical programs, etc. Products generated in this fashion are to be delivered to JPO for use in the overall task management in that office.

Results

This work was begun in March 1977. Activities to date have been concerned with data to be submitted in National Oceanic Data Center File Type 033, Ship and Aircraft Census. Although new types of data validation checks and revisions to program output formats are made continually, programming for the basic framework required in order to carry out the procedures described above became operational in June 1977.

Production work has been carried out on data from 91 field operations from five originators and covering the period from 1975 to the present. The data is in various stages of progress through the validation steps. Some require conversion to accepted protocol, and require the conversion step, while others will be ready for submission when final verification is made by the originator. Present operations are summarized in Figure 3, and the status of each field operation is given in Table 1.

After data sets are validated by these procedures, they will be converted into MIS data bases, and work can be initiated on product development.

***** CODEPULL *****

FOR CRUISE UCI501

THE MARMAP INFORMATION SYSTEM   OCSEAP - GULF OF ALASKA PROJECT

Figure 1. Partial listing of CODEPULL output

```
*** CODEPULL - CRUISE UCI501

--------------------------------------------------------------------------------------------------------------------
                          033UCI501SE03315700017031OW02521080350           15-1100001   06812980H21
RECORD #     2
TYPE 4 #     1  MISSING 2 CARD -->
                          033UCI501SE0334REFERENCE 033UCI501SEC104 COMMENTS FOR TRANSECT METHODS.      459
                          033UCI501SE0335UNDM8810100300000000003000010252000    0232201          H50460
                          033UCI501SE0335UNDM8810100300000000014000010252018    0232201          H50461
                          033UCI501SE0335UNDM8810100300000000006010202520001    0232201          H50462
                          033UCI501SE0335UNDK8810080300000000004000010252018    0232301          H50463
                          033UCI501SE0335UNDK8810080300000000001000010252000    0232401          H50464
                          033UCI501SE0335FULM8803020201000000001010202520001    0232501          H50465
                          033UCI501SE0335UNDK8810080300000000001020307520018    0232601          H50466
                          033UCI501SE0335UNDM881010030000000000100107520        0232701          H50467
                          033UCI501SE0335UNDM8810100300000000001020307520000    0232701          H50468
                          033UCI501SE0335FULM8803020201000000002000107520019    0232801          H50469
                          *33UCI501SE0335FULM8803020201000000001000107520000    0232801          H50470
                          033UCI501SE0335UNSW8803020400000000005000107520000    0232901          H50471
                          033UCI501SE0335UNSW8803020400000000002020307520000    0232901          H50472
RECORD #    16
TYPE 5 #    14  BAD CODE-->   033UCI501SE0335PARJ8810050102000000002000112542219    C233001          H50473
                                                                          **
                          033UCI501SE0334PAIR PARASITICJAEGERS FHYING SOUTH FOLLOWED SHIP FIVE MINUTES 474
                          033UCI501SE0335UNDM8810100300000000006000112520000    0233101          H20475
                          033UCI501SE0335TBLM881010030200000000200011250 1      0233201          H20476
                          033UCI501SE0335TBLM881010030200000000101021250 1      0233201          H20477
                          033UCI501SE0335TBLM881010030200000000402031250 1      0233201          H20478

--------------------------------------------------------------------------------------------------------------------
                          033UCI501SE03415709017059 4W02521080630          15-1100001   06812980H21
RECORD #    23
TYPE 2 #     1  BAD CODE-->   033UCI501SE0342024531003    0074        0084     0          900
                                          **
                          033UCI501SE0345FULM8803020201000000002000102520000    0233301          H20479
                          033UCI501SE0345UNDM8810100300000000010102025200 0     0233401          H20480
                          033UCI501SE0345UNDK8810080300000000001000102520019    0233501          H20481
                          033UCI501SE0345UNDK8810080300000000010102025200 0     0233501          H20482
                          033UCI501SE0345UNSW8803020400000000010102025201 8     0233601          H20483
                          033UCI501SE0345UNDM8810100300000000010203075201 8     0233701          H20484
                          033UCI501SE0345UNDM8810100300000000010203075200 0     0233701          H20485
                          033UCI501SE0345UNDK8810080300000000002000107520 18    0233801          H20486
RECORD #    32
TYPE 5 #    27  BAD CODE-->   033UCI501SE0345UNDJ8810050100000000001000107541 18    0233901          H20487
                                                                          **
                          033UCI501SE0344UNID.JAEGER PARASITIC OR POMARANIAN                     488
                          033UCI501SE0345GWGU881008010300000000100011253 2      0234001          H20489
                          033UCI501SE0345UNDK8810080300000000002000112520 18    0234101          H20490
                          033UCI501SE0345UNDM8810100300000000010001125200 0     0234201          H20491
                          033UCI501SE0345UNDM8810100300000000010001125201 8     0234301          H20492
                          033UCI501SE0345FULM8803020201000000001000112520 18    0234401          H20493
                          033UCI501SE0345FULM8803020201000000001020312520 18    0234401          H20494
                          033UCI501SE0345UNDK8810080300000000002000112520 18    0234501          H20495
                          033UCI501SE0345UNDK8810080300000000003020312520 18    0234501          H20496

--------------------------------------------------------------------------------------------------------------------
```

Figure 1 (Cont'd)

***** SUMMARY *****

FOR CRUISE UCI501

4952 TOTAL RECORDS

84 TYPE 1 RECORDS
66 TYPE 2 RECORDS
0 TYPE 3 RECORDS
51 TYPE 4 RECORDS
4751 TYPE 5 RECORDS

0 RECORDS WITH AN
INVALID TYPE

RECORD TYPE 1

CODE FIELD: O.B.S. REGION - FWS(1:28-30)

CODES	COMMENT
025	ST. GEORGE BASIN (SGB)

CODE FIELD: PLATFORM TYPE - FWS(1:67-68)

CODES	COMMENT
12	DISCOVERER
23	*** 000914 004809

CODE FIELD: SAMPLING TECHNIQUE - NODC(1:70) - FWS(1:69)

CODES	COMMENT
9	CTHER TECHNIQUE (SEE TEXT)
3	COUNT FROM SHIP TO FIXED DISTANCE WITH ZONE
8	*** 002355

CODE FIELD: SPEED TYPE - FWS(1:60)

CODES	COMMENT
1	SPEED MADE GOOD

Figure 1 (Cont'd)

```
***** LOGLIST *****

FOR CRUISE UCI501
CALL FILE ********
CARD TYPE 1

THE MARMAP INFORMATION SYSTEM        OCSEAP - GULF OF ALASKA PROJECT
```

Figure 2. Partial listing of LOGLIST output

```
*** LOGLIST - CRUISE UCI501 - CALL FILE ******** - CARD TYPE 1

        ACRONYM DEFINITIONS

     STA    STATION
     LAT    START LATITUDE
     LON    START LONGITUDE
      DEG    DEGREES (SUBFIELD OF LON)
     ORR    O.R.S. REGION
     DAT    DATE - DDMM
      DAY    DAY (SUBFIELD OF DAT)
      MON    MONTH (SUBFIELD OF DAT)
     TIM    TIME - HHMM
      HOR    HOUR (SUBFIELD OF TIM)
      MIN    MINUTES (SUBFIELD OF TIM)
     LTD    END LATITUDE
     LNG    END LONGITUDE
     ELT    ELAPSED TIME
     SPD    SPEED MADE GOOD
     TZS    TIME ZONE SIGN
     TZN    TIME ZONE NUMBER
     HED    COURSE MADE GOOD
     HGT    HEIGHT OF OBS. EYES (ABOVE SEA)
     PLT    PLATFORM TYPE
     SMP    SAMPLING TECHNIQUE
     ACT    SHIP ACTIVITY
     ORN    O.R.S. NUMBER
     LOC    LOCATION ON SHIP
```

Figure 2 (Cont'd)

SPECIAL CHARACTERS

- \- INDICATES A CODE FIELD
- * INDICATES A BLANK CHARACTER IN A FIELD
- . INDICATES A TOTALLY BLANK FIELD
- / FIELD IS LISTED IN THE DIAGNOSTICS IF NON-BLANK (DATA WOULD OTHERWISE NOT FIT ON ONE LINE)

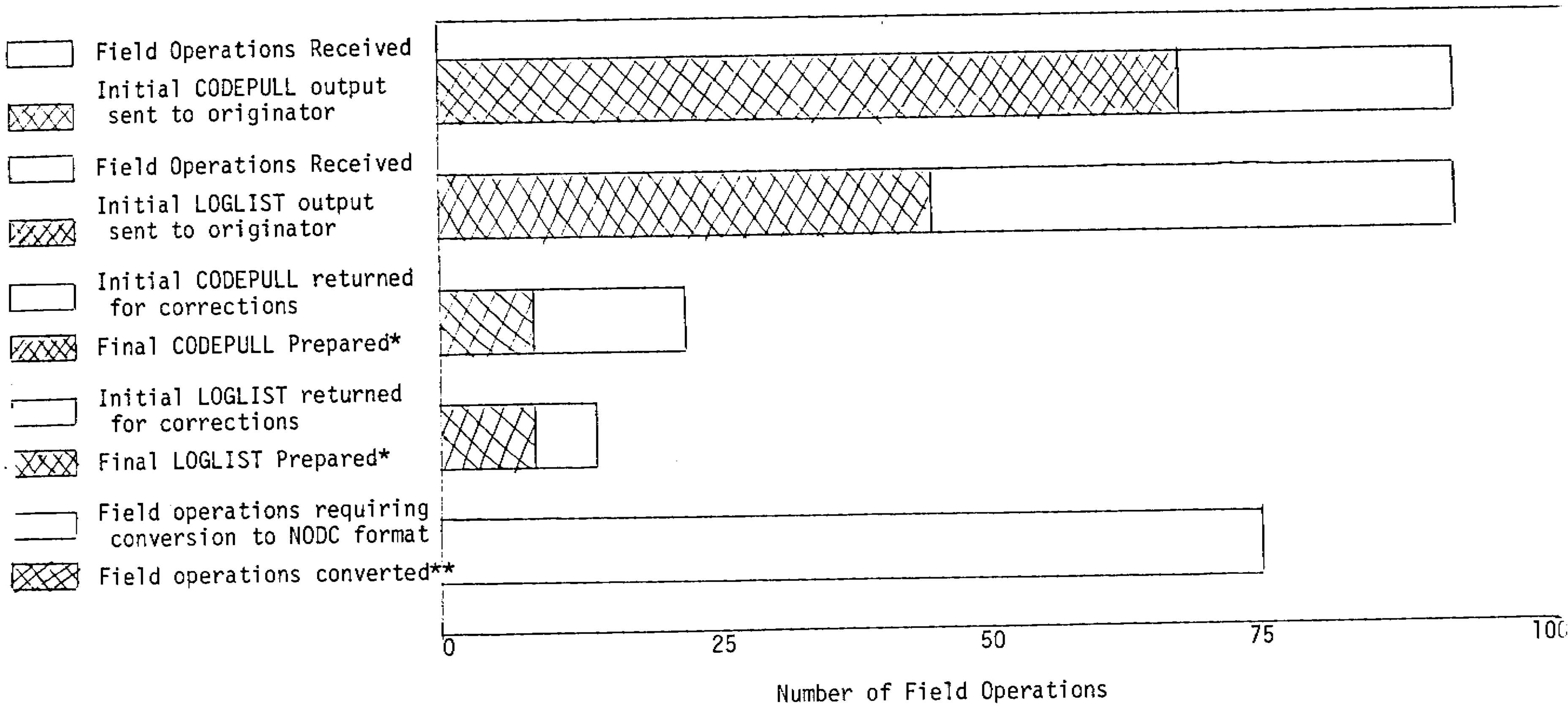
Figure 2 (Cont'd)

*** LOGLIST - CRUISE UCI501 - CALL FILE ******** - CARD TYPE 1

	STA	LAT	LON	OBR	DAT	TIM	LTD	LNG	ELT	SPD	TZS	TZN	HED	HGT	PLT	SMP	ACT	OBN	LOC	DIAGNOSTICS
51:	TS041	57035	170098W	025	2108	1710	.....	....	15	0100	-	11	132	068	12	3	3	H2	1	
52:	TS042	57002	170014W	025	2108	1730	.....	....	15	0115	-	11	131	068	12	3	3	H2	1	
53:	TS043	57000	170010W	025	2108	1750	.....	....	70	0100	-	11	131	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
54:	TS044	56510	169500W	025	2108	1820	56471	169410W	40	0100	-	11	131	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
55:	TS046	56470	169410W	025	2108	2030	56420	169300W	30	0105	-	11	130	068	12	3	3	H2	1	
56:	TS048	56420	169300W	025	2128	2100	.....	....	15	0105	-	11	096	068	12	3	3	H2	1	* MON FIELD OUTSIDE *
57:	TS049	.....	....	025	2108	2115	56348	169128W	45	0105	-	11	130	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
58:	TS050	56348	169128W	025	2108	2200	56300	171100W	15	0105	-	11	130	068	12	3	3	H2	1	
59:	TS052	56330	169070W	025	2108	2315	.....	....	45	0100	-	11	131	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
60:	TS053	56270	168550W	025	2208	0000	56180	168405W	70	0105	-	11	131	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
61:	TS056	56180	168400W	025	2108	0225	56170	168390W	15	0090	-	11	131	068	12	3	3	H2	1	
62:	TS057	56170	168380W	025	2208	0240	56140	169340W	20	0105	-	11	131	068	12	3	3	H2	1	
63:	TS057	56140	169340W	025	2208	0300	56140	169035W	60	0100	-	11	270	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
64:	TS059	56145	169145W	025	2208	0530	56154	169400W	60	0100	-	11	270	068	12	8	3	H2	1	* ELT FIELD OUTSIDE *
65:	TS061	57068	170226W	025	2208	1700	56584	170345W	60	0100	-	11	215	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
66:	TS062	56584	170345W	025	2208	1800	56090	170070W	60	0120	-	11	215	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
67:	TS064	56150	170100W	025	2208	2000	56330	170060W	90	0105	-	11	190	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
68:	TS065	56330	170060W	025	2208	2130	.....	....	25	0105	-	11	215	068	12	3	3	H2	1	
69:	TS066	56300	171120W	025	2208	1245	56150	171215W	95	0115	-	11	215	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
70:	TS067	56120	171340W	025	2308	0315	56150	171320W	75	0080	-	11	056	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
71:	TS068	56150	171320W	025	2308	0460	56150	171215W	30	0100	-	11	090	068	12	3	3	H2	1	* MIN FIELD OUTSIDE *
72:	TS069	56170	171150W	025	2308	0600	.....	....	90	0105	-	11	090	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
73:	TS070	.....	....	025	2308	0730	56160	169396W	90	0100	-	11	090	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
74:	TS072	57079	170050W	025	2308	1715	57100	170400W	75	0115	-	11	090	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
75:	TS074	57100	170400W	025	2308	1930	57270	169010W	75	0100	-	11	000	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *
76:	TS076	57260	169410W	025	2308	2200	.....	....	60	0090	-	11	225	068	12	3	3	H2	1	* ELT FIELD OUTSIDE *

Figure 2 (Cont'd)

Figure 3. DATA PROCESSING OPERATIONS
June 1 - September 30, 1977



* To be sent to originator 10/4/77

**Of the 91 field operations received to date, 75 will require data, code, and unit conversions. This step will be carried out after final data verification has been received.

TABLE I. CURRENT STATUS OF FIELD OPERATIONS
(as of September 30, 1977)

			Initial Validation Dates				Final Validation Dates			
Field Operation Identification[1]	Date Received	URI Tape Identification	CODEPULL Sent to Originator	LOGLIST Sent to Originator	CODEPULL Returned for Correction	LOGLIST Returned for Correction	CODEPULL Sent to Orginator w/Corrections	LOGLIST Sent to Orginator w/Corrections	CODEPULL & LOGLIST Final Verification	Format Code & Unit Conversion
FW5004	3-12	URI.EGS1.REB. FWT4T04	7-12	8-16	8-29					
FW5009	3-12	URI.EGS1.REB. FW9T32	7-12	8-16						
FW5013	3-12	" " "	7-12	8-16	8-29					
FW5018	3-12	" " "	7-12	8-16	8-29					
FW5023	3-12	" " "	7-12	8-16	8-29					
FW5024	3-12	" " "	7-12	8-16	8-29					
FW5030	3-12	" " "	7-12	8-16	8-29					
FW5032	3-12	" " "	7-12	8-16	8-29					
W05220	4-20	URI.QAK1.STW. OREGN1								N.A.[4]
W05221	4-20	" " "								"
W05310	4-20	" " "								"
W05311	4-20	" " "								"
W05320	4-20	" " "								"
W16140	4-20	" " "								"
W16150	4-20	" " "								"
W16161	4-20	" " "								"
W26140	4-20	" " "								"
W06211	4-20	" " "								"
W06221	4-20	" " "								"
W36070	4-20	" " "								"
FW5008	5-27	URI.QAK1. FW508T74	7-14	8-16	9-6	9-6				
FW5016	5-27	" " "	7-14	8-16	9-6	9-6				
FW5021	5-27	" " "	7-14	8-16	9-6	9-6				
FW5026	5-27	" " "	7-14	8-16	9-6	9-6				

TABLE I. (Cont.) CURRENT STATUS OF FIELD OPERATIONS

(as of September 30, 1977)

			Initial Validation Dates				Final Validation Dates			
Field Operation Identification[1]	Date Received	URI Tape Identification	CODEPULL Sent to Originator	LOGLIST Sent to Originator	CODEPULL Returned for Correction	LOGLIST Returned for Correction	CODEPULL Sent to Orginator w/Corrections	LOGLIST Sent to Orginator w/Corrections	CODEPULL & LOGLIST Final Verification	Format Code & Unit Conversion
FW5027	5-27	" " "	7-14	8-16	9-6	9-6				
FW5033	5-27	" " "	7-14	8-16	9-6	9-6				
FW5035	5-27	" " "	7-14	8-16	9-6	9-6				
FW6008	5-27	" " "	7-14	8-16						
FW6027	5-27	" " "	7-14	8-16	9-6	9-6				
FW6051	5-27	" " "	7-14	8-16	9-6	9-6				
FW6074	5-27	" " "	7-14	8-16	9-6	9-6				
FW6083	5-27	" " "	7-14	8-16	9-6	9-6				
FW6050	5-27	" " "	7-14	8-16	9-6	9-6				
FW5011	6-24	URI.QAK1. F511T694	8-16	8-16						
FW5012	6-24	" " "	8-16	8-16						
FW5020	6-24	" " "	8-16	8-16						
FW5031	6-24	" " "	8-16	8-16						
FW5034	6-24	" " "	8-16	8-16						
FW6015	6-24	" " "	8-16	8-16						
FW6018	6-24	" " "	8-16	8-16						
FW6019	6-24	" " "	8-16	8-16						
FW6067	6-24	" " "	8-16	8-16						
FW6068	6-24	" " "	8-16	8-16						
FW6088	6-24	" " "	8-16[2]	9-29						
FW6089	6-24	" " "	8-16	8-16						
FW6094	6-24	" " "	8-16	8-16						
FW5015	7-1	URI.QAK1.ROG. ALASKA 5	8-16[2]	9-29						
FW5025	7-1	" " "	8-16[2]	9-29						
FW6001	7-1	" " "	8-16[2]	9-29						
FW6002	7-1	" " "	8-16[2]	9-29						
FW6007	7-1	" " "	8-16[2]	9-29						
FW6009	7-1	" " "	8-16[2]	9-29						
FW6021	7-1	" " "	8-16[2]							
FW6026	7-1	" " "	8-16[2]	9-29						
FW6029	7-1	" " "	8-16[2]	9-29						
FW6057	7-1	" " "	8-16[2]	9-29						
FW6064	7-1	" " "	8-16[2]	9-29						
FW6066	7-1	" " "	8-16[2]	9-29						
FW6070	7-1	" " "	8-16[2]	9-29						
FW6095	7-1	" " "	8-16[2]	9-29						

TABLE I. (Cont.) CURRENT STATUS OF FIELD OPERATIONS

(as of September 30, 1977)

			Initial Validation Dates				Final Validation Dates			
Field Operation Identification[1]	Date Received	URI Tape Identification	CODEPULL Sent to Originator	LOGLIST Sent to Originator	CODEPULL Returned for Correction	LOGLIST Returned for Correction	CODEPULL Sent to Orginator w/Corrections	LOGLIST Sent to Orginator w/Corrections	CODEPULL & LOGLIST Final Verification	Format Code & Unit Conversion
FW5014	7-7	URI.QAK1.ROG. ALASKA 6	8-16							
FW5022	7-7	" " "	8-16							
FW5029	7-7	" " "	8-16							
FW5036	7-7	" " "	8-16							
FW5037	7-7	" " "	8-16							
FW6004	7-7	" " "	8-16							
FW6005	7-7	" " "	8-16							
FW6010	7-7	" " "	8-16							
FW6011	7-7	" " "	8-16							
FW6012	7-7	" " "	8-16							
FW6016	7-7	" " "	8-16							
FW6028	7-7	" " "	8-16							
FW6052	7-7	" " "	8-16							
FW6077	7-7	" " "	8-16							
FW6078	7-7	" " "	8-16							
FW6084	7-7	" " "	8-16							
FW6085	7-7	" " "	8-16							
FW6092	7-7	" " "	8-16							
FW7026	7-7	" " "	8-16							
FW7027	7-7	" " "	8-16							
UCI501	7-7	URI.QAK1.ROG. ALASKA 7								
UCI601	7-7	" " "								
FW5038	7-28	URI.QAK1.ROG. ALASKA 8	8-16							
FW6013	7-28	" " "	8-16							
FW6025	7-28	" " "	8-16							
FW6082	7-28	" " "	8-16							
FW6087	7-28	" " "	8-16							
01UC75	8-1	URI.QAK1.ROG. CANADA 1								N.A.
FW5003	8-3	URI.QAK1.ROG.[3] ALASKA 9								
FW5006	8-3	" " "								
FW5010	8-3	" " "								
FW6006	8-3	" " "								
FW6014	8-3	" " "								
FW7032	9-6	URI.QAK1.ROG. Alaska 10								N.A.

1. Field operations received from: FW=Dr. Calvin Lensink; UCI=Dr. George L. Hunt; W=Dr. John A. Weins; 01UC75 = Dr. Juan Guzman
2. Revised version CODEPULL output for these field operations sent on 9/29/77
3. Tape was unreadable, returned for correction
4. N.A.=Not applicable

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